Buletin Peternakan 48 (1): 48-54, February 2024

ISSTAP
Indonesian Society for Sustainable Tropical Animal Production

Bulletin of Animal Science

ISSN-0126-4400/E-ISSN-2407-876X Accredited: 36a/E/KPT/2016
http://buletinpeternakan.fapet.ugm.ac.id/

Doi: 10.21059/buletinpeternak.v48i1.89124

Influence of Dietary Black Cumin Meal (*Nigella sativa* L.) on the Performance and Body Measurements of Garut Sheep

Karina Natasya Juandita[1*], Iman Hernaman[2], Ken Ratu Gharizah Alhuur[3], and Diky Ramdani[3]

[1]Postgraduate Study Program, Faculty of Animal Husbandry, Universitas Padjadjaran, Sumedang, 45363, Indonesia
[2]Department of Animal Nutrition and Feed Technology, Faculty of Animal Husbandry, Universitas Padjadjaran, Sumedang, 45363, Indonesia
[3]Department of Animal Production, Faculty of Animal Husbandry, Universitas Padjadjaran, Sumedang, 45363, Indonesia

Article history
Submitted: 18 September 2023
Accepted: 15 December 2023

* Corresponding author:
E-mail: karina22009@mail.unpad.ac.id

ABSTRACT

Black cumin meal has potential as feed ingredient of sheep. This study aimed to evaluate the influence of dietary black cumin meal on the performance and body measurements of Garut sheep. The study used 28 heads of male Garut sheep aged ±10 months with an average initial body weight of 20 ± 2.34 kg/head. A completely randomized design (CRD) was used to compare the influence of 4 different levels (0%, 5%, 10%, and 15%) of black cumin meal in the diet on dry matter intake (DMI, g/head/d), average daily gain (ADG, g/head/d), feed efficiency (%), body length gain (cm), chest circumference gain (cm), and height at withers gain (cm) during 70 d feeding trial using 7 replicates. The data were statistically analyzed using a One-Way Analysis of Variance and continued with Duncan new Multiple Range Test for significant results, operated by the IBM SPSS 26 program. The results showed that DMI ($P<0.05$), ADG ($P<0.01$), and feed efficiency ($P<0.05$) of Garut sheep were increased for a diet containing black cumin meal compared with control. Furthermore, dietary black cumin meal enhanced body length gain ($P<0.05$), followed by chest circumference gain, and height at withers gain ($P<0.01$). Dietary black cumin meal 10% is the optimum level to increase the performance and body measurements. In conclusion, dietary black cumin meal improves the performance and body measurements of Garut sheep.

Keywords: Black cumin meal, Body measurements, Garut sheep, Performance

Introduction

Sheep has a huge contribution to overall red meat production. The sheep's population in West Java reached 9.987.870 heads in 2022 (Directorate General of Livestock and Animal Health, 2022). Garut sheep (Indonesian National Standard 7532:2009) is one of the most popular local sheep in West Java. Garut sheep have characteristics such as a combination of *telinga rumpung* or *ngadaun hiris* (the shape of the earlobe resembles an iris leaf <4 cm), and *ngabuntut bagong* or *ngabuntut beurit* (the shape of tail resembles a triangle with fat deposits at the base of the tail with a width of >11 cm and tapers at the tip of the tail). Compared to other local sheep, Garut sheep have a good weight gain and a high carcass percentage, so they a wide marketplace in Indonesia, especially in West Java (Nurjannah *et al*., 2019).

In Garut sheep farming systems, feeding management is a factor in increasing productivity. The component of nutrition in the diet must be balanced to improve sheep performance. In addition, the diet also requires 60% to 80% of the total production costs (Sanjaya *et al*., 2020). So, feed technology is needed that can reduce production costs and increase efficiency. Nascimento *et al.* (2019) reported that in a sheep fattening system, the feed consists of forage in both fresh and fermented, and concentrate. The use of straw is also used as a substitute for fresh forage even though it has low protein and high lignin content, it will reduce its digestibility (He *et al*., 2020).

Black cumin (*Nigella sativa* L.) is one of the plants that is known as a feed supplement because it has rich oil and contains various phytochemical compositions (Ahmed *et al*., 2022; Cherif *et al.*, 2018). Basically, black cumin seed has the main function as a human medicine to treat various diseases with its efficacy as a phytopharmaca. In Indonesia, the potential availability of black cumin seed can reach 1.997.779 kg/year based on import number from India and other Middle Eastern countries (Central Bureau of Statistics, 2022). Black cumin seed will be processed into a product of "*Habbatussauda* essential oil", this industry produces residue called black cumin meal (BCM). According to (Obeidat, 2021), BCM represents 70-

75% of the essential oil industry. Due to the high number of imported black cumin seed, Indonesia has the estimation of BCM production up to 1.398.445 kg/year. Black cumin meal has high dry matter and crude protein. It also contains the main active ingredient, such as thymoquinone, which functions as an antioxidant and boosts the sheep's immunity (Retnani *et al.*, 2019). Other active substances found in BCM are tannins and flavonoids (Paarakh, 2010). Those active substances and chemical compositions in several doses are expected to increase the ability of rumen microbes to feed degradation. It is also supposed to increase productivity during the increase of body weight and body measurements.

The use of black cumin meal as feed in Indonesia is not commonly used, then the study about BCM has not been carried out on the performance and body measurement of Garut sheep. Previous studies informed that the use of 15% BCM was able to replace soybean meal and increase the body weight gain of Awwasi sheep (Obeidat, 2020). The addition of BCM 20% was also able to improve the performance of sheep fed by elephant grass (Retnani *et al*., 2019). Therefore, this study aims to evaluate the influence of dietary BCM on the performance and body measurement of Garut sheep.

Materials and Methods

Animals

The object of research used in this study were 28 male Garut sheep aged ± 10 months and initial body weight 20 ± 2.34 kg/head (coefficient of variation <13%). All sheeps were housed individually (1.0 × 1.0 m). During the adaptation period, each sheep was cleaned and sheared. They were also given anthelmintic by Veta Bendazole®, injected with vitamin B-Sanplex® and Limoxin-200 LA® at prescribed doses.

Diet preparation and chemical analysis

The study was conducted for 84 d with details of 14 d of feeding adaptation period, and 70 d of feeding trial. The schedule of feeding was carried out 3 times a day, at 07.00 am, 12.00 pm, and 04.00 pm. The diets were based on dry matter, which had been formulated at 3–4% dry matter intake (DMI) requirement from the body weight according to Paul *et al*. (2003). Those diets were formulated with 30:70 of fermented paddy straw and commercial concentrate, while the black cumin meal formulation replaced the amount of commercial concentrate. During the study, the diets were taken to analyze the chemical composition. For chemical composition determination, all ground diet samples were analyzed for dry matter (DM), ash, crude protein (CP), and ether extract (EE) using AOAC procedures (AOAC, 1990). The neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed following the procedures of Van Soest *et al.* (1991). Total tannin (TT) was analyzed using the Folin–Ciocalteu method following the procedure of Makkar (2003). Drinking water was provided ad libitum. The formula of diets and chemical composition in the study are provided in Table 1 and 2.

Analysis of performance

Animals were weighed at day 0 and 70 using a digital scale (accuracy 1 kg). The weighing process was carried out in the morning before morning feeding and average daily gain expressed in units of g/head/d. The DMI was calculated daily using a digital scale (accuracy 1 g). The calculation of DMI was carried out by subtracting the amount of dry matter that was given with the remaining dry matter of the residual diet in units of gram (g/head/d). Moreover, feed efficiency was calculated by comparing the average daily gain with DMI and expressed as a percentage (%), it could be calculated using following equation:

$$\text{Feed efficiency (\%)} = \frac{\sum \text{average daily gain (g)}}{\sum \text{dry matter intake (g)}} \, x \; 100\,\%$$

Body measurements

Body Length is the distance in a straight line from the *spinous processus* of the highest *thoracic vertebrae* to the lump of the sieve bone (sitting bone), it was measured using a measuring tape in cm units. Chest circumference was measured by circling the chest cavity through *os scapula* using a measuring tape in cm. Then the height at withers is the highest distance from the shoulder to the ground, it was measured using a measuring stick in cm (Heriyadi and Mayasari, 2006).

Experimental design and statistical analysis

The design used was a completely randomized design (CRD) with 4 treatments. Each treatment had 7 replications. Statistical significance for all parameters conducted analysis were set at P<0.05. The data that showed a significant effect were continued with Duncan's test. The data were statistically analyzed by one-way ANOVA in IBM SPSS Statistics 26.

Results and Discussion

Performance of Garut sheep

The influence of dietary BCM 0% (T0), 5% (T1), 10% (T2), and 15% (T3) of Garut sheep on performance (DMI, ADG, and feed efficiency) during 70 d of the feeding trial are presented in Table 3. The average initial body weight of Garut sheep in each treatment did not show a significant difference (P>0.05). This shows that the sheep given as experimental units were similar. After feeding trial period, they also produced the same final weight (P>0.05). Table 3 indicates that dietary black cumin meal had a significant difference to DMI (P<0.05). This difference was also followed by ADG (P<0.01) and feed efficiency (P<0.05).

Table 1. Chemical composition of feed ingredients

Ingredients	Fermented paddy straw	Commercial concentrate	Black cumin meal
Dry matter (%)	31.7	93.5	94.9
Crude ash (%)	21.0	10.2	6.64
Crude protein (%)	7.33	14.7	36.8
Ether extract (%)	2.04	4.88	5.55
NDF (%)	56.2	44.4	24.5
ADF (%)	38.2	28.0	15.5
Metabolizable energy (MJ/kg DM)	3.38	6.70	6.63
Total tannin	-	-	21.6

Analyzed in Laboratory of Research and Experiment Biotechnology, Animal Husbandry Faculty, Universitas Padjadjaran (2023).
NDF: neutral detergent fiber; ADF: acid detergent fiber.

Table 2. Ingredients and chemical composition of diets

Ingredients	Treatments			
	T0	T1	T2	T3
	------------ % ------------			
Fermented paddy straw	30.0	30.0	30.0	30.0
Commercial concentrate	70.0	65.0	60.0	55.0
Black cumin meal	0.00	5.00	10.0	15.0
Chemical composition				
Dry matter (%)	73.9	74.0	74.1	74.1
Metabolizable energy (MJ/kg DM)	5.84	5.84	5.83	5.83
Ash (%)	13.5	13.3	13.1	12.9
Crude protein (%)	12.5	13.6	14.7	15.8
Ether extract (%)	4.03	4.06	4.10	4.13
ADF (%)	31.0	30.4	29.8	29.2
NDF (%)	47.9	47.0	46.0	45.0

T0: Fermented paddy straw 30% + commercial concentrate 70% + black cumin meal 0%, T1: Fermented paddy straw 30% + commercial concentrate 65% + black cumin meal 5, T2: Fermented paddy straw 30% + commercial concentrate 60% + black cumin meal 10%, T3: Fermented paddy straw 30% + commercial concentrate 55% + black cumin meal 15%.
NDF: neutral detergent fiber; ADF: acid detergent fiber.
Analyzed in Laboratory of Research and Experiment Biotechnology, Animal Husbandry Faculty, Universitas Padjadjaran (2023).

Table 3. Effects of black cumin meal on performance of Garut sheep during 70 d

Parameters	T0	T1	T2	T3	SEM	*P-value*
Initial body weight (kg)	21.0 ± 2.70	22.6 ± 0.90	20.6 ± 3.00	18.6 ± 2.75	0.90	0.060
Final body weight (kg)	30.1 ± 3.23	32.4 ± 2.24	33.0 ± 3.04	29.1 ± 2.77	1.08	0.120
Average daily gain (g/head/d)	130.0 ± 26.4^{a}	140.0 ± 26.5^{ab}	177.1 ± 19.2^{c}	160.0 ± 13.3^{bc}	8.18	0.003
Dry matter intake (g/head/d)	1,128 ± 36.7^{a}	1,181 ± 36.5^{b}	1,200 ± 38.0^{b}	1,180 ± 52.4^{b}	15.8	0.020
Feed efficiency (%)	11.4 ± 2.12^{a}	11.8 ± 2.43^{a}	14.7 ± 1.58^{b}	13.5 ± 1.44^{ab}	0.72	0.017

T0: Fermented paddy straw 30% + commercial concentrate 70% + black cumin meal 0%, T1: Fermented paddy straw 30% + commercial concentrate 65% + black cumin meal 5, T2: Fermented paddy straw 30% + commercial concentrate 60% + black cumin meal 10%, T3: Fermented paddy straw 30% + commercial concentrate 55% + black cumin meal 15%.
SEM: standard error of mean. Mean values were significantly different at (P<0.05).
^{a,b,c} The value in the same row with different alphabet showed a difference (Duncan multiple test).

Average daily gain

The results in Table 3 shows that there was an influence of dietary BCM by the increased average daily gain (ADG) (P<0.01). According to Abdullah and Farghaly (2019) reported that the supplementation of BCM improved the ADG. The control diet (T0) had a lower ADG than T2 and T3 (P<0.01), although it was similar with T1 (P>0.05). Dietary of BCM 10% (T2) was greater to enhance ADG although it was similar compared with the level 15% (T3) (P>0.05). The average daily gain in this study ranged from 130.0 ± 26.4 - 177.1 ± 19.2 g/head/d. Retnani *et al.* (2019) reported that the ADG of local sheep reached 126.3 g/head/d.

Body weight showed the nutrient intake that could fulfil basic life requirements and production (Khotijah *et al*., 2014). Average daily gain was also used to determine the growth rate of sheep. The high amount of DMI and palatability of diet could influence the ADG. The higher of ADG of dietary BCM than control (T0) caused by the amount of DMI, which increased the amount of nutrient intake that would be digested in rumen. Nutrient intake is used for the metabolic system in the livestock's body to fulfil their basic life requirements and increase the body weight. According to Soepranianondo *et al*. (2007) stated the amount of DMI would determine the amount of nutrient intake.

The diets that have high quality and palatability can quickly increase ADG (Nurjannah *et al.*, 2019). Providing dietary protein balanced with energy would increase the formation of adipose tissue and ultimately increased body weight (Danso *et al*., 2018). Protein and energy have the main function of supporting body functions and tissue repair processes (Adiwimarta, 2021). Black cumin meal has protein of 36.8%, the high protein in BCM could improve the quality of diet, which caused total protein intake would higher and increase the body weight (Table 1). The protein content of BCM could be used to build muscle in the sheep's body and increase the body weight.

Dry matter intake

In the current study, dietary BCM could increase DMI (P<0.05) compared with control. However, as BCM levels increased, a similar effect also occurred with increasing DMI (P>0.05). According Obeidat (2020), BCM had a positive effect on DMI. Dietary BCM 10% (T2) was the optimum level that provided the higher amount of DMI. The DMI in this study was ranged from 1,128 ± 36.7 - 1,200 ± 38.0 g/head/d. Retnani *et al*. (2019) reported DMI of local sheep was 864 g/head/d. The higher value of DMI in this study could be speculated by the increased of diet's palatability.

Palatability is one of the factors that influence DMI and it shows the level of the preference for diet. The texture, color, aroma, and taste that livestock like show that the quality of the feed is very good to increase palatability (Christi *et al*., 2018). The aromatic components such as phenolics, alkaloids, tannins, and flavonoids, which are good to increase palatability. The aroma from diet plays a role in stimulating livestock to choose the diet quickly without needing to consume it before (Adiwimarta, 2021). Black cumin meal contains tannin, this component would provide an aroma that could stimulate Garut sheep to consume the diet and increased the palatability.

Dry matter intake aims to reach nutrient requirements and determine livestock productivity. The amount of DMI also to determine the amount of nutrient intake of the livestock (Soepranianondo *et al*., 2007). The DMI would provide opportunities for nutrient intake, especially for protein and energy to be utilized by the sheep's body. Moreover, the treatment of the dietary BCM increased the protein content of the diet, which provided greater opportunities for used by microbes in the rumen and increase the digestibility (Table 2). Tannin component in BCM was also thought to help protein content to be directly digested by the sheep's body without fermentation by microbes in the rumen. Tannin would be beneficial because it was a by-pass protein, which would escape rumen microbial degradation, this protein would be used by the sheep's body through the post-rumen tract (small intestine) (Sagito *et al*., 2022). According to (Akbar, 2007), DMI also inseparable from the digestive process, including fermentation in the rumen. If fermentation in the rumen occurred on optimally, this condition would make the rumen contents to be empty quickly and stimulated the livestock to increase consumption.

Feed efficiency

Enhanced DMI in this study is followed by the high amount of ADG (Table 3). This proved that the feed conversion into the body weight would reflect the feed efficiency. The increasing of feed efficiency was directly proportional to the amount of DMI and ADG. This condition could affect the small amount of DMI, then it could increase the body weight highly, so that the efficiency value of the diet would increase. Table 3 shows a significant result of the feed efficiency (P<0.05), especially in T2 which similar with T3 compared to T1 and control treatment (T0). The feed efficiency in this study ranged from 11.4 ± 2.12 - 14.7 ± 1.58 %. It was related to Abrori *et al.* (2022) that the feed efficiency of local male sheep could reach 14.3%.

Feed efficiency is one of the factors in the sheep farming industry, including economic environmental, and social. Obeidat (2020) reported that the inclusion of BCM could reduce the feed costs. This opinion shows that BCM was an efficient source of feed ingredients. A similar thing happened in this study, BCM was able to increase the feed efficiency throughout with increasing of average daily gain and DMI. In addition, compared to wasting them, it might lessen environmental pollution and would be an alternative feed ingredient in sheep farming industry.

Body measurements of Garut sheep

The results of body measurements of Garut sheep during 70 d of feeding trial are shown in Table 4. It shows that the average initial body measurements for each treatment did not show a significant difference (P>0.05). After 70 d of feeding trial, there was a significant difference on final body length and chest circumference measurements (P<0.01). However, the final height at withers measurements shows the same similarity (P>0.05). The results indicates that there was a significant difference to enhance the body length gain (P<0.05), dietary BCM also affected on the chest circumference gain and the height at withers gain (P<0.01).

Body length gain

The average body length gain of Garut sheep is provided in Table 4. The results shows that dietary BCM affected (P<0.05) on body length gain as long as the increasing of the BCM's level. The dietary BCM 5% (T1) and 10% (T2) was similar with 15% (T3) and control treatment (P>0.05), while T3 shown the optimum result of the body length gain and significant diference compared with control treatment (T0) (P<0.05).

Table 4. Effect of black cumin meal on body measurement of Garut sheep during 70 d

Parameters	T0	T1	T2	T3	SEM	*P-value*
Initial body length (cm)	48.0 ± 3.74	50.0 ± 2.38	50.29 ± 0.95	50.0 ± 2.09	0.88	0.323
Final body length (cm)	54.1 ± 5.30^{a}	60.0 ± 3.0^{b}	60.2 ± 2.57^{b}	61.9 ± 3.30^{b}	1.37	0.004
Body length gain (cm)	6.19 ± 2.93^{a}	10.0 ± 4.43^{ab}	10.0± 2.77^{ab}	11.9 ± 3.20^{b}	1.28	0.037
Initial chest circumference (cm)	64.43 ± 1.71	67.0 ± 2.16	65.0 ± 2.70	64.0 ± 3.22	0.95	0.152
Final chest circumference (cm)	67.5 ± 2.28^{a}	71.9 ± 2.54^{b}	72.6± 2.5^{b}	71.8± 3.82^{b}	1.08	0.010
Chest circumference gain (cm)	3.09 ± 1.60^{a}	4.90 ± 2.92^{a}	7.62 ± 1.88^{b}	7.83 ± 1.77^{b}	0.78	0.001
Initial height at withers (cm)	60.8 ± 2.41	60.5 ± 1.61	59.4 ± 4.61	60.3 ± 3.88	1.21	0.866
Final height at withers (cm)	63.8 ± 2.26	65.7 ± 2.28	66.1 ± 3.53	66.3 ± 3.54	1.12	0.315
Height at withers gain (cm)	3.00 ± 2.23^{a}	5.14 ± 1.77^{ab}	6.71 ± 2.05^{b}	6.50 ± 1.64^{b}	0.74	0.007

T0: Fermented paddy straw 30% + commercial concentrate 70% + black cumin meal 0%, T1: Fermented paddy straw 30% + commercial concentrate 65% + black cumin meal 5, T2: Fermented paddy straw 30% + commercial concentrate 60% + black cumin meal 10%, T3: Fermented paddy straw 30% + commercial concentrate 55% + black cumin meal 15%.

SEM: standard error of mean. Mean values were significantly different at (P<0.05).

[a,b,c] The value in the same row with different alphabet showed a difference (Duncan multiple test).

The results of this study indicates that BCM would enhance the body length gain along with the increased body weight of Garut sheep. It was caused by the high ADG in this study that might be correlated with the increased body length. Body length is a body measurement that is closely related to body weight, and the body length gain is due to growth and takes place more quickly in young sheep (Wahyudi *et al*., 2023). Furthermore, it could be speculated that protein content of BCM could enhance protein intake for muscle and bone formation. According to Wang *et al.* (2020) protein availability in diet could increase the amino acid absorption in livestock's body and eventually result in increased growth performance (fat, bone, and muscle).

Chest circumference gain

The data in Table 4 shows that the use of BCM had an influence (P<0.01) on chest circumference gain of Garut sheep. The dietary BCM 5% (T1) was similar affected compared with control (T0) (P>0.05). On the other side, the treatment of BCM 10% (T2) was greater affected to increase the chest circumference (P<0.01) compared with T1 and control treatment (T0), although it was similar with BCM 15% (T3) (P>0.05). The increasing of chest circumference was caused by an increase in body weight. This is in accordance with the opinion of Haryanti *et al*. (2015) that chest circumference has a high contribution to increase the body weight of sheep. Dietary of black cumin meal resulted in a higher ADG, thereby increased the chest circumference gain as well (Table 3 and 4). The chest circumference gain is a reflection of increased muscle and fat in that area (Kriskenda *et al*., 2018). The improvement in DMI, especially in BCM treatments could provide protein intake then increased muscle and fat formation in sheep. The protein content in BCM, which can be supplemented to ruminant diets to improve their live weight, body condition score, and carcass characteristics (Obeidat, 2021).

Height at withers gain

The results in Table 4 indicates that the use of BCM in diet affected (P<0.01) height at withers gain The control diet (T0) had a lower height at withers gain than T2 and T3 (P<0.01) although it was similar with T1 (P>0.05). Furthermore, dietary of BCM 10% (T2) gave the optimum result (P<0.01) on height at withers gain, while it was similar compared with the BCM 5% (T1) and 15% (T3) (P>0.05). The average height at withers gain in the study ranged from 3.09 ± 1.60 - 7.83 ± 1.77 cm. Younas *et al*. (2013) reported that body weight was correlated with height at withers. The protein content in BCM also thought to contribute to increase in height at withers. According to (Irshad *et al.*, 2013) reported that an appropriate and consistent protein supply from diet would support tissue growth and maintenance. The protein content in BCM helps in the formation of muscle and bone tissue. This indicates that the higher the BCM in diet increases height at withers and an increase in body weight indicates it.

Conclusion

Based on results obtained, it could be concluded that the influence of dietary BCM in fermented paddy straw-based diet improved performance and body measurement (DMI, ADG, feed efficiency, body length gain, chest circumference gain, and height at withers gain) of Garut sheep compared with the control diet. Dietary black cumin meal 10% is the optimum level to increase the performance and body measurements of Garut sheep. Moreover, more research is needed to find the effect of BCM at different levels on carcass characteristics, cost of gain, and in vitro study of sheep or other ruminants.

Conflict of interest

The authors whose names are listed have no affiliations with or involvement in any organization or entity with any financial interest or nonfinancial interest in the subject matter or materials discussed in this manuscript.

Acknowledgement

The authors would like to thank Universitas Padjadjaran, which funded this research through the Riset Percepatan Lektor Kepala 2023 (RPLK), and to Paddy Farm which given permission and provided research material. Last but not least, We are thankful to Baqara Farm for providing the black cumin meal.

Author's Contribution

All authors contributed to the work that is being presented here. KNJ carried out experimental study, collected data and statistical analysis, then prepared the manuscript. IH performed the literature search and reviewed the manuscript. KRGA contributed in writing and reviewing of the manuscript. DR as the supervisor and designed the experimental study. All authors have read and agreed to the published version of the manuscript.

Ethics Approval

This in vivo study has received approval from the Research Ethics Commission of Universitas Padjadjaran Number: 246/UN6.KEP/EC/2023.

References

Abdullah, M. A. and M. M. Farghaly. 2019. Impact of partial replacement of cottonseed meal by *Nigella sativa* meal on nutrients digestibility, rumen fermentation, blood parameters, growth performance of growing lambs. Egyptian J. Nutrition Feeds 22: 11–20. https://doi.org/10.21608/ejnf.2019.102283

Abrori, A. S., U. Ali, and A. F. Rozi. 2022. Increasing growth, feed efficiency, and income in sheep fattening using fermented palm dust feed. JPI 24: 270–280. https://doi.org/10.25077/jpi.24.3.270-280.2022

Adiwimarta, K. I. S. 2021. Nutrisi Ruminansia: Kepentingan Energi dan Protein. Gadjah Mada University Press, Yogyakarta.

Ahmed, S., R. Mahmood, A. R. Muhammad, I. Mohsin, G. A. Chishti, and M. Q. Javed. 2022. Effect of *Nigella sativa* seeds on growth, nutrients digestibility and some blood metabolites in male Beetal goats. JAPS. 32: 1194–1199. https://doi.org/10.36899/JAPS.2022.5.0525

Akbar, S. A. 2007. Utilization of fermented palm bunches trash combined with defaunation and rumen by pass protein on sheep performance. J. Indon. Trop. Anim. Agric. 32: 80-85.

AOAC. 1990. Official Methods of Analysis 15th ed. Association of Official Analytical Chemist. Arlington.

Central Bureau of Statistics. 2022. Foreign Trade Statistics Import of Indonesia 2022 1st ed. Central Bureau of Statistics, Jakarta.

Cherif, M., H. Ben Salem, and S. Abidi, 2018. Effect of the addition of *Nigella sativa* seeds to low or high concentrate diets on intake, digestion, blood metabolites, growth and carcass traits of Barbarine lamb. Small Rumin. Res. 158: 1–8. https://doi.org/10.1016/j.smallrumres.2017.11.008

Christi, R. F., A. Rochana, and I. Hernaman. 2018. Physical quality and palatability of fermented concentrates diets of Ettawa cross goats. Jurnal Ilmu Ternak 18: 121–125. https://doi.org/10.24198/jit.v18i2.19461

Danso, A. S., P. C. H. Morel, P. R, Kenyon, and H. T. Blair. 2018. Effects of dietary protein and energy intake on growth, body composition and nutrient utilisation in lambs reared artificially with milk replacers and pellet feeds. Anim. Feed Sci. Technol. 237: 35–45. https://doi.org/10.1016/j.anifeedsci.2018.01.007

Directorate General of Livestock and Animal Health. 2022. Livestock and Animal Health Statistics 2022. Directorate General of Livestock and Animal Health. Jakarta.

Haryanti, Y., E. Kurnianto, and C. M. Lestari. 2015. Estimation of body weight using body measurement on Wonosobo sheep. JSPI. 10: 1–6. https://doi.org/https://doi.org/10.31186/jspi.id.10.1.1-6

He, L., W. Zho, Y. Xing, R. Pian, X. Chen, and Q. Zhang. 2020. Improving the quality of rice straw silage with *Moringa oleifera* leaves and propionic acid: Fermentation, nutrition, aerobic stability and microbial communities. Bioresour. Technol. 299: 1–8. https://doi.org/https://doi.org/10.1016/j.biortech.2019.122579

Heriyadi, D. and N. Mayasari. 2006. The body measurement of Garut sheep and prospective resource regions in Bandung Regencies. Jurnal Ilmu Ternak 6: 57–62.

Indonesian National Standard 7532:2009. 2009. Bibit Domba Garut. National Standardization Agency of Indonesia, Jakarta.

Irshad, A., K. Gurunathan, S. Kumar, A. A Kumar, M.R. Vishnuraj, and V. Shukla. 2013. Factors influencing carcass composition of livestock: a Review. J. Anim. Prod. Adv. 3: 177-186. https://doi.org/10.5455/japa.20130531093231

Khotijah, L., R. Zulihar, M. A. Setiadi, K. G. Wiryawan, and D. A. Astuti. 2014. Effect of sun flower oil addition (*Helianthus annuus*) in diet on nutrient intake, growth performance and characteristics of estrous of pre-mating Garut sheep. JITV. 19: 9–16. https://doi.org/http://dx.doi.org/10.14334/jitv.v19i1.989.

Kriskenda, Y., D. Heriyadi, and I. Hernaman. 2018. Performance of local rams fed diets containing treated corn cob by bice husk ash filtrate. Jurnal Ilmu Ternak 18: 21-25. https://doi.org/https://doi.org/10.24198/jit.v18i1.15152

Makkar, H. P. S. 2003. Quantification of Tannins in Tree and Shrub Foliage: a Laboratory Manual. Springer Science & Business Media. Dordrecht.

Nascimento, C. De. O., S. A. Santos, D. Dos S. Pina, M. S. L. Tosto, L. F. B. Pinto, D. N. Eiras, D. Y. C. de Assis, A.F. Perazzo, M. LG. M. L. de Araújo, J. A. G. Azevêdo, G. B. Mourão, and G. G. P. de Carvalho. 2019. Effect of roughage-to-concentrate ratios combined with different preserved tropical forages on the productive performance of feedlot lambs. Small. Rumin. Res. 182: 15–21. https://doi.org/10.1016/j.smallrumres.2019.11.002

Nurjannah, S., B. Ayuningsih, I. Hernaman, and I. Susilawati, I. 2019. The use of *Calliandra calothyrsus, Indigofera sp*. and its mix in diet to substitute concentrate on productivity of male Garut sheep. JIPT 7: 293–298. https://doi.org/http://dx.doi.org/10.23960/jipt.v7i3.p293-298

Obeidat, B. S. 2020. The inclusion of black cumin meal improves growth performance of growing awassi lambs. Vet. Sci. 7: 1–8. https://doi.org/10.3390/VETSCI7020040

Obeidat, B. S. 2021. The inclusion of black cumin meal improves the carcass characteristics of growing Awassi lambs. Vet. World. 14: 237–241. https://doi.org/10.14202/vetworld.2021.237-241

Paarakh, P. M. 2010. *Nigella sativa* Linn.–A comprehensive review. IJNPR. 1: 409–429.

Paul, S. S., A. B. Mandal, G. P. Mandal, A. Kannan, and N. N. Pathak. 2003. Deriving nutrient requirements of growing Indian sheep under tropical condition using performance and intake data emanated from feeding trials conducted in different research institutes. Small Rumin. Res. 50: 97–107. https://doi.org/https://doi.org/10.1016/S0921-4488(03)00119-6

Retnani, Y., G. K. Wiryawa, L. Khotijah, N. Nurmilati, G. R. Agung, and I. R. Dermawan. 2019. Growth performance, blood metabolites and nitrogen utilization of lambs fed with *Nigella sativa* meal. Pak. J. Nut. 18: 247–253. https://doi.org/10.3923/pjn.2019.247.253

Sagito, N. D., R. Hidayat, and U. H. Tanuwiria. 2022. The Effect of giving rations containing golden snail (*Pomacea canaliculata* L.) flour protected by various level of tannins on ration crude fiber and energy digestibility of male local sheep. JNTTIP 4: 10–18.

Sanjaya, R., T. Dhalika, and R. Hidayat. 2020. The effect of molasses additive substitution with soy sauce sludge in corn ensilage on dry and organic matter digestibility of male sheep Garut ration. JNTTIP. 2: 207–216. https://doi.org/https://doi.org/10.24198/jnttip.v2i4.31548

Soepranianondo, K., D. S. Nazar, D. and Handiyatno. 2007. Potency rice straw was deammoniated and fermented by celulolytic bacteria on the dry matter consumption, body weight gain and feed conversion of sheep. MKH 23: 202–205.

Van Soest, P. V., J. B. Robertson, and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74: 3583–3597.

Wahyudi, F. E., S. Maylinda, and T. E. Susilorini. 2023. Relationship between linear body measurements and body weight of Texel sheep and Awassi sheep. J. Agripet. 23: 85–90. https://doi.org/10.17969/agripet.v23i1.24871

Wang, X., T. Xu, X. Zhang, Y. Geng, S. Kang, and S. Xu. 2020. Effects of dietary protein levels on growth performance, carcass traits, serum metabolites, and meat composition of tibetan sheep during the cold season on the Qinghai-Tibetan plateau. Animals. 10: 1–12. https://doi.org/10.3390/ani10050801

Younas, U., M. Abdullah, J. A. Bhatti, T. N. Pasha, N. Ahmad, M. Nasir, and A. Hussain. 2013. Inter-relationship of body weight with linear body measurements in Hissardale sheep at different stages of life. JAPS. 23: 40–44.