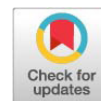


Research Article



Effects of *Garcinia atroviridis* Leaf Meal and Zeolite Supplementation on Performance, Carcass Traits, Commercial Cuts, and Non-Carcass Components of Local Sheep

DEWI WAHYUNI*, DEDE KARDAYA, ANGGRAENI, IKHSAN QODRI PRAMARTAA, DEDEN SUDRAJAT, BENI ADNAN FIRDAUS, ALFIAN FEBRIANSYAH HERMAWAN, IMAN NURJAMAN, M. HIKMAL MAULANA

Department of Animal Husbandry, Faculty of Agriculture, Universitas Djuanda, Indonesia.

Abstract | This study aimed to evaluate the effects of dietary supplementation of *Garcinia atroviridis* leaf meal and zeolite, or in combination, on growth performance, carcass traits, commercial cuts and non-carcass components of local sheep. Twenty male sheep with an average initial body weight of 15 ± 1.5 kg were assigned in a completely randomized design to four dietary treatments: R1 (control diet without supplementation), R2 (diet with 0.5% *Garcinia atroviridis* leaf meal), R3 (diet with 1% zeolite), and R4 (diet with 0.5% *Garcinia atroviridis* leaf meal + 1% zeolite). The feeding trial lasted 60 days, following a 7-day adaptation period. The results showed that dietary supplementation did not significantly affect total feed intake, carcass weight, dressing percentage, commercial cut proportions, or non-carcass components ($P > 0.05$). However, lambs fed the combined supplementation (R4) showed higher forage intake (approximately 12%) and a numerical increase in average daily gain of about 51.9%, accompanied by an improvement in feed conversion ratio of approximately 13.6% compared with the control diet. Carcass yield tended to be slightly higher in supplemented lambs ($\approx 1.4\%$) without adverse effects on internal organ weights or physiological indicators. These findings indicate that the combined supplementation of *Garcinia atroviridis* leaf meal and zeolite can improve growth efficiency without compromising carcass quality or animal health in local sheep.

Keywords | Clinoptilolite, Small ruminants, Hydroxycitric acid, Growth efficiency, Organ proportion

Received | December 13, 2025; **Accepted** | March 18, 2026; **Published** | September 03, 2026

***Correspondence** | Dewi Wahyuni, Department of Animal Husbandry, Faculty of Agriculture, Universitas Djuanda Indonesia; **Email:** dewi.wahyuni@unida.ac.id

Citation | Wahyuni D, Kardaya D, Anggraeni, Pramartaa IQ, Sudrajat D, Firdaus BA, Hermawan AF, Nurjaman I, Maulana MH (2026). Effects of *Garcinia atroviridis* leaf meal and zeolite supplementation on performance, carcass traits, commercial cuts, and non-carcass components of local sheep. J. Anim. Health Prod. 14(4): 1302-1310.

DOI | <https://dx.doi.org/10.17582/journal.jahp/2026/14.4.1302.1310>

ISSN (Online) | 2308-2801



Copyright: 2026 by the authors. Licensee ResearchersLinks Ltd, England, UK.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

INTRODUCTION

Local sheep are an essential source of animal protein, contributing to food security and the livelihoods of smallholder farmers in many tropical regions, including Indonesia. However, their growth rate, feed efficiency, and carcass quality are generally lower than those of improved breeds. Carcass percentage (dressing percentage) is widely recognized as a key indicator of livestock productivity

because it reflects the proportion of carcass weight relative to live weight, and previous research has shown that live weight at slaughter is a strong predictor of carcass traits in sheep. Higher slaughter live weight generally corresponds to improved carcass yield under various feeding systems (Wang *et al.*, 2024; Zonabend *et al.*, 2017). These limitations pose challenges in managing local sheep, highlighting the need to improve growth performance and carcass quality as a focus in ruminant production

systems. Nutritional strategies have emerged as promising approaches to enhance productivity and carcass quality, particularly through supplementation with natural feed additives. Among these, herbal feed additives have received considerable attention (Wahyuni *et al.*, 2021).

One natural compound with potential is hydroxycitric acid (HCA), a derivative of citric acid, which is found in South Asian plants such as *Garcinia cambogia*, *Garcinia indica*, and *Garcinia atroviridis* (Onakpoya *et al.*, 2011). HCA has been reported to exert anti-obesity effects by suppressing appetite, increasing satiety, reducing the rate of fat oxidation, and inhibiting de novo lipogenesis. The leaves of *Garcinia atroviridis* (asam gelugur) contain bioactive compounds such as flavonoids, alkaloids, saponins, tannins, phenolics, carbohydrates, and proteins, as well as organic acids including ascorbic, malic, tartaric, pentadecanoic, nonadecanoic, dodecanoic, and hydroxycitric acids (Kardaya *et al.*, 2022).

Zeolite, characterized by its porous crystalline structure and negatively charged surface (Dongoran *et al.*, 2021), possesses high cation-exchange and absorption capacities, enabling it to bind ammonium ions in ruminal fluid and thereby improve the efficiency of feed utilization (Kardaya *et al.*, 2012, 2023; Toprak *et al.*, 2016; Salam *et al.*, 2022). Supplementation of zeolite in local sheep diets has improved nutrient digestibility, feed efficiency, and body weight gain (Kardaya *et al.*, 2023). Moreover, inclusion of 20–40 g/kg zeolite in the ration has been reported to positively influence weight gain, ruminal fermentation patterns, and estimates of rumen-fermentable energy, while supplementation at 60 g/kg enhanced nitrogen retention in ewe lambs (Roque-Jiménez *et al.*, 2019).

Although zeolite and hydroxycitric acid (HCA) or *Garcinia*-based feed additives have individually demonstrated potential to improve digestion, rumen fermentation, and lipid metabolism, recent literature indicates that their effects vary with dosage, form, and animal species. The combined use of mineral adsorbents, such as zeolite, with metabolic bioactive, such as HCA, has rarely been investigated in local sheep. The aim of study was to examine the effects of dietary supplementation with both zeolite and hydroxycitric acid to evaluate their potential synergistic effects on growth performance, feed efficiency, and carcass characteristics, including commercial cuts and non-carcass components, in local sheep.

MATERIALS AND METHODS

The experiment was arranged in a completely randomized design (CRD) with four dietary treatments and five replications, using 20 local sheep (initial body weight 15

± 1.5 kg). The adaptation period was 7 days, followed by a 60-day feeding trial. The animals were housed in individual pens measuring 90 cm x 120 cm, which provided adequate space for movement and comfort. Each pen was fitted with separate feeding and drinking facilities to eliminate the risk of diet contamination. The pen's floor is made of wooden battens with bars 1.5 cm apart to prevent dirt from falling under the cage's floor. The floor materials were cleaned, and proper ventilation was maintained to reduce stress and promote animal comfort.

Four rations were formulated: R1 = control ration (without supplementation); R2 = ration containing 0.5% *Garcinia atroviridis* leaf meal (natural HCA); R3 = ration containing 1% zeolite; R4 = ration containing a combination of 0.5% *Garcinia atroviridis* leaf meal and 1% zeolite. The basal diet consisted of field grass and concentrate in a ratio of 55:45 (dry matter basis), Table 1. Rations were offered at 2.5% of body weight (dry matter basis) daily, divided into two equal meals at 08:00 and 16:00 h. Water was provided *ad libitum*.

Table 1: Ingredient composition of experimental diets (% dry matter basis).

Ingredients	R1 (%)	R2 (%)	R3 (%)	R4(%)
Field grass	55.0	55.0	55.0	55.0
Wheat pollard	4.0	4.0	4.0	3.5
Yellow maize	14.0	14.0	14.0	14.0
Soybean meal	15.5	15.5	16.0	16.5
Palm Kernel cake	10.0	9.5	8.5	8.0
Zeolite	0.0	0.0	1.0	1.0
<i>Garcinia atroviridis</i> leaf meal	0.0	0.5	0.0	0.5
Palm oil	1.5	1.5	1.5	1.5
Total	100	100	100	100

Note: R1 (control diet without supplementation), R2 (diet with 0.5% *Garcinia atroviridis* leaf meal), R3 (diet with 1% zeolite), and R4 (diet with 0.5% *Garcinia atroviridis* leaf meal + 1% zeolite). Diets consisted of 55% forage and 45% concentrate (on a dry matter basis).

The proximate composition of the rations was determined following AOAC (2019). The nutrient composition is presented in Table 2.

All experimental procedures involving animals in this study were reviewed, approved, and authorized in accordance with the Research Ethics Clearance in the Field of Livestock and Utilization, under reference number 203/KE.02/SK/08/2024.

OBSERVED PARAMETERS

Performance traits included feed intake, average daily gain (ADG), and feed efficiency ratio (FER). Carcass traits included slaughter weight, hot carcass weight,

Table 2: Proximate composition of experimental diets (% dry matter basis; gross energy in kcal/kg).

Treatment	DM (%)	CP(%)	EE (%)	CF (%)	Ash (%)	DE(Kcal/kg)	BETN (%)
R1	91.54	20.66	3.79	20.03	9.55	3962.80	37.51
R2	91.65	20.22	4.07	18.84	9.51	3964.15	39.01
R3	91.69	21.10	3.96	18.13	10.36	3939.85	38.15
R4	91.87	21.36	4.17	18.19	10.25	3943.45	37.91

Note: R1–R4 = Diets consisting of forage and concentrate; *NFE (Nitrogen-Free Extract), DE (Digestible Energy). BETN was calculated using the formula $BETN = DM - CP - EE - CF - Ash$ —proximate analysis results (2025).

Table 3: Performance of Lamb fed experimental rations.

Performances parameters	R1	R2	R3	R4
Dry matter intake				
Concentrate (g)	296.47±21.61	319.07±18.18	322.07±4.43	305.49±3.33
grass (g)	338.87±4.51 ^a	355.46±23.51 ^{ab}	358.65±16.97 ^{ab}	379.5±16.63 ^b
Total, (g)	635.33±20.09	674.53±38.40	680.72±29.91	684.65±24.85
Final body weight (kg)	18.98±1.93	19.82±1.92	19.41±0.87	19.78±0.81
Average daily gain (g/h/d)	70.50±30.34	79.35±19.72	89.17±21.96	107.1±23.66
Feed conversion ratio	7.73±0.68	7.78±0.33	7.98±1.89	6.68±1.62

Note: R1 (control diet without supplementation), R2 (diet with 0.5% *Garcinia atroviridis* leaf meal), R3 (diet with 1% zeolite), and R4 (diet with 0.5% *Garcinia atroviridis* leaf meal + 1% zeolite). Diets consisted of 55% forage and 45% concentrate (on a dry matter basis). Different superscript letters in a row differ significantly ($P < 0.05$).

carcass percentage, kidney weight, and kidney percentage. Slaughter weight was recorded after 12 h fasting with free access to water. Carcass percentage was calculated as:

$$\text{Carcass percentage (\%)} = \frac{\text{Carcass weight}}{\text{Slaughter weight}} \times 100$$

SLAUGHTER PROCEDURE

Lambs were slaughtered in accordance with Islamic halal practices (*dhabh*), involving severing the trachea, esophagus, jugular veins, and carotid arteries with a single incision while invoking the name of Allah. This procedure is considered humane and compliant with halal requirements.

CARCASS EVALUATION

Carcasses were skinned, eviscerated, and weighed to obtain hot carcass weight. Each carcass was split longitudinally, and the left half dissected into primal cuts (leg, loin, rack, shoulder, breast, flank, neck) following standard carcass evaluation methods (AOAC, 2019). Kidneys were removed and weighed; kidney percentage was calculated relative to slaughter weight.

$$\text{Kidneys percentages} = \frac{\text{kidneys weight}}{\text{Carcass weight}} \times 100$$

COMMERCIAL CUTS

Each right Carcass was divided into eight parts according to the commercial cut, consisting of neck, shoulder, breast, flank, shank, leg, rack, and loin (Khotijah *et al.*, 2019).

NON CARCASS

Head, pelt, fore and hind feet, internal fat, testes and

internal organs (heart, liver, spleen, kidneys and lungs) were weighed. The whole GIT and various segments (stomach and small and large intestines) of the GIT were weighed before complete emptying and recorded as full weight. Then, the empty GIT, stomach and intestine weights were also weighed and recorded. The lengths of the small and large intestines were measured (Jatnika *et al.*, 2023).

STATISTICAL ANALYSIS

Prior to ANOVA, data were tested for normality using the Shapiro–Wilk test and for homogeneity of variances using Levene’s test. Only data that met the assumptions of parametric analysis were subjected to one-way analysis of variance (ANOVA) under a completely randomized design (CRD). Differences among treatment means were considered significant at $\alpha = 0.05$, and when significant, means were separated using Duncan’s multiple range test. Statistical analyses were performed using SPSS version 25 (IBM Corp., Armonk, NY, USA) following the procedures described by Steel and Torrie (1986).

RESULTS

PERFORMANCE

The results indicated that dietary supplementation with *Garcinia atroviridis* leaf meal and zeolite did not result in significant differences ($P > 0.05$) in concentrate intake, total feed intake, final body weight, average daily gain (ADG), or feed conversion ratio (FCR) (Table 3). However, a significant effect ($P < 0.05$) on forage intake was observed. Forage consumption increased from 338.87 g/head/day in R1 to 355.46 g (R2), 358.65 g (R3). It reached the

highest level in R4 with 379.50 g/head/day, representing a numerical increase of approximately 12.0% compared with the control diet. The final body weight indicated that supplementation with *Garcinia* leaf meal and zeolite did not improve growth performance; in fact, the combination treatment (R4) resulted in a higher final body weight than the other groups. A numerical improvement in ADG was observed, increasing from 70.5 g/day in R1 to 79.35 g/day in R2 ($\approx 12.6\%$) and 79.33 g/day in R3 ($\approx 12.5\%$), and reaching 107.1 g/day in R4, corresponding to a numerical increase of approximately 51.9% compared with the control group. Similarly, FCR numerically improved from 7.73 in the control group (R1) to 6.68 in R4, indicating a numerical improvement in feed efficiency of approximately 13.6% (Table 3).

CARCASS CHARACTERISTICS

Carcass weight and carcass percentage did not differ significantly among treatments ($P>0.05$) (Table 4), with carcass weight ranging from 7.39 to 7.78 kg and carcass percentage ranging from 38.73% to 40.14%. Lambs fed diets supplemented with *Garcinia atroviridis* leaf meal (R2), zeolite (R3), or their combination (R4) showed slightly higher carcass weights than the control group, although these differences were minimal. Carcass percentage in R4 (39.32%) was approximately 1.4% higher than in the control group (38.79%), while the highest value was observed in R3 (40.14%). These results indicate a slight numerical increase in carcass yield in supplemented lambs.

Kidney weight and kidney percentage also did not differ significantly ($P>0.05$), ranging from 0.060–0.075 kg and 0.85%–0.97%, respectively. All values were within normal physiological limits, suggesting that supplementation with *Garcinia* leaf meal and zeolite did not negatively affect kidney development or function.

COMMERCIAL CUTS

The weights and percentages of commercial carcass cuts were not significantly influenced by dietary treatments ($P>0.05$). Nevertheless, numerical variations were observed. Leg weight tended to increase in the supplemented groups, with the highest value recorded in R4 (1385 g), representing a numerical increase of approximately 4.4% compared with the control group (1327 g). Loin weight showed no

considerable variation, remaining between 267 and 277 g. Shoulder weight increased notably with supplementation of *Garcinia* leaf meal (R2; 871 g) and zeolite (R3; 878 g), corresponding to increases of approximately 16.0% and 16.9%, respectively, compared with the control group (751 g). Breast and rack weights also increased in certain supplemented groups, particularly R2 and R4. Neck weight was higher in R2 and R4 compared to R1. Shank and flank weights exhibited minor variations, with the highest shank (184.5 g) and flank (183.75 g) recorded in R3.

The percentage distribution of commercial cuts remained relatively consistent across treatments as shown in Table 5. Leg percentage ranged from 17.25% to 17.87%, representing a numerical increase of approximately 3.6% in R4 compared with R1. Shoulder percentage tended to be higher in the supplemented groups (14.28–14.40%) than in the control group (12.31%), corresponding to a numerical increase of approximately 16–17%.

NON-CARCASS COMPONENTS

Tables 6 and 7 show that the total non-carcass weight ranged from 11590 to 12112 g, with the highest value in R2 and the lowest in R1. Represents a numerical increase of approximately 4.5% in R2 compared with the control group. Collected blood weight remained relatively stable across treatments (1575–1810 g). Some components, such as the head and skin, were heavier in the supplemented groups (R2 and R4), whereas the feet were heavier in R2 (635 g) than in the control. The weights of the reproductive organs, liver, heart, lungs, and trachea were similar across treatments, indicating that supplementation did not have adverse effects on these organs. Gastrointestinal components were also within normal ranges, with notable variation in digesta content, which was highest in R4.

Based on percentages, the total non-carcass proportion ranged from 59.87% to 61.26%, with no significant differences among treatments ($P>0.05$). The percentages of head, skin, feet, and internal organs were relatively uniform, indicating that supplementation did not alter the distribution of non-carcass tissues. Abdominal fat percentage increased slightly in R4 (1.34%), corresponding to a numerical increase of approximately 34%, while gastrointestinal content percentage ranged from 24.56% to 27.03%,

Table 4: Carcass of Lamb fed experimental rations.

Carcass Parameters	R1	R2	R3	R4
Carcass weight (kg)	7.39 $\pm$ 1.20	7.71 $\pm$ 0.20	7.77 $\pm$ 0.27	7.78 $\pm$ 0.43
Carcass percentage (%)	38.79 $\pm$ 3.32	38.73 $\pm$ 2.56	40.14 $\pm$ 2.93	39.32 $\pm$ 1.11
Kidney weight (kg)	0.065 $\pm$ 0.008	0.064 $\pm$ 0.007	0.075 $\pm$ 0.001	0.060 $\pm$ 0.007
Kidney percentage (%)	0.89 $\pm$ 0.095	0.86 $\pm$ 0.25	0.97 $\pm$ 0.02	0.85 $\pm$ 0.12

Note: R1 (control diet without supplementation), R2 (diet with 0.5% *Garcinia atroviridis* leaf meal), R3 (diet with 1% zeolite), and R4 (diet with 0.5% *Garcinia atroviridis* leaf meal + 1% zeolite). Diets consisted of 55% forage and 45% concentrate (on a dry matter basis).

Table 5: Commercial cut components of lamb carcasses fed experimental diets.

Commercial cuts	R1	R2	R3	R4
Weight (gram)				
Leg	1327±272.1	1327.50±183.59	1346.25±64.2	1385±139.3
Loin	273±36.7	276.25±76.9	267.50±44.06	277±50.57
Shoulder	751±173.1	871.25±47.7	878.25±87.9	858±70.6
Breast	246±27.01	278.75±96.9	276.25±49.56	285±42.86
Neck	275±69.9	355±81.75	288.75±43.27	351±48.6
Shank	149±26.78	173.75±25.94	184.50±40.47	165±12.24
Flank	177±39.63	152.50±21.79	183.75±4.93	164±17.10
Rack	381±74.3	446.67±95.7	390±19.15	405±38.25
Percentages (%)				
Leg	17.87±1.27	17.25±0.45	17.31±0.33	17.78±1.27
Loin	4.47±0.60	4.53±1.25	4.38±0.73	4.54±0.83
Shoulder	12.31±2.83	14.28±0.78	14.40±1.44	14.06±1.15
Breast	4.03±0.44	4.57±1.57	4.53±0.81	4.67±0.71
Neck	4.51±1.15	5.82±1.34	4.73±0.71	5.75±0.79
Shank	2.44±0.44	2.84±0.43	3.022±0.67	2.70±0.20
Flank	2.90±0.65	2.49±0.35	3.01±0.25	2.69±0.28
Rack	6.25±1.21	6.47±2.13	6.39±0.31	6.64±0.63

Note: R1 (control diet without supplementation), R2 (diet with 0.5% *Garcinia atroviridis* leaf meal), R3 (diet with 1% zeolite), and R4 (diet with 0.5% *Garcinia atroviridis* leaf meal + 1% zeolite). Diets consisted of 55% forage and 45% concentrate (on a dry matter basis).

Table 6: Non-carcass weights of lambs fed experimental diets.

Non-Carcass Parameters	R1	R2	R3	R4
	(gram)			
Total non-carcass weight	11590±1008.5	12112±781.4	11637±1077	12000±494.9
Collected blood	1810±651.3	1575±322.7	1637±131.5	1640±535.9
Head	1341.6±60.6	1485±167.18	1467.5±98.78	1499±94.0
Skin	1336±193.5	1535±249.4	1401±114.7	1426±186.9
Feet	559.8±50.22	635.75±49.61	616.0±48.29	603.6±45.45
Tail	102±85.8	72.25±37.2	104.25±71.9	58.0±28.0
Reproduction organs	261.60±28.6	246.5±59.39	268.5±62.30	278.8±36.56
Liver	365±31.3	362.25±21.7	382±30.3	358.6±22.08
Lungs and trachea	180.4±26.8	223.5±72.36	233±66.79	220±28.31
Heart	84.8±10.3	87.25±8.61	93.5±16.1	84.6±8.41
Spleen	49.0±14.0	40.2±7.13	57.75±36.61	38.80±10.63
Abdominal fat	196±45.1	215±54.7	207±74.2	263±98.1
Stomach	627±79.0	632.5±49.2	621.2±59.3	638±51.6
Small intestine	571±88.76	505±102.9	436±101.8	517±78.4
Large intestine	295±32.5	203.7±20.5	317.5±136.7	255.0±51.35
Gastrointestinal contents	5012.0±693.17	5206.25±479.48	4802.50±1242.8	5345±334.8

Note: R1 (control diet without supplementation), R2 (diet with 0.5% *Garcinia atroviridis* leaf meal), R3 (diet with 1% zeolite), and R4 (diet with 0.5% *Garcinia atroviridis* leaf meal + 1% zeolite). Diets consisted of 55% forage and 45% concentrate (on a dry matter basis).

representing a numerical increase of approximately 10.1% in R4 compared with R1. Overall, these results confirm that supplementation with *Garcinia atroviridis* leaf meal,

zeolite, or their combination did not significantly modify non-carcass composition or tissue distribution.

Table 7: Non-carcass percentages of lambs fed experimental diets.

Non carcass parameters	R1	R2	R3	R4
Percentages	(%)			
Total non-carcass weight	61.23±3.32	61.26±2.57	59.87±2.93	60.67±1.11
Collected blood	9.37±2.71	7.92±1.21	8.47±1.03	8.24±2.47
Head	7.12±0.68	7.49±0.56	7.56±0.56	7.58±0.53
Skin	7.09±1.15	7.72±0.87	7.21±0.40	7.20±0.87
Feet	2.99±0.56	3.21±0.13	3.17±0.25	3.05±0.23
Tail	0.52±0.40	0.36±0.17	0.54±0.39	0.29±0.13
Reproduction organs	1.37±0.08	1.23±0.23	1.37±0.27	1.40±0.14
Liver	1.93±0.14	1.84±0.23	1.96±0.15	1.81±0.18
Lungs and trachea	0.95±0.17	1.16±0.52	1.20±0.34	1.11±0.16
Heart	0.45±0.04	0.44±0.04	0.48±0.09	0.42±0.04
Spleen	0.27±0.10	0.20±0.03	0.30±0.19	0.19±0.05
Abdominal fat	1.02±0.17	1.08±0.21	1.06±0.33	1.34±0.53
Stomach	3.31±0.34	3.20±0.27	3.19±0.25	3.22±0.16
Small intestine	3.00±0.29	2.59±0.79	2.25±0.57	2.62±0.47
Large intestine	1.58±0.29	1.03±0.09	1.63±0.69	1.28±0.23
Gastrointestinal contents	26.50±3.63	26.34±2.10	24.56±5.25	27.03±1.67

Note: R1 (control diet without supplementation), R2 (diet with 0.5% *Garcinia atroviridis* leaf meal), R3 (diet with 1% zeolite), and R4 (diet with 0.5% *Garcinia atroviridis* leaf meal + 1% zeolite). Diets consisted of 55% forage and 45% concentrate (on a dry matter basis).

DISCUSSION

The absence of significant differences in total feed intake, average daily gain, and feed conversion ratio among dietary treatments indicates that supplementation with *Garcinia atroviridis* leaf meal and zeolite did not adversely affect feed palatability or basal nutrient utilization in local sheep. This finding is consistent with previous studies reporting that herbal additives and mineral adsorbents at low inclusion levels generally do not alter voluntary feed intake in small ruminants when dietary energy and protein are adequate (Ali *et al.*, 2025; Sallam *et al.*, 2022).

The higher forage intake observed in lambs receiving zeolite and combined supplementation may be attributed to zeolite's ability to stabilize ruminal ammonia concentration and improve rumen environmental conditions, thereby enhancing microbial activity and fibre digestion. Improved rumen stability has been shown to stimulate forage utilization and promote more efficient fermentation of fibrous feeds (Urias-Estrada *et al.*, 2023; Papaioannou *et al.*, 2005). In addition, organic acids and hydroxycitric acid present in *Garcinia atroviridis* leaves may enhance sensory perception and salivary secretion, indirectly supporting increased forage intake and rumination activity (Jena *et al.*, 2002; Shahid *et al.*, 2022).

Although growth performance parameters were not statistically different, the biological response observed in

the combined treatment suggests a complementary mode of action between zeolite and hydroxycitric acid. Zeolite improves nitrogen retention and post-ruminal amino acid availability by reducing excessive ruminal protein degradation, while hydroxycitric acid modulates energy metabolism by inhibiting lipogenesis and promoting lean tissue accretion (Roque-Jiménez *et al.*, 2019; Jena *et al.*, 2002). This complementary mechanism may explain the improved growth efficiency observed in lambs receiving the combined supplementation.

The lack of significant effects on carcass weight and dressing percentage indicates that dietary supplementation did not markedly alter tissue deposition patterns. This outcome is commonly observed when animals receive diets with comparable energy density, as moderate improvements in metabolic efficiency may not be sufficient to produce measurable changes in carcass traits (Castro-Pérez *et al.*, 2023). Previous studies have reported that zeolite supplementation often exerts a greater influence on nutrient utilization and growth dynamics rather than on carcass yield per se (Kardaya *et al.*, 2023).

Kidney weight and kidney proportion remained within normal physiological ranges, confirming the safety of both additives. This finding is in agreement with Papaioannou *et al.* (2005), who demonstrated that natural zeolite functions as an inert rumen modifier without inducing metabolic stress or organ hypertrophy. The absence of adverse effects

on internal organs suggests that the supplementation levels used in this study were physiologically appropriate for growing lambs.

Commercial cuts of lamb carcasses represent a critical parameter for evaluating carcass economic value, as they reflect both the yield and market desirability of specific primal cuts. In lamb production systems, significant cuts such as the neck, shoulder, loin, rack, and leg are widely recognized as indicators of carcass quality because they differ in muscle content, fat deposition, and consumer preference (Batista *et al.*, 2021). The leg and loin, in particular, are considered premium cuts due to their higher lean edible tissue content and their strong influence on retail value and market acceptance (Sánchez-Hernández *et al.*, 2023).

Suggests that supplementation with *Garcinia atroviridis* leaf meal, zeolite, or their combination did not substantially modify muscle deposition patterns across the carcass. Similar findings have been reported by Khotijah *et al.* (2019), who observed that modifications in dietary composition, including the addition of oils or specific feed ingredients, do not consistently affect the distribution of commercial cuts in young lambs. These results indicate that primal cut distribution is relatively stable and may be more strongly influenced by genetic factors, slaughter weight, and overall growth rate rather than dietary additives when nutrient supply remains within adequate physiological limits. The slight increases observed in specific cuts for example, the higher shoulder weights in R2 and R3 or the heavier leg in R4 may reflect improved protein utilization and muscle accretion associated with enhanced rumen fermentation, as previously described in studies examining mineral and organic acid supplementation (Urías-Estrada *et al.*, 2023). However, the absence of statistical differences aligns with previous evidence showing that minor improvements in nutrient efficiency often translate more readily into increased daily weight gain rather than significant alterations in carcass partitioning (Sánchez-Hernández *et al.*, 2023). Carcass partition tends to be highly conserved biologically, and only substantial changes in energy balance or hormonal status result in shifts in the proportions of commercial cuts.

Non-carcass components are essential indicators for assessing the physiological condition and nutrient utilization efficiency in lambs. Components such as the liver, heart, lungs, trachea, and reproductive organs showed relatively stable weights, indicating that supplementation with *Garcinia atroviridis* or zeolite did not induce physiological alterations or organ hypertrophy. This stability is consistent with findings by Urías-Estrada *et al.* (2023), who reported that zeolite is a safe rumen additive

that does not adversely affect internal organ health.

The increased gastrointestinal content observed in treatment R4 is likely associated with higher forage intake and greater digesta retention, as reported by Jatnika *et al.* (2023), who demonstrated that diets with higher crude fibre levels significantly increase the weight of rumen and other digestive compartments in thin-tailed sheep. Nevertheless, because the proportional contribution of non-carcass components did not differ significantly, this variation did not affect overall body component distribution. The total non-carcass percentage (59.87–61.26%) remained within the normal range reported for growing sheep, indicating that moderate dietary variation without extreme changes in energy or protein supply does not markedly alter non-carcass composition. Also aligns with previous studies, which suggest that dietary variation without extreme changes in energy or protein levels does not significantly modify non-carcass components (Khotijah *et al.*, 2019). These findings indicate that non-carcass traits are relatively stable and less responsive to moderate nutritional supplementation, with physiological differences being more readily reflected in growth performance rather than in the distribution of non-carcass components.

CONCLUSIONS

Dietary supplementation with *Garcinia atroviridis* leaf meal and zeolite, either individually or in combination, did not negatively affect feed intake, carcass characteristics, commercial cuts, or non-carcass components of local sheep. The combined supplementation (0.5% *Garcinia atroviridis* leaf meal + 1% zeolite) numerically increased forage intake by approximately 12% and average daily gain by about 51.9%, while improving feed conversion ratio by around 13.6% compared with the control diet. Although carcass weight and dressing percentage were not significantly affected, carcass yield tended to be slightly higher ($\approx 1.4\%$) in supplemented lambs. Overall, the combination of *Garcinia atroviridis* leaf meal and zeolite shows potential as a safe natural feed additive to enhance growth efficiency without compromising carcass quality or physiological health in local sheep.

ACKNOWLEDGEMENTS

Acknowledgment is given to the Directorate of Research and Community Service, Directorate General of Research and Development, Ministry of Higher Education, Science and Technology of the Republic of Indonesia, in accordance with Research Contract Number: 594/01/K-X/VI/2025 and Master Contract Number: 125/C3/DT.05.00/PL/2025 dated 28 May 2025.

This study presents the first documented evaluation of the combined supplementation of *Garcinia atroviridis* leaf meal, a natural source of hydroxycitric acid, and zeolite in diets of Indonesian local sheep. While previous studies have examined the individual effects of herbal additives or zeolite on ruminant performance, evidence on their combined use and potential complementary effects in local sheep remains limited. This research demonstrates that the combined supplementation improves forage intake and growth efficiency without adversely affecting carcass traits, commercial cuts, or non-carcass components. The findings provide new insight into the safe application of plant- and mineral-based natural feed additives to enhance production efficiency in small ruminant systems under tropical conditions.

AUTHORS CONTRIBUTION

DW: Conceptualization, methodology design, research supervision, data validation, original draft writing, and final manuscript editing. DK: Contribution to conceptualization, methodology, result interpretation, and critical manuscript review. A: Fieldwork implementation, data collection, and preparation of the results section. IQP: Data analysis, preparation of tables and figures, and contribution to the discussion section. DS: Sample processing, laboratory analyses, and validation of feed nutrient data. BAF: Data collection, preliminary study, and drafting of the results section. AHF: Data processing, introduction and literature review drafting, and manuscript formatting. IN: Data collection, preliminary analysis, and drafting of the results section. HM: Data collection, preliminary study, and manuscript formatting.

GENERATIVE AI AND AI ASSISTED TECHNOLOGY STATEMENT

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

REFERENCES

- Ali AI, Hussein SN, Azeez AK. 2025. Phytogenic feed additives in ruminant nutrition: Rumen modulation, performance, and sustainability – A review. *Tikrit Journal of Veterinary Sciences*. 1(2):55–66. <https://doi.org/10.25130/tjvs.4.2.8>
- AOAC (2019). Official methods of analysis (21st ed.). Association of Official Analytical Chemists.
- Batista AC, Santos V, Afonso J, Guedes C, Azevedo J, Teixeira A, Silva S (2021). Evaluation of an image analysis approach to predicting primal cuts and lean in light lamb

- carcasses. *Animals*, 11(5): 1368. <https://doi.org/10.3390/ani11051368>
- Castro-Pérez, B. I., Rodríguez-Vázquez, J., Estrada-Angulo, A., Ríos-Rincón, F. G., Urías-Estrada, J. D., & Ponce-Barraza E (2023). Effect of particle size of zeolite clay included in high-energy diets for feedlot lambs. *J. Adv. Vet. Anim. Res.*, 10(3): 500–506. <https://doi.org/10.5455/javar.2023.j703>
- Dongoran J, Sulistiawati P, Simangunsong SY, Paksi PGR, Pasaribu MH (2021). Perkembangan zeolit sebagai katalis alam potensial. *J. Jejaring Matematika Dan Sains*, 3(2): 28–39. <https://doi.org/10.36873/jjms.2021.v3.i2.604>
- Jatnika AR, Munandar I, Husni NS, Priyanto R, Abdullah L (2023). Non-carcass composition of thin-tailed sheep fed indigofera zollingeriana with different maintenance systems. *J. Ilmu Produksi Teknol. Hasil Peternakan.*, 11(1): 1–6. <https://doi.org/10.29244/jipthp.11.1.1-6>
- Jena BS, Jayaprakasha GK, Singh RP, Sakariah KK (2002). Chemistry and biochemistry of (–)-hydroxycitric acid from *Garcinia*. *J. Agric. Food Chem.*, 50(1): 10–22. <https://doi.org/10.1021/jf010753k>
- Kardaya D, Ratnasari A, Wahyuni D (2022). Percentage of carcasses and commercial cuts of spent layer ducks fed *Garcinia atroviridis* leaf meal as feed additive in a smallholder farm. *J. Anim. Health Prod.*, 10(4): 438–442. <https://doi.org/10.17582/journal.jahp/2022/10.4.438.442>
- Kardaya D, Sudrajat D, Dihansih E (2012). Efficacy of dietary urea-impregnated zeolite in improving rumen fermentation characteristics of local lamb. *Media Peternakan*. Fakultas Peternakan Institut Pertanian Bogor., 35(3): 207–213. <https://doi.org/10.5398/medpet.2012.35.3.207>
- Kardaya D, Sudrajat D, Wahyuni D (2023). Performance of local sheep fed diets containing urea-impregnated zeolite. *J. Anim. Health Prod.*, 11(2): 199–205. <https://doi.org/10.17582/journal.jahp/2023/11.2.199.205>
- Khotijah L, Suryati T, Fandi M (2019). Characteristics and commercial cutting of five-month-old young sheep carcasses that were fed a complete ration containing sunflower seed oil. *J. Ilmu Nutr. Pakan.*, 17(3): 78–82. <https://doi.org/10.29244/jintp.17.3.78-82>
- Onakpoya I, Hung SK, Perry R, Ernst E (2010). The use of *Garcinia* extract (Hydroxycitric acid) as a weight-loss agent: A systematic review and meta-analysis. *J. Obesity*, Article ID 509038. <https://doi.org/10.1155/2011/509038>
- Papaioannou DS, Katsoulos PD, Panousis N, Karatzias H (2005). The role of natural zeolites as feed additives. *Microp. Mesoporous Mater.*, 84(1–3): 161–170. <https://doi.org/10.1016/j.micromeso.2005.05.030>
- Roque-Jiménez JA, Pinos-Rodríguez JM, Rojo-Rub R, Mendoza GD, Vázquez A, De Jesús JAC, Lee-Rangel HA (2019). Effect of natural zeolite on live weight changes, ruminal fermentation, and nitrogen metabolism of ewe lambs. *South Afr. J. Anim. Sci.*, 48(6): 1081–1090. <https://doi.org/10.4314/sajas.v48i6.19>
- Salam SMA, Abozeid HM, Abaza MA, Zaiat EH (2022). Nutrient intake, digestibility, growth performance, and carcass of sheep fed urea-based diet supplemented with natural clinoptilolite. *Anim. Sci. J.*, 93(1). <https://doi.org/10.1111/asj.13689>
- Sánchez-Hernández MA, Morales-Terán G, Fraire-Cordero S, Mendoza-Pedroza SI. 2023. Carcass yield and primal cuts of lambs fed on different diets in the humid tropics. *Agro Productividad*. 16(12): 95–101. <https://doi.org/10.32854/agrop.v16i12.2776>

- Shahid M, Law D, Azfaralariff A, Mackeen MM, Chong TF, Fazry S (2022). Phytochemicals and biological activities of *Garcinia atroviridis*. *Toxics*, 10(11): 656. <https://doi.org/10.3390/toxics10110656>
- Silalahi M (2021). *Garcinia atroviridis*: Botani, pemanfaatan, dan bioaktivitasnya. *J. Emasains*, 10(2): 45–54. <https://doi.org/10.33541/pro-life.v8i2.3203>
- Steel RGD, Torrie JH (1986). Principles and procedures of statistics: A biometrical approach. McGraw-Hill.
- Toprak NN, Yilmaz A, Öztürk E, Yigit O, Cedden F (2016). Effect of micronized zeolite addition to lamb concentrate feeds on growth performance and some blood chemistry and metabolites. *South African Journal of Animal Science*, 46(3), 313–320. <https://doi.org/10.4314/sajas.v46i3.11>
- Urias-Estrada JD, Estrada-Ángulo A, Castro-Pérez BI, Ríos-Rincón FG, Corona L, Serrano-Pérez B (2023). Impact of zeolite in diets for lambs supplemented with zilpaterol. *Chilean J. Agric. Res.*, 83(6). <https://doi.org/10.4067/S0718-58392023000600768>
- Wahyuni D, Malik B, Dihansih E (2021). Effects of giving asam gelugur leaf meal in non-conventional rations on carcass percentage and carcass composition of male and female ducks in grower phase. *Indonesian J. Appl. Res.*, 2(1): 42–49. <https://doi.org/10.30997/ijar.v2i1.87>
- Wang W, Zhang X, Wei H, Wang S, Ye Y, He L, Zhang K, Lu Y, Zhang Z, Huang Y (2024). Effects of feeding systems on the growth performance, carcass characteristics, and meat quality in sheep: A meta-analysis. *Animals*, 14(18): 2738. <https://doi.org/10.3390/ani14182738>
- Zonabend KE, Ojango JMK, Audho J, Mirkena T, Strandberg E, Okeyo AM, Philipsson J (2017). Live weight, conformation, carcass traits and economic values of ram lambs of Red Maasai and Dorper sheep and their crosses. *Trop. Anim. Health Prod.*, 49(1): 121–129. <https://doi.org/10.1007/s11250-016-1168-5>