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Research Article

Evaluating the Impact of Indonesian Herbal Mixture on Recovery and Performance of Bali Cattle After Long-Distance Transportation

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Abstract: Cattle traveling for an extended period on the road are often experience a decrease in body weight between 10 and 20%. This decrease causes significant losses for farmers, showing the importance of implementing treatment programs for recovery. To overcome the losses, a potential solution could be the use of an Indonesian Herbal Mixture (IHM) comprising various herbal ingredients such as galangal, java ginger, turmeric, garlic, cinnamon, and bitter ginger. Therefore, this study aimed to determine the optimal level of IHM required to enhance and sustain the performance of 16 male Bali cattle after long-distance transportation with a total distance approaching 3,516 km, via livestock vessels and trucks. A randomized block design (4×4) was used, comprising four IHM treatment levels and four body weight groups as replicates. The average initial body weight was 239 kg (G_1), 233.5 kg (G_2), 231.7 kg (G_3), and 237.6 kg (G_4). The treatments were designated as follows T_0 was Kumpai grass plus concentrate and tofu dreg, T_1 was T_0 plus 100 ml IHM, T_2 was T_0 plus 150 ml IHM, and T_3 was T_0 plus 200 mL IHM. The experimental period lasted a total of 10 weeks, during which we observed several variables, including the ratio of Dry Matter Intake (DMI), protein consumption, Average Daily Gain (ADG), and feed efficiency. The findings indicated that the administration of IHM at a dosage of 200 mL led to a statistically significant improvement in DMI, protein consumption, ADG, and feed efficiency for 1-month duration. A strong positive correlation was observed between all variables, showing that IHM could function as a natural feed supplement, promoting the performance of cattle experiencing long-distance transportation stress.

Keywords: Body Weight Loss, Cattle, Dry Matter Intake, Feed Efficiency, Natural Feed Supplement

Introduction

High productivity is the target of farmers in the cattle fattening business through a significant increase in body weight. Achieving high body weight depends on the amount of consumption and health factors of beef cattle (Gionbelli *et al.*, 2015; Smith, 2023). However, a problem is often experienced by farmers, especially for Bali cattle (*Bos javanicus*), where the procurement of quality breeding stock is sourced from outside the region or island. Long distances in the transportation of animals will result in a decrease or shrinkage of the body weight of about 10-15% (Nugroho *et al.*, 2021). The mode of transportation such as using trucks and ships also triggers stress levels, which can be observed in body weight and carcass quality (Yulindra *et al.*, 2023). Based on the results of Widayati *et al.* (2019), the process of transporting and loading Bali cattle onto livestock vessels has the potential to cause stress, as indicated by cortisol levels reaching 138.41 ng/mL. Therefore, there is a need to mitigate weight loss when cattle arrive at their destination to avoid economic loss (Van Engen and Coetzee, 2018). To facilitate an increase in body weight recovery, the nutritional requirements of Bali cattle must be met. Achieving this goal can be challenging, as the response to recovery is highly dependent on feed intake. Herbal medicine can be administered as a feed supplement to mitigate the effects of transportation stress and enhance nutritional intake, thereby maintaining optimal animal health and well-being (Ma *et al.*, 2023;

Alem, 2024). Herbal supplementation to ruminants is reported to increase compensation gain through the presence of volatile components such as aryl alkanes from ginger that stimulate appetite and feed palatability (Ibrahim *et al.*, 2022).

Several traditional Indonesian plants with medicinal properties, commonly used for human consumption, can also be applied as feed supplements for cattle (Lien *et al.*, 2013). This includes curcuma (*Curcuma xanthorriza*), which has shown significant antioxidant potential and positive effects on performance parameters in beef cattle production (Suteky *et al.*, 2020; Zulpadly and Meitasari, 2024). According to Lawand and Gandhi (2013), major active components found in curcuma were curcuminoid, consisting of 76.9% curcumin, 17.6% demethoxycurcumin and bis-demethoxycurcumin. Similarly, turmeric (*Curcuma longa*) is composed of approximately 2.5-6% of curcuminoids (Cambell, 2021). Aromatic ginger (*Kaempferia galanga*) has flavonoid content and 2.4-3.9% of essential oil. Other ingredients such as galangal and bitter ginger also consist of essential oil, which offers several benefits, including antibiotics, anti-microbes, and anti-parasite to increase feed intake. Pamungkas *et al.* (2019) found that supplementation of an herbal mixture containing galangal and bitter ginger promoted better daily weight gain in Ongole cattle compared to zinc-mineral. Herbal plants contain antibacterial properties that improve immune system functioning and enhance the taste and regularity of animal feed intake (Bhatt, 2015; Abdallah *et al.*, 2019). The herbal ingredients promote better digestive function, improve metabolism as well as influence the sensory and nutritive properties of the animal product (Meineri *et al.*, 2010).

Several studies reported that herbal supplements increased ruminant body weight (Rochmi *et al.*, 2021; Ibrahim *et al.*, 2022). This improvement was attributed to the presence of phytonutrients, such as curcumin, which optimized the functionality of the digestive organs and enhanced nutrient absorption (Khurun'in *et al.*, 2023). Therefore, this study aimed to determine the optimal level of Indonesian Herbal Mixture (IHM) supplementation in Bali cattle to enhance performance and nutrient consumption after long-distance transportation.

Materials and Methods

Animal

The study period started when cattle arrived at the Pudak Farm, Jambi after completing the long travel distance from Kupang, East Nusa Tenggara to Jambi, Indonesia with a total distance of 3,516 km (Figure 1). Cattle were transported using livestock vessels and trucks. In accordance with government regulations, each animal was given one dose of mandatory vaccination (Aftopor®, France) to prevent foot-and-mouth disease before being shipped out of the region. In addition, a vet evaluates animals' health before and after traveling. The transportation across islands, particularly over long distances, was observed to induce stress and weight loss. Prior to transport, each cattle were weighed to determine initial weight. This study used 16 male Bali cattle aged 2.5-3.5 years with an average initial body weight group of 239 kg (G_1), 233.5 kg (G_2), 231.7 kg (G_3), and 237.6 kg (G_4). Once the cattle had arrived at the experimental site, a weighing procedure was conducted to determine the post-transportation weight loss. On average, the groups had a body weight of 208 kg (G_1), 203.3 kg (G_2), 202.8 kg (G_3) and 205.2 kg (G_4). Cattle were kept in individual pens with *ad libitum* drinking water. The experimental ratio composition and nutrient content obtained are presented in Tables (1-2).

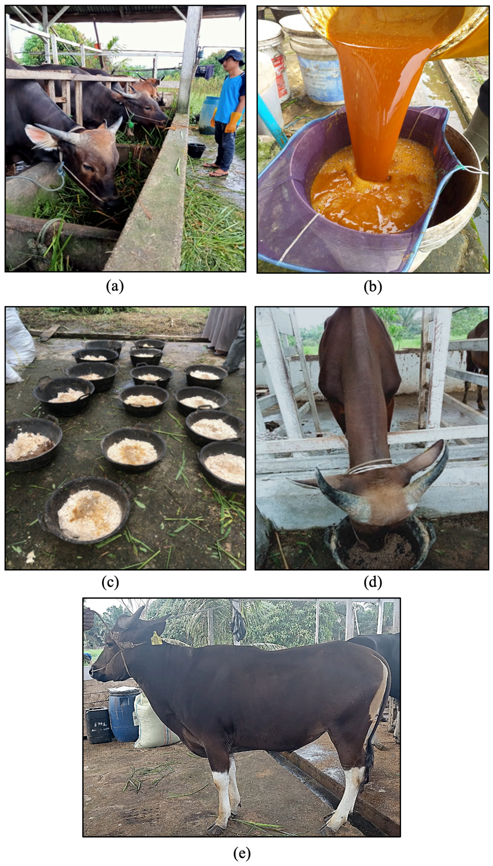

Fig. 1: Animal preparation and IHM supplementation; a: Planning cattle group, b: IHM preparation, c: IHM mixed with concentrate, d: Feeding treatment, e: Bali cattle after 10 weeks of IHM supplementation

Table 1: Ration composition for Bali cattle at Pudak Farm, Jambi, Indonesia

Ration	Composition (%)
Kumpai grass	70
Commercial concentrate	20
Tofu dreg	10

Table 2: Nutrient content of ration

Nutrient content (% DM)	Kumpai grass	Concentrate	Tofu dreg	Total
Dry matter	33.7	77	25.65	41.55
Crude protein	11.37	15	27.96	13.75
Crude fiber	26.69	12.5	12.31	22.41
Ether extract	0.4	11	7.24	3.2
Ash	9.14	9.5	4.24	8.72
Nitrogen-free extract	52.8	66.85	48.25	55.15
Total digestible nutrient	65.33	72	64.94	66.62

Experimental Treatment

Herbal ingredients consisted of galangal (*Kaempferia galanga*), java ginger (*Curcuma xanthorrhiza*), turmeric (*Curcuma longa*), cinnamon (*Cinnamomum verum*), garlic (*Allium sativum*) and bitter ginger (*Zingiber zerumbet*). The herbal material was ground into a smooth consistency and mixed with a 15-liter solution of water and 1 kg of molasses. The mixture was heated to boiling point for 7 min and allowed to reach room temperature. Subsequently, it was mixed with tofu dreg and commercial concentrate (Enfeed FR-15 Pro, Indonesia) containing total digestible nutrients and crude protein at a minimum of 72 and 15%, respectively. As shown in Table (3), the IHM application was conducted over a total period of 10 weeks (70 days), which included a 15-day adaptation period before the treatment began. The treatment groups consisted of 0 mL (T_0), 100 mL (T_1), 150 mL (T_2) and 200 mL (T_3). The ration was administered based on protein and energy requirement, in line with body weight and the percentage of Dry Matter (DM) that was ± 3% (National Research Council, 2001). The feeding method was based on 3 times, namely morning (0800), afternoon (1300), and evening (1800), in accordance with the treatment.

Table 3: Formula of Indonesian Herbal Mixture (IHM) used in the present study

IHM formula	Amount
Galangal (*Kaempferia galanga*)	250 g
Java ginger (*Curcumma xanthorriza*)	250 g
Turmeric (*Curcuma longa*)	250 g
Garlic (*Allium sativum*)	250 g
Cinnamon (*Cinnamomum verum*)	250 g
Bitter ginger (*Zingiber zerumbet*)	100 g
Water	15 l
Molasses	1 kg

Dry Matter Intake (DMI)

DM intake is the amount of ration provided minus the remaining amount at the time of feeding, expressed in kg/head/day (Sodikin *et al.*, 2016). The calculation of DM (Parakkasi, 1999) in (kg/head/day) = daily ration consumption (kg) × daily DM ration content (%).

Protein Consumption

The ratio of protein consumption was calculated by multiplying DM with protein content (Mariani *et al.*, 2017). This was expressed as ration protein consumption (Fitriyani *et al.*, 2024) in (kg/head/day) = DM intake (kg/day) × ration protein content (%).

Average Daily Gain (ADG)

ADG is obtained by reducing the final body weight of cattle minus the initial body weight of cattle divided by the length of days of rearing or fattening, expressed in kg/head/day. The calculation follows (Fitriyani *et al.*, 2024), where ADG (kg/head/day) = (final weight in kg - initial weight in kg)/experimental period (day).

Feed Efficiency

Feed efficiency is the value obtained from ADG produced per unit of total ration DM intake (Mualimin *et al.*, 2015). Feed efficiency (%) = (ADG / DMI) ×100%.

Statistical Analysis

This study was designed based on a randomized block design, which was divided into four body weight groups and four IHM supplementation treatments. Each IHM supplementation was performed in quadruplicate. Data obtained were analyzed using a two-way analysis of variance. When a significant effect ($p<0.05$) was observed between treatments, analysis proceeded with Duncan's multiple ranges using SAS version 9.2. software. Subsequently, correlation identification between variables through Pearson's test (r) was conducted, with results shown in heatmap format using JASP version 0.19 (Goss-Sampson, 2024).

Results

DMI

The consumption of DMI from Bali cattle given 200 mL IHM (T_3) was significantly higher compared to those receiving 150 mL (T_2) and 100 mL (T_1) and control (T_0, $p<0.05$). However, the provision of 150 mL (T_2) and 100 mL (T_1) of herbal in concentrate ration consumption was not significantly different ($p>0.05$). DMI of Bali cattle given various levels of IHM is presented in Table (4).

Protein Consumption

Protein consumption from treated cattle given various levels of IHM in concentrates is presented in Table (5). The T_3 group showed significantly higher protein consumption compared to T_2, T_1, and T_0 ($p<0.05$). The highest average consumption of 0.85 kg/head/day was achieved in T_3, followed by 0.77 kg/head/day in T_2 and T_1, as well as 0.70 kg/head/day in T_0.

ADG

Table (6) shows Bali cattle given various levels of IHM increased body weight gain by 40% in T_3 as well as

16% for T_2 and T_1 compared to T_0 ($p<0.05$). The highest average daily body weight gain achieved was 0.58 kg/head/day in T_3, followed by 0.34 kg/head/day in T_2 and T_1. Furthermore, Bali cattle concentrate only achieved ADG of 0.18 kg/day.

Feed Efficiency

The administration of IHM in feed to 200 mL (T_3) significantly increased the ration efficiency ($p<0.05$) by 10% compared to 150 mL (T_2) and 100 mL (T_1) by 6% and without IHM (T_0) by 4%. The efficiency of the ratio obtained from this study is presented in Table (7).

Table 4: Dry matter intake (kg/head/day) in Bali cattle given

Group	Treatment			
	T_0	T_1	T_2	T_3
G_1	4.71	5.34	4.93	5.81
G_2	4.97	5.31	5.46	5.83
G_3	4.8	5.22	5.52	5.95
G_4	4.78	5.3	5.27	5.9
Average	4.82 ± 0.11^c	5.29 ± 0.05^b	5.30 ± 0.27^b	5.87 ± 0.06^a

Note: Different superscripts in the same line show significant differences ($p<0.05$). G_1 Average body weight 239 kg, G_2 Average body weight 233.5 kg, G_3 Average body weight 231.7 kg, G_4 Average body weight 237.3 kg. T_0 without IHM, T_1 100 ml IHM, T_2 150 ml IHM, T_3 200 ml IHM

Table 5: Average protein consumption (kg/head/day) of Bali cattle given several levels of Indonesia herbal mixture (IHM) in concentrate

Group	Treatment			
	T_0	T_1	T_2	T_3
G_1	0.69	0.78	0.72	0.84
G_2	0.72	0.77	0.79	0.85
G_3	0.7	0.76	0.8	0.87
G_4	0.7	0.78	0.78	0.83
Average	0.70 ± 0.01^c	0.77 ± 0.01^b	0.77 ± 0.04^b	0.85 ± 0.02^a

Note: Different superscripts in the same line show significant differences ($p<0.05$). G_1 Average body weight 239 kg, G_2 Average body weight 233.5 kg, G_3 Average body weight 231.7 kg, G_4 Average body weight 237.3 kg. T_0 without IHM, T_1 100 ml IHM, T_2 150 ml IHM, T_3 200 ml IHM

Table 6: Average daily gain (kg/head/day) for Bali cattle supplemented with various levels of Indonesia herbal mixture (IHM)

Group	Treatment			
	T_0	T_1	T_2	T_3
G_1	0.16	0.24	0.36	0.58
G_2	0.2	0.47	0.34	0.67
G_3	0.22	0.38	0.31	0.51
G_4	0.15	0.27	0.35	0.54
Average	0.18 ± 0.03^c	0.34 ± 0.11^b	0.34 ± 0.02^b	0.58 ± 0.07^a

Note: Different superscripts in the same line show significant differences ($p<0.05$). G_1 Average body weight 239 kg, G_2 Average body weight 233.5 kg, G_3 Average body weight 231.7 kg, G_4 Average body weight 237.3 kg. T_0 without IHM, T_1 100 ml IHM, T_2 150 ml IHM, T_3 200 ml IHM

Table 7: Average feed efficiency (%) of Bali cattle given various levels of Indonesia herbal mixture (IHM)

Group	Treatment			
	T_0	T_1	T_2	T_3
G_1	2.55	4.28	7.3	9.98
G_2	4.04	8.29	6.27	11.28
G_3	4.59	6.57	5.72	8.61
G_4	3.74	6.38	6.41	9.95
Average	3.73 ± 0.86^b	6.38 ± 1.64^b	6.43 ± 0.65^b	9.96 ± 1.09^a

Note: Different superscripts in the same line show significant differences ($p<0.05$). G_1 Average body weight 239 kg, G_2 Average body weight 233.5 kg, G_3 Average body weight 231.7 kg, G_4 Average body weight 237.3 kg. T_0 without IHM, T_1 100 ml IHM, T_2 150 ml IHM, T_3 200 ml IHM

Correlation between Variables

Based on the results presented in Figure (2), all variables were notably positively correlated (r >0.5), particularly between DMI and protein consumption (r = 0.999) as well as ADG and feed efficiency (r = 0.993).

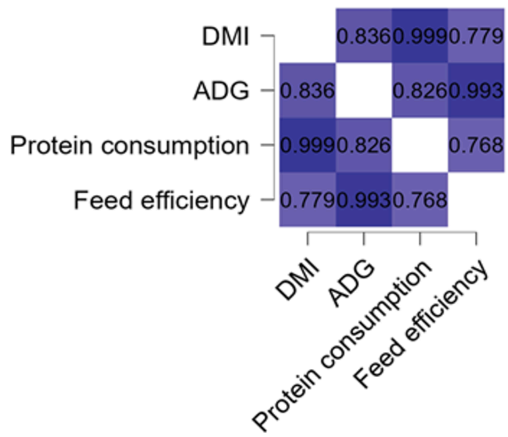

Fig. 2: Pearson's correlation heatmap between the different variables. The lighter color indicates a weak correlation, while the darker purple color shows a strong correlation.

Discussion

Several factors influence DMI consumption in ruminants, including livestock species, feed type, and body condition. Additionally, external factors such as temperature and humidity have been shown to impact DMI (Hilmia *et al.*, 2024). The increase in DMI of cattle that received IHM in concentrates was due to herbal ingredients containing essential oil and compounds with strong antimicrobial activity and inhibiting rumen ammonia production (Makmur *et al.*, 2023). This may have led to an increase in feed intake, thereby improving the DMI of cattle rations.

Essential oils found in cinnamon are rich in bioactive compounds known to enhance metabolic activity. These compounds include antioxidants, flavonoids, alkaloids, tannins, and saponins (Tasia and Widyaningsih, 2014). Curcuma rhizome also contains active ingredients with the potential for health, including xanthorrizol, curcuminoids, and essential oils, which are efficacious for increasing feed intake and improving digestive function (Ng *et al.*, 2020). The observed increase in dry matter intake during the perinatal period, following dietary supplementation with a poly-herbal mixture (*Foeniculum vulgare*, *Trachyspermum ammi*, *Trigonella foenum-graecum*, *Zingiber officinale*, *Anethum graveolens*, and *Ellettaria cardomum*), may be linked to its potential to reduce enteric methane emissions and rumen protein degradation, while simultaneously promoting higher propionic acid production (Sriranga *et al.*, 2021).

The increased protein consumption of cattle receiving IHM was influenced by the amount of DMI. Similarly, Sultan *et al.* (2009) reported that the protein content of feed ingredients had a positive correlation with the amount of ration consumption. This showed that Bali cattle with body weight ranging from 198-207 kg given complete feed with different protein and energy content, consumed protein ranging from 0.52 to 0.80 kg/head/day (Mariani *et al.*, 2017). Supplementation of ginger powder to Ossimi rams showed significant improvement in protein digestion (Ali *et al.*, 2024). This is due to the bioactive content of gingerol and shagaols which can improve the performance of ruminant digestive enzymes. Furthermore, the collective impact of dietary garlic supplementation on ruminant animals is an increase in average daily gain (ADG), crude protein intake, and nutrient digestibility. This is achieved through the presence of allicin, which improves the rumen fermentation profile (Ding *et al.*, 2023).

ADG serves as an indicator of both the performance rate and the efficiency of feed utilization (Dahlanuddin *et al.*, 2014). Cattle performance is influenced by breed, sex, age, feed quality, processing, and management (Afzalani *et al.*, 2017). Transportation over long distances showed cattle 12.72% lost, as observed in a decrease from 234.5 kg to 204.67 kg after arriving at the destination. This weight loss was caused by the stress before, during, and after transportation (Syarifuddin and Te'ne, 2023). Long-distance transportation will reduce the body weight of cattle by approximately 10-15%. This condition is due to stress, fatigue, or excessive movement during transportation. Additionally, weight loss can be caused by the loss of fluids in the body and muscles of cattle due to transportation stress (Nugroho *et al.*, 2021). The increase in ADG achieved in this study was due to DMI and high consumption of protein. This effect may be attributed to the aromatic profile of the IHM ingredients, which has been demonstrated to enhance feed palatability and stimulate appetite. Specifically, administering 200 mL IHM increased feed intake, which contributed to improved DMI and body weight gain. Animal performance was strongly influenced by the suitability, quality, and quantity of rations consumed (Usman *et al.*, 2013). Due to the close relationship, cattle that experienced a lack of feed consumption would have low weight gain (Nurwahidah *et al.*, 2016). This showed that the addition of herbal medicine to feed in various forms often had a positive effect on the health, growth, and production performance of livestock (Paskudska *et al.*, 2018). The daily weight gain in this study showed promising results. Where several previous studies showed the effect of herbal mixture supplementation on local beef cattle ranged from 0.47 to 0.62 kg/head/day (Pamungkas *et al.*, 2019; Zulpadly and Meitasari, 2024). This may be the result of the bioactive components of IHM increasing the population of fibrolytic microbes and the production of volatile fatty acids, particularly propionate, and butyrate, which serve as sources of energy for ruminants. Furthermore, it is expected that IHM supplementation will increase the activity of enzymes that play a role in the endogenous antioxidant system of animals. Supplementation of a herbal mixture containing *Z. officinale* and *C. longa* has been carried out by Dwatmadji *et al.* (2020) who reported higher ADG performance of Bali cattle around 1.25 and 0.79 kg/day. This may be due to the fact that under normal rearing conditions (stress-free), herbal mixture supplementation provides better performance.

Feed efficiency is often used to measure how well animals convert food into weight gain. A higher feed efficiency value means better feed consumption (Wati and Yusuf, 2020). The efficiency value of this ratio showed that cattle given IHM were more efficient, leading to a rise in ADG. A higher feed efficiency value indicates that feed is more efficient in promoting body weight gain. This may be attributed to optimized nutrient utilization in cattle that have been supplemented with IHM. Previous studies showed that Bali cattle consuming forage combined with concentrate have a range of feed efficiency, with values between 7.14 and 16.58 (Mariani *et al.*, 2017; Tahuk *et al.*, 2018). These results suggest that 200 ml of IHM supplementation offers a promising strategy for enhancing feed efficiency. The increase in DMI, which is directly proportional to the increase in animal body weight, also enhances the ration efficiency value (Suroso *et al.*, 2023). Higher DMI by livestock on the same ration, followed by an increase in the amount of protein consumption, can improve body weight. Furthermore, cattle receiving higher protein were more efficient in using ration (Abutani *et al.*, 2010). Herbal substances (tannin, essential oil, and flavonoids) also increase feed intake, which contributes to better feed conversion (Paskudska *et al.*, 2018).

The results were higher than those reported by Dwatmadji *et al.* (2020), where supplementation of *Z. officinale* and *C. longa* in block form (50 mg/kg/body weight/day) showed statistically insignificant increases in DMI and crude protein intake in Bali cattle. Previous studies showed that the improvement in ADG and feed efficiency achieved from IHM supplementation was an accepted method in Indonesian livestock farming (Wati and Suhadi, 2020). Aromatic ginger and Java ginger are used by local farmers to stimulate appetite and mitigate bloating following concentrate feeding (Pratama *et al.*, 2021). The results of a meta-analysis show that supplementation of essential oil derived from medicinal plants, such as cinnamon, has the effect of increasing the DMI and ADG of cattle, while simultaneously reducing the formation of rumen ammonia (Jesus Ferreira *et al.*, 2024). The positive correlation between DMI and protein consumption indicates that a higher DMI will increase protein intake, provided the diet contains adequate crude protein levels. Conversely, ADG and feed efficiency are inversely related, with a higher ADG typically indicating better feed efficiency. This study has limitations in measuring blood cortisol levels as a reference for determining stress levels in ruminants. Future research is needed to explore the effects of IHM supplementation in reducing cortisol spikes during livestock transportation.

Conclusion

In conclusion, this study showed that IHM supplementation up to 200 ml can improve several key parameters in Bali cattle, including DMI, protein consumption, ADG, and feed efficiency. After administering IHM, a body weight gain recovery of 0.58 kg/head/day was observed. The administration of a specific herbal mixture as a feed supplement was observed to enhance the performance of cattle subjected to long-distance transportation. However, it is recommended to increase the level of IHM supplementation to study its effects on animal immunity, and blood cortisol levels before, during, and after transportation, as well as on the rumen microbial community.

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Author's Contributions

Sri Arnita Abu Tani: Designed and supervised the experiment.

Adi Candra: Managed the animal and the experiment.

Sri Arnita Abu Tani and Malik Makmur: Performed the statistical analysis and drafted the manuscript. All authors read and approved the final version of the manuscript.

Ethics

The implementation refers to the ethics of research using experimental animals based on the Law of the Government of Indonesia No. 18, Article 66, 2009, which regulates animal welfare.

All authors declare no conflicts of interest.

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