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Feeding by Logistic Feed (Mash, Silage, Pellet and Wafer) Compared with Conventional Feed on Physiological, Blood Biochemical and Body Weight Gain Recovery in Tropical Sheep Pasca Transportation

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Abstract: The process of transportation of animals from one to another area can lead to stress. Animals tend to reduce feed intake which then affects animal performance, so palatable feed is needed, with high energy content, and can speed up the body weight recovery process. This study aimed to evaluate the effect of logistic feed (mash, silage, pellet, and wafer) compared with conventional feed on physiological parameters, blood metabolite profiles, and body weight recovery of tropical sheep pasca transportation. This study used Randomized Block Design (RBD) consisting of 5 treatments and 6 replications using 30 male local sheep: P 0 = conventional feed (100% forage), P 1: Mash, P 2: Silage, P 3: Pellet, P 4: Wafer. The logistic feed has a significant effect on dry matter, crude protein and ether extract intake, blood glucose level, leukocytes lymphocyte, Neutrophil and Lymphocyte (N/L) ratio, and basophil level in sheep blood, total body weight gain, feed efficiency, and income over feed cost (P<0.05). A logistic feed can accelerate the increase in the body weight recovery process of sheep pasca transportation. Moreover, the provision of logistic feed in the form of silage resulted in the highest feed efficiency and income over feed costs.

Keywords: Logistic Feed, Mash, Pellet, Silage, Tropical Sheep, Wafer

Introduction

The process of transporting animal from one area to another is very common, both for supplying animals for intake purposes as well as for domesticated animals or cultivation. The transportation process can affect the condition of the animal, both before transportation, during the transportation, and when the animal arrives at their destination. The transportation process raises various concerns because it can cause extreme stress on livestock. Stress is a biological response that is elicited when an animal perceives a threat to its homeostasis (Moberg, 2000). Stress can occur due to psychological stress, such as placement in a new cage and handling animals when they arrive at a place, or physical stress, such as hunger, thirst, injury, or extreme temperatures. Behavioral change is one of the quantitative physiological variables and the clearest indicator that an animal is experiencing stress (Broom, 1993). In addition, an animal will also experience weight loss when there is a lack of food and water. Machado *et al.* (2016) estimate the rate of body weight loss can reach 12% of the initial weight of an animal. Body weight reduction is the most important economic effect because animal trade is usually based on body weight variables (Bravo *et al.*, 2018). Loss of body weight occurred when animals were not fed during the first 24 h and most losses occur during the first 12 h (Knowles *et al.*, 1999). Lack of food and water in transportation is a major factor causing weight loss (Marques *et al.*, 2012). Stress due to transportation can also affect physiological responses, animal behavior, decreased body resistance, carcass and meat quality, and mortality (Bhatt *et al.*, 2021).

Stress on animals during transportation can be reduced by improving the quality of the facilities used during transportation, designing suitable means of transportation, improving the way animal are handled during or after transportation, and following transport criteria based on animal welfare regulations (Fisher *et al*., 2010). The focus on animal welfare does not only focus on the correct transportation process following animal welfare rules but also has a positive impact on the economy and efficiency (Schwartzkopf-Genswein *et al*., 2016). Energy loss or hypoglycemia is one of the typical effects of transportation and handling. Efforts that can be made to alleviate these conditions are by providing electrolytes and high-energy feed before or after transportation. Supplementation of high-energy feed before transport results in an increase in carcass weight when cattle are shipped to market (Grumpelt *et al*., 2015). This method is successful both in the efficient management of feedlot animals (Cole *et al*., 1988) and in the regulation of deviations in meat quality and carcass yield (Eldridge and Winfield, 1988).

The provision of logistics feed with a high energy content that has good palatability is expected to accelerate the recovery of animal body weight pasca transportation. Different feed forms (mash, pellets, and blocks) contain the same nutrients that can affect feed intake and nutrient digestibility, feed fermentation in the rumen, body weight and feed conversion ratio (Karimizadeh *et al*., 2017), retention of calcium and phosphorus (Verma *et al*., 1996), dry matter and organic matter digestibility, crude protein, fiber digestibility (Samanta *et al*., 2003). Differences in the form of feed can affect animal feeding behavior and the fermentation process in the rumen (Barkah *et al*., 2022). The existence of a suppression process in pellet making causes an increase in agglomeration and hardness of feed particles which can affect rumination behavior due to a longer mastication process than chewing feed in the form of mash (Bertipaglia *et al*., 2010). This study aimed to evaluate the effect of logistic feed (mash, silage, pellet, and wafer) compared to conventional feed on physiological parameters, blood metabolites, and post-transportation recovery of body weight of tropical sheep.

Materials and Methods

Ethical Approval

The experiment had been approved by the Faculty of Animal Science, Bogor Agricultural University, Indonesia.

Experimental Animals and Feeding Trial

Thirty Indonesian male local sheep 5 months of age with an average initial body weight of 21.06±2.68 kg were randomly assigned to 5 different feed treatments: P0 (forage, control), P1 (mash), P2 (silage), P3 (pellet), and P4 (wafer) comprising 6 replicates with 1 animal per replicate. The sheep were kept in individual pens for 2 weeks. Water was provided ad libitum. The adaptation period was 2 weeks allowing the sheep to adapt to the news feed. Before the adaptation period, 2 mL Albendazole was orally administered to each sheep to minimize disease due to worm infection. Supposedly every day the sheep were given 2 times feed in the morning and in the evening. The remaining feed was weighed every next morning.

Evaluation of Growth Performance, Serum Biochemical and Hematological Parameters

Evaluation of sheep growth performance was measured through the nutrient intake, average daily gain, the efficiency of ration usage, and Income Over Feed Cost (IOFC). Nutrient intake was calculated based on the feed intake. The calculated nutrient intakes; are Dry Matter Intake (DMI), Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF), and the Nitrogen Free Extract (NFE). Average Daily Gain (ADG) of sheep was performed every 2 weeks to determine the weight gain. Efficiency value can be obtained from feed intake and weight gain during maintenance. The IOFC value was calculated to know the profit gained after the maintenance process. The IOFC value was based on the purchase and selling price of sheep and feeding costs during the research period. The purchase and selling price of sheep was obtained from the price in effect in October 2021 in the Bogor market, West Java, Indonesia:

IOFC = Selling price of sheep- (purchase price of sheep + feed cost during research period)

Blood samples were taken in the 8th week after the treatment to analyze metabolite profiles and blood hematology of sheep. Blood was taken through the jugular vein by using a 5 mL syringe with the size of the needle 22G X $1^1/_2$ inch. The blood that has been taken was inserted into 2 types of vacutainer tubes; tubes that contained Ethylene Diamine Tetra Acetate (EDTA) anticoagulants and tubes containing the gel separator (Serum Separator Tube/SST). Blood was inserted into a cooler and brought to the laboratory for subsequent analysis.

Blood serum samples were taken in the vacutainer tubes containing the gel separator (Serum separator tube/SST). The blood metabolites measured were glucose, and total protein. Serum total protein was determined according to biuret colorimetric method. Analysis of blood glucose based on Glucose Oxidase-Peroxidase Aminotypirin (GOD-PAP) method at a wavelength of 500 nm (Subiyono and Gabrela, 2016). Blood hematology analysis determined the number of erythrocytes according to the method of Sastradipradja *et al.* (1989). Meanwhile, analysis of the number of leukocytes and hemoglobin level were determined using Hematology Analyzer (Medtroni) according to the method Nathalie *et al*. (2009).

Statistical Analysis

Data obtained from this study were analyzed using ANOVA (analysis of variance) through SPSS v 20.0 and the significantly different data among treatment groups were determined by using the Duncan's Multiple Range Test (DMRT) and considered at P<0.05.

Results

Physiological Response of Sheep

Table 2 shows the results of measuring the physiological response of sheep after transportation and after the recovery period. In this study, the average rectal temperature of sheep post-transportation and after 1 month of logistical feeding was 39.41 and 39.02°C, respectively. The average respiration rate of sheep post-transportation and after 1 month of logistical feeding was 34.93 and 48.08 breath/min. The average pulse rate of sheep pasca transportation and after 1 month of logistic feed treatment was 107.21 and 104.37 rate/min. All the average values for this physiological response are still within the normal range according to Jackson and Cockcroft (2007).

Nutrient Intake

Table 3 shows that the provision of logistical feed in different forms to post-transportation sheep had a significant effect compared to forage treatment (P<0.05). The lowest average dry matter intake was in the forage treatment, which was 346.85 g/head/day and the highest was in the mash treatment, which was 836.44 g/head/day. This is also in line with the intake of other nutrients, such as crude protein, ether extract, and crude fiber.

Blood Biochemical and Hematological Profiles

Table 4 shows that blood glucose level, leukocytes, lymphocyte, neutrophil and lymphocyte (N/L) ratio, and basophil level showed significant differences (P<0.05), but other parameteres showed non-significant changes which are still in the normal range. The glucose level of the P1 (mash) treatment was significantly higher than in the other treatments (P<0.05). P1 has the highest glucose level of 64.49 mg/dL and P0 has the lowest glucose level of 44.91 mg/dL. The leukocyte values and leukocyte neutrophil ratio were also significantly different among treatments. The highest leukocyte values and N/L ratio were found in the P0 treatment: 13.73 thousand mm^3 and 0.73, respectively, however, the lowest values were found in the P2 (silage) treatment, namely 8.77 thousand mm^3 and 0.51, respectively. In addition, the basophil value was also significantly different between the P0 treatment and other treatments (P<0.05). P0 has the highest basophil value of 1.65 thousand mm^{-3} but P3 (pellet) has the lowest basophil value of 0.88 thousand mm^3.

Table 1: Feed ingredients and chemical composition of different forms of logistic feedstuffs for tropical sheep

Component	P0 (forage)	P1 (mash)	P2 (silage)	P3 (pellet)	P4 (wafer)
Ingredient composition (%)					
Bean sprouts waste	-	25.00	25.00	25.00	25.00
Corn hulls	-	10.00	10.00	10.00	10.00
Pollard	-	14.50	14.50	14.50	14.50
Nigella sativa meal	-	10.00	10.00	10.00	10.00
Copra meal	-	25.00	25.00	25.00	25.00
Molasses	-	9.00	9.00	9.00	9.00
Prill fat	-	2.50	2.50	2.50	2.50
CaO_3	-	1.00	1.00	1.00	1.00
Urea	-	1.00	1.00	1.00	1.00
Premix	-	1.00	1.00	1.00	1.00
Dicalcium phospate	-	1.00	1.00	1.00	1.00
Chemical composition (%)					
Dry matter	41.94	88.55	76.02	88.07	90.42
Ash	11.54	9.41	9.04	8.69	9.16
Crude protein	10.26	20.05	20.63	17.57	18.38
Ether extract	1.39	2.26	2.16	4.95	3.75
Crude fiber	30.78	16.21	14.73	13.59	14.49
Nitrogen free extract	46.02	52.08	53.43	55.21	54.21

[a]Estimated results of calculations based on the nutrient content of each ingredient. [b]Total Digestible Nutrient (TDN)in concentrate and grass is calculated using. TDN content in grass (%) = 1.6899+(1.3844 x % CP) - (0.8279 x % EE) + (0.3673 x % CF) + (0.7526 x % NFE); TDN content in concentrate (%) = 2.6407+(0.6964 x % CP) - (1.2159 x % EE) + (0.1043 x % CF) + (0.9194 x % NFE). CP is crude protein, EE is ether extract, CF is crude fat and NFE is nitrogen free extract

Table 2: Effect of different forms of logistic feedstuffs on physiological parameters in tropical sheep pasca transportation

	P0		P1		P2		P3		P4		
Parameter	A	R	A	R	A	R	A	R	A	R	Normal (A
RT (°C)	39.77±0.81	38.38±1.12	39.20±0.35	39.12±0.30	39.35±0.43	39.17±0.36	39.40±0.64	39.18±0.41	39.35±0.45	39.27±0.21	39.0-40.0
RR (breath/min)	33.00±6.69^{a}	50.75±7.27^{b}	35.50±5.24^{a}	45.00±2.92^{b}	40.33±2.80^{a}	44.00±4.24^{a}	33.67±7.99^{a}	50.33±5.43^{b}	32.17±9.54^{a}	50.33±11.99^{b}	36-48
PR (rate/min)	111.33±5.39	100.00±13.37	110.33±3.61	100.50±17.58	107.50±7.82	103.67±13.76	106.50±11.17	107.00±17.50	100.40±20.25	110.67±22.66	80-100

P0: Forage, P1: Mash, P2: Silage, P3: Pellet, P4: Wafer, SE: Standard Error, RT: Rectal Temperature, RR: Respiration Rate, PR: Pulse Rate, A: After transportation,
R: After one-month logistic feed treatment
Different superscripts (^{a,b}) in the same row indicate significant differences (P<0.05)
Jacksosn and Cockroft (2002)

Table 3: Effect of different forms of logistic feedstuffs on nutrient intake of tropical sheep pasca transportation

Parameters	P0	P1	P2	P3	P4
Nutrient intake					
Dry matter (g/head day)	346.85±46.96^{a}	836.44±122.73^{b}	761.13±114.83^{b}	779.63±107.38^{b}	775.91±71.60^{b}
Crude protein (g/head day)	35.59±4.82^{a}	167.71±24.61^{b}	157.02±23.69^{b}	135.98±18.85^{b}	142.61±13.16^{b}
Ether extract (g/head day)	4.82±00.65^{a}	18.90±20.77^{b}	16.44±20.48^{b}	38.59±50.31^{c}	29.10±20.68^{c}
Crude fiber (g/head day)	106.76±14.45^{a}	135.59±19.89^{b}	112.12±16.91^{a}	105.95±14.58^{a}	112.43±10.37^{a}

P0: Forage, P1: Mash, P2: Silage, P3: Pellet, P4: Wafer, SE: Standard Error
Different superscripts (^{a,b}) in the same row indicate significant differences (P<0.05)

Table 4: Effect of different forms of logistic feed on blood biochemical profiles in tropical sheep pasca transportation

Parameters	P0	P1	P2	P3	P4	Normal level
Blood biochemical						
Glucose (mg dL^{-1})	44.91±7.05^{a}	64.49±7.88^{b}	45.70±5.62^{a}	50.85±5.37^{a}	53.60±10.09^{a}	50-100 (A)
Total protein(mg dL^{-1})	5.88±0.56	5.92±0.47	5.33±0.34	5.61±0.94	5.76±00.46	6.8-7.8(B)
Blood profiles						
Erythrocytes (million mm^{-3})	11.32±2.10	11.23±2.37	13.03±3.32	13.13±2.95	12.21±2.43	9-15(C)
Leukocytes (thousand mm^{-3})	13.73±4.63^{c}	10.78±1.56^{ab}	8.77±1.89^{a}	9.88±3.06^{ab}	12.81±2.97^{bc}	4-12 (C)
Lymphocyte	49.21±3.05^{a}	54.64±3.70^{b}	60.17±3.47^{c}	59.78±4.39^{c}	53.14±1.61^{ab}	40-75(C)
Neutrophil	36.03±5.29	34.96±4.55	30.19±2.54	31.06±3.50	35.13±3.04	30-50(D)
N/L	0.73±0.11^{b}	0.65±0.13^{b}	0.51±0.07^{a}	0.52±0.08^{a}	0.66±0.06^{b}	<1.50000
Eosinophil	7.46±2.32	7.36±1.62	6.41±1.13	5.81±3.14	7.91±2.98	1-10(A)
Basophil	1.65±0.67^{b}	1.05±0.27^{a}	1.01±0.31^{a}	0.88±0.07^{a}	1.03±0.30^{a}	0-3(A)
Monocyte	2.98±0.79	1.99±0.47	2.21±0.58	2.48±0.99	2.80±0.97	0-6(A)

P0: Forage, P1: Mash, P2: Silage, P3: Pellet, P4: Wafer, SE: Standard Error
Different superscript (^{a,b}) in the same row indicate significant differences (P<0.05)
Kaneko *et al*. (2008); (B) Al-Hadithy and Badawi (2015); (C) Kramer (2000); Egbe-Nwiyi *et al*. (2000)

Table 5: Effect of a different form of logistic feed on growth rate (mean ± SE) in tropical sheep

Parameters	P0	P1	P2	P3	P4
Body weight changes (kg)					
Average initial body weight (kg)	17.97 ±2.10	18.40±3.66	18.02±2.88	18.25±2.67	17.97±2.10
Average final body weight (kg)	16.61±2.96	21.66±3.09	22.24±2.38	21.83±2.70	21.60±2.74
Average total body weight gain (kg)	-1.36±1.50^{a}	3.26±0.93^{b}	4.22±1.22^{b}	3.58±0.83^{b}	3.38±1.42^{b}
Average daily weight gain (kg $head^{-1}$ day^{-1})	-0.049±0.05^{a}	0.116±0.03^{b}	0.151±0.04^{b}	0.128±0.03^{b}	0.121±0.05^{b}
Feed efficiency(%)	-9.09±11.63^{a}	13.84±3.23^{b}	20.34±6.95^{c}	16.45±3.30^{c}	15.41±5.76^{c}
Income over feed cost (Rp)	-99432±98912^{a}	191322±72679^{b}	263928±108052^{b}	215375±64632^{b}	203826±115597^{b}

P0: Forage, P1: Mash, P2: Silage, P3: Pellet, P4: Wafer, SE: Standard Error
Different superscripts ($^{a, b}$) in the same row indicate significant differences (P<0.05)

Body Weight Recovery

Table 5 shows that logistic feed had a significant effect on the average daily weight gain of sheep, feed efficiency, and income over feed cost (P<0.05). Differences in the form of logistic feed did not affect the performance of sheep, but logistic feed in the form of silage, pellet, and wafer resulted in better feed efficiency than other treatments (P<0.05).

Discussion

Physiological Response of Sheep

The physiological response of animal to the transportation process can be observed by measuring rectal temperature, respiration rate, and pulse rate. Measurement of physiological responses (rectal temperature, respiratory rate, and pulse rate) of sheep transported from Garut to Bogor, West Java, Indonesia with a travel time of 16 h showed that all physiological responses were still relatively normal except for pulse rate. The pulse rate of post-transported sheep increased beyond the limit of the sheep heart rate under normal conditions. This can indicate that after the process of transportation the animal is under stress. Stress is generally thought to be a reflex reaction that naturally occurs when animals experience uncomfortable conditions. New or unusual experiences can be a source of stress in animal causing physiological and psychological changes. Physiological changes involve activation of the hypothalamic-pituitary-adrenal axis, leading to increased cortisol concentrations, and suppression of immunity, respiration, and heart rate. Stress might impact the hypothalamic-adreno-cortical process, which is associated with neurogenic stressors such as noise and transportation, according to Mitchell *et al.* (1988). The combination of several stressful events creates the body reaction to various external factors called stress factors.

The respiration rate in sheep after transportation and after recovery experienced a significant difference (P<0.05). This could be due to differences in the condition of the animal when their respiration rate was measured. Measurement of respiration rate after transportation was carried out when the animal arrived at the experimental pen. The measurement of respiration after the recovery period was carried out after the sheep were kept for 1 month in individual cages. The process of removing sheep from individual pens may cause excessive stress to the sheep which causes an increase in respiration rate.

Nutrient Intake

Feed intake is related to the quantity of feed consumed by animal in a certain period. Intake is one of the important factors that can affect animal performance. According to McDonald *et al*. (2002), feed intake is influenced by the type and quality of feed, animal species, and the environment. Feed factors are influenced by nutrient content and its ability to meet basic needs, growth and reproduction (Teferedegne, 2000), physical and chemical characteristics (Forbes, 2007), feed form (McDonald *et al*., 2002), as well as processing type and fermentation rhythms in the rumen (Jayanegara *et al*., 2017).

Dry Matter (DM) intake was significantly different in control feed (P0) with feed that underwent different processing (P<0.05). As for logistical feed, the difference in the form of feed does not affect the intake of DM. This indicates that the feed processing type does not interfere with the palatability of the sheep, so it does not affect the amount of feed consumed. The intake of DM by sheep in this study was in the range of 346 to 836 g/head/day. Therefore, the sheep fed with logistical feed had met the dietary requirements recommended by Kearl (1982) for sheep weighing 20 kg with an Average Daily Gain (ADG) of 150 g/head/day was 650 g/head/day. This intake of 650 to 780 g/head/day has also met the DM requirement recommended by the NRC (2006) for sheep of the same weight and ADG. As for the control feed, dry matter intake was still below the recommendations of Kearl and NRC. This is because the feed given contains low dry matter, thus affecting the low dry matter consumed. Animal will consume feed according to their nutritional needs. However, because P0 feed is bulky feed and the stomachs of animal have limitations in consuming feed and this results in low dry matter intakes.

Crude Protein (CP) intake was significantly different in the control feed compared with feed that underwent different processing (P<0.05). As for the logistic feed, the difference in the form of the feed did not affect the intake of CP. CP intake recommendations in Kearl (1982) and NRC (2006) for sheep weighing 20 kg and ADG 150 g/head/day were 81 g/head/day and 70-104 g/head/day, respectively. Thus, the P0 feed had CP intake that did not meet the recommended requirement. This was due to the low CP content of the P0 feed, so the CP intake was low. As for logistical feeds with different forms, CP intake has exceeded the recommended one. The high level of CP intake exceeding the recommendations of Kearl (1982) and NRC (2006) can be attributed to the high need for CP for maintenance and the need CP for daily body weight gain in sheep in Indonesia, one of which is related to high temperatures in the tropical areas (Jayanegara *et al*., 2017).

Ether Extract (EE) or crude fat intake has significantly different among treatments (P<0.05). Differences in EE intake could be due to differences in EE content among treatments (Table 1). Fat can be used as a source of energy needed by sheep. Fat is a source of energy with a calorific value of about 2.25 times higher than carbohydrates. The intake of Crude Fiber (CF) was significantly different among treatments. In ruminants, carbohydrates that are mostly consumed are usually in the form of polysaccharides (cellulose and hemicellulose derived from fibrous feeds). When carbohydrates enter the rumen, they will undergo two stages of digestion by enzymes produced by rumen microbes and will be converted into short-chain compounds and VFAs. According to McDonald *et al*. (2002), carbohydrates will undergo hydrolysis into monosaccharides, such as glucose, fructose, and pentose. Then the simple sugars will be broken down into acetic acid, propionic acid, butyric acid, CO2, and CH4.

Blood Biochemical Profiles

Logistics feed is a complete feed consisting of forage and grains. Forage provides cell wall polysaccharides and all intracellular carbohydrates present in forage are broken into short-chain volatile fatty acids, which are then absorbed by the rumen epithelium (Bird *et al*., 1996). Grains provide large amounts of starch for ruminal and intestinal digestion. Ruminants obtain glucose from gluconeogenesis with propionate as the main substrate. The amount of propionate absorbed from the rumen of well-fed animals is often sufficient to meet the animal requirements for glucose synthesis (Bergman, 1973). However, sheep in treatment P0 and P2 had low blood glucose levels below normal limits. This could be due to the low amount of propionate available as a substrate for gluconeogenesis.

The leukocyte profiles, neutrophil and lymphocyte ratios, and basophils were significantly different among treatments. These three parameters were higher in P0 sheep that were not fed logistic feed. High levels of leukocytes can indicate a response to inflammation or infection. However, the levels of leukocytes, neutrophils, and lymphocytes were still at normal levels, so they did not interfere with the overall physiology of the sheep.

Body Weight Recovery

Logistics feeding had a significant effect on body weight recovery, feed efficiency, and income over feed cost in post-transportation livestock ($P<0.05$). However, the difference in the form of logistical feed given did not have a significant effect on body weight gain. According to NRC (2006) that one of the factors that can affect body weight gain is the intake of protein derived from feed. Logistical feeding significantly increased CP intake. This is in line with the improvement of animal recovery until finally the animal experience body weight gain.

Logistic feed in the form of silage, pellet, and wafer produced better feed efficiency than logistic feed in the form of mash ($P<0.05$). This could be because the feed in the form of mash had a higher intake rate than other forms of feed but were not accompanied by higher body weight gain. This causes the feed efficiency of mash logistics to feed to be lower than other forms of logistics feed. The IOFC value of logistic feed was not significantly different from the difference in the form of feed. However, logistic feed in the form of silage has the highest IOFC value compared to other treatments. Different forms of feed can affect the rate of fermentation in the rumen.

Conclusion

Logistics feeding can accelerate the increase in the body weight of sheep after transportation. Differences in the form of logistic feed did not have a significant effect on dry matter consumption, crude protein, body weight gain, feed efficiency, and income over feed cost. However, the provision of logistical feed in the form of silage resulted in the highest feed efficiency and income over feed costs.

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Author’s Contributions

Yuli Retnani: Designed the research plan, supervised and interpreted the data, and proofread the manuscript.

Anuraga Jayanegara: Supervised the manuscript and publication planning.

Sazli Tutur Risyahadi: Supervised growth performance experiment and data collection.

Mahirah Firdaus: Examined blood metabolite profiles experiment and data collection.

Rafli Ismiadi Wicaksono: Examined growth performance experiment and data interpretation.

Nisa Nurmilati Barkah: Participated in data analysis and manuscript writing.

Taryati: Participated in blood metabolite profile and growth performance experiments and data interpretation.

Muhamad Baihaqi: Supervised growth performance experiments and data interpretation.

Tekad Urip Pambudi Sujarnoko: Supervised growth performance experiments and data interpretation.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and that no ethical issues are involved.

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