2025 SCIENCELINE

Online Journal of Animal and Feed Research

Volume 14, Issue 1: 33-40; January 30, 2025

ISSN 2228-7701

DOI: https://dx.doi.org/10.51227/ojafr.2025.5

PRIMAL CUTS OF CARCASS AND MEAT CHARACTERISTICS OF KACANG GOAT FED TOTAL MIXED RATION CONTAINING DIFFERENT SOURCES OF RUMINALLY UNDEGRADED PROTEIN

Retno ADIWINARTI[1], KUSTANTINAH[2], RUSMAN[3], Edy RIANTO[1], Agung PURNOMOADI[1], Mukh ARIFIN[1], SUTARYO[1], and Vita RESTITRISNANI[1]

[1]*Department of Animal Sciences, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Indonesia*
[2]*Department of Animal Nutrition and Feeds Science, Faculty of Animal Science, Gadjah Mada University, Indonesia*
[3]*Department of Animal Product Technology, Faculty of Animal Science, Gadjah Mada University, Indonesia*

Email: retnoadiwinarti@lecturer.undip.ac.id

Supporting Information

RESEARCH ARTICLE
PII: S222877012500005-15
Received: May 13, 2024
Revised: January 16, 2025
Accepted: January 18, 2025

ABSTRACT: This study was designed to evaluate the effect of feed quality improvement using gliricidia and different sources of protein in total mixed ration (TMR) on the primal cuts, loin eye area, and fatty acids profile of goat meat. This study used twenty yearling Kacang goats weighing 17.42±1.63 kg. The goats were randomly allocated into 4 different treatments in a completely randomized design. The treatments involved the use of natural grass from rangeland (NGFR; control) as well as improving the quality of feed through TMR containing various ruminally undegraded protein sources, i.e. TMR contains fish meal (TMR-FM), TMR contains soybean meal (TMR-SBM) and TMR contains formaldehyde treated soybean meal (TMR-TSBM). The parameters observed were primal cuts yield, loin eye area, meat, fat, bone of primal cuts, and fatty acids profile. Data were analyzed using a one-way analysis of variance. The results showed that the goats fed TMR-FM and TMR-TSBM produced significantly higher meat percentage than control goats. The meat yield of TMR-SBM and TMR-TSBM goats were significantly higher than those of control goats. Goats fed TMR-SBM produced the highest primal cuts yield and shoulder weight, while the weight of rib, loin, and leg of TMR-SBM goats were similar to those of TMR-TSBM goats. Loin eye area was similar between the treatments. Saturated fatty acids content in TMR groups was similar to those in control. It can be concluded that improved feed quality using TMR-SBM produced significantly higher primal cuts weight, while TMR-TSBM had better meat-to-bone ratio than control. TMR-TSBM goats produced significantly leaner meat than TMR-SBM goats. Fatty acid profiles were similar between treatments.

Keywords: Fatty acids, Fish meal, Goat meat, Meat quality, Total mixed ration.

INTRODUCTION

Goats are widely raised traditionally by farmers in Indonesia. They are usulally kept in the yard and fed natural forages from the rangeland, so that they have low growth rate. Nevertheless, they produce high quality of meat (Slimeni et al., 2022) due to their high content of unsaturated fatty acids (Makmur et al., 2020). Goat meat is considered a healthier meat compared to other red meat products for its leaness (Slimeni et al., 2022; Gawat et al., 2023), and has a higher ratio of polyunsaturated fatty acids to saturated fatty acid (PUFA/SFA) when fed with forage-based diet (Lee et al., 2023). Lee et al. (2023) reported that dietary nutrient contents influence fatty acids composition of Korean native black goat meat, and forage-based diet increased PUFA to SFA ratio. To increase the goat production, Slimeni et al. (2022) added concentrate and hay for pasture grazing goats. Low production of goats kept extensively was caused by the scarcity of good quality forages, limited of herbaceous plants and the low quality of shrubs (Slimeni et al., 2022). Goats are selective eaters, preferring wild grass over soft grass (Lee et al., 2019) and showing a preference for woody plants (Chebli et al., 2022). Fish meal (FM) and soybean meal (SBM) are common protein sources in animal diet. Fish meal tends to be less degraded in the rumen than SBM (Falahatizow et al., 2015), but it is more expensive than SBM. Additionally, goats do not favor diets containing FM (Adiwinarti et al., 2016). Therefore, a better option is to use total mixed ration (TMR) for blending feed ingredients, ensuring that animals cannot selectively choose the feed based on their preference (Fluharty et al., 2017; Santana et al., 2017). Total mixed ration can be formulated based on the animals need. Santana et al. (2017) stated that TMR could maintain nutrient content in the ration. Protein in SBM is easily degraded in the rumen (Wang et al., 2021; Phesatcha et al., 2022) and provide about 65% of rumen-degradable protein (Phesatcha et al., 2022). In order to improve carcass weight, primal cuts and meat yield, protein in feed must be efficiently utilized by reducing rumen protein digestibility, so that post-rumen utilization of protein is more optimal. There have been many studies have been done to reduce the degradability of SBM in the rumen. Rooke et al. (1983) reported that degradability of formaldehyde-treated SBM was lower than that of untreated SBM. Widyobroto et al. (2010) stated that formaldehyde protected SBM increased rumen undegraded protein about 50-80%, but the formaldehyde protected SBM did not decrease the degradability in the small intestine. This study was set up to improve carcass weight, primal cuts yield, meat yield, and goat meat quality by enhanching the feed quality using TMR. Natural grass from rangeland (forage-based diet) was used as control to represent the common practice of goat rearing in the rural area, while improved feed quality involved TMR consisting of Napier grass, gliricidia, and concentrate with different protein sources (fish meal, SBM, and formaldehyde-treated SBM). The objectives of this study were to evaluate the carcass weight, primal cuts yield, meat yield, and meat

Citation: Adiwinarti R, Kustantinah, Rusman, Rianto E, Purnomoadi A, Arifin M, Sutaryo, and Restitrisnani V (2025). Primal cuts of carcass and meat characteristics of Kacang goat fed total mixed ration containing different sources of ruminally undegraded protein. *Online J. Anim. Feed Res.*, 15(1): 33-40. DOI: https://dx.doi.org/10.51227/ojafr.2025.5

quality of goats fed with forage-based diet compared to those fed with higher-quality feed (TMR containing different protein sources: fish meal, SBM, and formaldehyde-treated SBM).

MATERIALS AND METHODS

Animals, feeds, and experimental design

Twenty yearling Kacang goats with the initial body weight of 17.42±1.63 kg were reared 95 days before being slaughtered. The goats were randomly allocated into 4 different treatments using completely randomized design. The treatments were: 100% natural grass from rangeland (NGFR) as the control and 3 improved feed quality used total mixed ration consisted of 30% Napier grass, 30% gliricidia leaves, and 40% concentrate with different sources of protein, i.e. TMR containing fish meal (TMR-FM), TRM containing soybean (TMR-SBM) and TMR containing formaldehyde treated soybean meal (TMR-TSBM) (Table 1). A 1% of formaldehyde treated soybean meal was made by using formalin and it was formulated to contain 1% of formaldehyde that was used to treat SBM in dry matter bases calculation.

Animals care and management

In order to protect from internal and external parasites, all goats were treated orally with 1.5 mL/head of Valbendazol and injected by 0.5 mL/head of Intermectin. Goats were housed individually, provided feed and water *ad libitum* given at 8:00 AM, 12:00 PM, and 4:00 PM.

Table 1 - The composition of feed ingredients, chemical composition and Fatty acids composition (%) of the rations

Parameters	NGFR	TMR-FM	TMR-SBM	TMR-TSBM
Feed ingredients composition				
Natural grass from rangeland	100	-	-	-
Napier grass	-	30	30	30
Gliricidia leaves	-	30	30	30
Concentrate feed consisted of:	-	40	40	40
Cassava waste product		50.2	48.0	48.0
Wheat bran		34.4	34.5	34.5
Fish meal		15.4	0	0
Soybean meal		0	17.5	0
Formaldehyde treated soybean meal		0	0	17.5
Chemical composition				
Dry matter	18.6	91.3	91.5	91.4
Crude protein	10.9	15.3	15.6	14.3
Total digestible nutrients	63.2	56.2	58.0	60.1
Fatty acids composition				
Myristic acid (C14:0)	14.76	1.70	0.00	3.95
Palmitic acid (C16:0)	53.62	29.02	28.56	28.93
Stearic acid (C18:0)	12.54	11.97	9.34	10.62
Palmitoleic acid (C16:1)	0.00	0.64	0.00	0.57
Oleic acid (C18:1)	3.80	18.76	19.85	14.27
Linoleic acid (C18:2)	15.27	24.37	29.50	28.48
Linolenic acid (C18:3)	0.00	13.54	12.75	13.19
SFA (saturated fatty acids)	80.93	42.69	37.91	43.50
MUFA (mono unsaturated fatty acids)	3.80	19.40	19.85	14.84
PUFA (poly unsaturated fatty acids)	15.27	37.91	42.25	41.66
UFA (unsaturated fatty acids)	3.71	36.48	32.63	29.78

NGFR: natural grass from rangeland, TMR-FM: total mixed ration containing fish meal, TMR-SBM: total mixed ration containing soybean meal, TMR-TSBM: total mixed ration containing formaldehyde treated soybean meal

During the experimental period, two goats from the TMR-FM and TMR-TSBM groups became ill and died, resulting in only 18 goats being available for data collection. After a treatment periods of 95 days, the goats were deprived of feed and given only clean water for 12 hours. Subsequently, the goats were weighed and slaughtered. Goats were slaughtered to obtain carcass, which was then cooled at a temperature of 4°C for 12 hours before further carcass observation were conducted. Carcass were cut and the primal cuts (shoulder, rib, loin, leg) were dissected for meat, fat, and bone separation to observe weight and percentage of carcass composition (meat, fat, and bone). Loin eye areas were measured following the method of Rezende et al. (2020).

Sampling and sample analysis

Samples from *Biceps femoris* muscle were frozen before fatty acids analysis. Fatty acids composition was analyzed using Gas Chromatography-mass Spectrometry (Stashenko and Martinez, 2014).

Statistical analysis

Data were analyzed by a one-way analysis of variance using significance level based on $p<0.05$ (Steel and Torrie, 1980). If there was a significantly different between the treatments, Duncan's Multiple Range test was used for further analysis (Steel and Torrie, 1980).

Table 2 – Performance, carcass, and primal cuts characteristics of goats fed natural grass and total mixed ration

Parameters	NGFR	TMR-FM	TMR-SBM	TMR-TSBM	P-value
Performance					
Dry matter intake (g)	485.27[b]±58.31	620.71[ab]±47.54	740.24[a]±132.16	648.00[a]±106.29	0.007
Protein intake (g)	53.00[c]±6.37	94.72[b]±7.25	115.43[a]±20.61	92.40[b]±15.16	0.0001
Total digestible nutrients intake (g)	309.28[b]±42.89	349.55[ab]±40.33	438.19[a]±101.57	388.55[ab]±58.86	0.053
Average daily gain (g)	28.92[c]±7.05	57.56[b]±21.42	78.54[a]±10.23	56.19[b]±4.94	0.0001
feed conversion ratio	17.60[a]±4.67	12.52[ab]±6.35	9.45[b]±1.30	11.48[b]±1.11	0.035
Slaughter weight (kg)	20.04[c]±1.66	20.59[c]±1.72	25.09[a]±1.33	22.97[bc]±0.55	0.0001
Carcass weight (g)	7,174.80[c]±1,076.00	7,979.75[bc]±1,288.16	10,042.20[a]±1,021.03	8,882.75[ab]±703.26	0.005
Primal cuts (% carcass)	74.25±2.02	73.68±1.32	75.48±1.36	72.47±3.13	0.218
Primal cuts yield (g)	5,322.29[c]±770.19	5,868.42[bc]±863.04	7,573.89[a]±699.17	6,434.48[b]±541.31	0.002
Shoulder (g)	1,983.02[b]±323.04	2,271.63[b]±547.55	2,842.38[a]±252.23	2,314.69[b]±280.65	0.015
Rib (g)	553.98[b]±125.82	595.60[b]±57.94	850.42[a]±214.31	723.95[ab]±41.91	0.019
Loin (g)	636.04[b]±168.13	670.56[b]±89.49	925.54[a]±85.19	826.59[ab]±169.77	0.016
Leg (g)	2,149.26[b]±289.18	2,330.63[b]±227.17	2,955.55[a]±491.55	2,569.25[ab]±261.80	0.014
Primal cuts composition					
Meat (g)	3,758.10[c]±560.60	4,371.55[bc]±789.55	5,458.95[a]±445.56	4,815.94[ab]±384.64	0.002
Meat (%)	70.58[b]±1.24	74.21[a]±2.53	72.17[ab]±3.16	74.87[a]±0.51	0.039
Fat (g)	381.17[b]±133.70	322.29[b]±56.58	661.89[a]±186.73	420.71[b]±182.34	0.019
Fat (%)	7.06±2.00	5.59±1.29	8.72±2.33	6.47±2.38	0.182
Bone (g)	1,183.02±163.40	1,174.58±89.05	1,453.04±243.81	1,197.83±120.25	0.069
Bone (%)	22.36[a]±2.40	20.19[ab]±1.79	19.11[b]±1.70	18.67[b]±1.88	0.053
Edible portion (%)	77.64[b]±2.40	79.81[ab]±1.79	80.89[a]±1.70	81.33[a]±1.88	0.053
Meat-bone ratio	3.19[b]±0.36	3.70[ab]±0.44	3.81[ab]±0.46	4.04[a]±0.39	0.043
Meat+fat-bone ratio	3.51±0.47	3.98±0.44	4.27±0.46	4.40±0.55	0.058
Loin eye area (cm^2)	4.75±1.32	5.47±1.82	7.72±2.96	7.22±1.80	0.140

NGFR: natural grass from rangeland, TMR-FM: total mixed ration containing fish meal, TMR-SBM: total mixed ration containing soybean meal, TMR-TSBM: total mixed ration containing formaldehyde treated soybean meal

Citation: Adiwinarti R, Kustantinah, Rusman, Rianto E, Purnomoadi A, Arifin M, Sutaryo, and Restitrisnani V (2025). Primal cuts of carcass and meat characteristics of Kacang goat fed total mixed ration containing different sources of ruminally undegraded protein. *Online J. Anim. Feed Res.*, 15(1): 33-40. DOI: https://dx.doi.org/10.51227/ojafr.2025.5

Table 3 - Fatty acids concentration of goat meat

Parameters	NGFR	TMR-FM	TMR-SBM	TMR-TSBM	P-value	Average
SFA (%)	52.77±1.63	43.45±8.92	42.25±6.72	42.93±10.27	0.127	45.59
Myristic acid (%)	1.24±0.89	1.92±1.69	1.38±1.04	1.29±0.64	0.798	1.44
Palmitic acid (%)	21.43±1.72	19.12±5.45	17.59±3.21	21.87±3.36	0.259	19.95
Stearic acid (%)	30.10±1.29	22.40±2.25	23.28±5.19	19.77±13.34	0.176	24.20
MUFA (%)	46.07±2.09	49.40±11.89	57.06±6.76	56.34±10.80	0.169	52.15
Palmitoleic acid (%)	1.58±0.97	1.66±0.76	1.61±0.84	1.82±1.10	0.981	1.66
Oleic acid (%)	44.50±2.32	47.74±11.14	55.45±7.47	54.52±9.83	0.153	50.49
PUFA (%)	1.16±0.60	0.77±0.91	0.69±0.34	0.73±0.55	0.602	0.85
Linolenic acid (%)	0.16±0.35	0.44±0.75	0.19±0.21	0	0.521	0.17
Arachidonic acid (%)	1.00±0.52	0.33±0.29	0.51±0.16	0.73±0.55	0.167	1.44
UFA (MUFA+PUFA) (%)	47.23±1.63	56.55±8.92	57.75±6.72	57.07±10.27	0.127	54.41
MUFA/SFA	0.88±0.07	1.19±0.45	1.41±0.45	1.43±0.68	0.235	1.22
PUFA/SFA	0.02±0.01	0.02±0.03	0.02±0.01	0.02±0.01	0.856	0.02

NGFR: natural grass from rangeland; TMR-FM: total mixed ration containing fish meal; TMR-SBM: total mixed ration containing soybean meal; TMR-TSBM: total mixed ration containing formaldehyde treated soybean meal; SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; UFA: unsaturated fatty acids.

RESULTS

After being raised for 95 days, the performance of the goats including feed intake, growth rate, and feed conversion ratio are presented in the Table 2. Those parameters were significantly different between the treatments ($P<0.05$). The slaughter weights of the goats were significantly different between the treatments ($P<0.01$). Carcass weights and primal cuts yield also showed significant differences between the treatments ($P<0.01$) (Table 2). In fact, the primal cut percentages were similar across all treatments. Additionally, there were significant differences in the meat-to-bone ratio of primal cuts between the treatments ($P<0.05$). The fatty acids composition (%) of the rations is presented in the Table 1. The main fatty acids identified in goat meat in this study included myristic acid, palmitic acid, stearic acid, palmitoleic acid, oleic acid, linolenic acid, and arachidonic acid. Myristic acid, palmitic acid, stearic acid are grouped into saturated fatty acids (SFA), while palmitoleic acid and oleic acid belong to the category of mono-unsaturated fatty acids (MUFA), and linolenic acid and arachidonic acid are poly-unsaturated fatty acids (PUFA). There were no significant differences observed in the fatty acids content between the treatments (Table 3).

DISCUSSION

Productivity of goats fed natural grass and total mixed ration

Carcass weight of goats fed TMR containing SBM and TSBM were higher than those of control goats (NGFR) (Table 2). The higher carcass weight because of their average daily gain were higher than those of control goats. In addition, the faster growth of TMR goats was caused by the more dry matter and protein intake (Table 2).

Primal cuts were used as a parameter of goat production in this study because they represent about 74.07±2.16% of the total carcass. Primal cuts consisted of shoulder, rib, loin, and leg (Rezende et al., 2020). Total primal cuts yield (g) and shoulder (g) of TMR-SBM were higher than other treatments, while the weight of rib, loin, and leg (g) of TMR-SBM were similar to those of TMR-TSBM. This indicated that improved feed quality using TMR-SBM and TMR-TSBM produced higher product than control.

Goats in TMR-SBM and TMR-TSBM produced more primal cuts meat compared to control. In fact, the meat percentage of TMR-TSBM and TMR-FM was higher than those of control (Table 2). Goats from TMR-SBM and TMR-TSBM had bone percentage that was lower than control. In addition, the meat-to-bone ratio and the percentage of edible portion in TMR-TSBM were higher compared to the control group. However, the fat content in TMR-SBM was the highest ($p<0.05$) compared to the other treatments. These findings suggest that goats fed TMR produced better product than those in the control group, particularly when TMR containing SBM and TSBM. The meat from TMR-TSBM goats also appeared leaner compared to the meat from the TMR-SBM goats. Bambou et al. (2021) stated that diet is one of the factors influencing meat production. Goats fed with TMR-TSBM might increase the bypass protein level, thereby enhancing meat production. Rooke et al. (1983) reported that the degradation rate of formaldehyde-treated SBM decreased from 0.90 (untreated SBM) to 0.40 (formaldehyde-treated SBM). Widyobroto et al. (2010) stated that formaldehyde protected SBM can increase rumen undegraded protein by about 50-80%. However, it is essential to note that formaldehyde treatment did not reduce the protein degradation ability in the small intestine. Therefore, undegraded rumen protein can be efficiently utilized to enhance meat production. Additionally, tannin in gliricidia might reduce the digestibility of dry matter, organic matter, and crude protein as reported by Aguerre et al. (2016). Adiwinarti et al. (2019) reported that retained protein to meat conversion ratio of goat fed ration containing 50% untreated SBM+50% formaldehyde treated SBM is better than those of goats fed a diet containing untreated SBM or those of goats fed a diet containing treated SBM.

The meat content (%) in this study was relatively similar to the findings of Bambou et al. (2021), who reported values ranging from approximately 69.1% to 75.1%. The meat-to-bone ratio of primal cuts in TMR goats was higher compared to the meat-to-bone ratio reported by Cruz et al. (2023), which ranged between 3.08 to 3.28. However, Bambou et al. (2021) reported that the muscle-to-bone ratio in the left shoulder is between 2.8 and 4.2.

Loin eye area of goats was relatively similar between the treatments. Loin eye area of NGFR (4.75 cm^2) and TMR-FM (5.47 cm^2) were smaller than those reported by Cruz et al. (2023), but those of TMR-SBM (7.72 cm^2) and TMR-TSBM (7.22 cm^2) were relatively similar. Some researchers reported that loin eye areas are 7.35-8.00 cm^2 in goat having 21.8 to 23.4 kg of body weight (Cruz et al., 2023), 8.51-9.36 cm^2 in growing period and 12.81-13.01 cm^2 in fattening period of Nubian goats (Chen et al., 2022), 13.91-15.12 cm^2 in goat with body weight of 44.9 to 48.4 kg (Kafle et al., 2021).

Fatty acids of goats fed natural grass and total mixed ration

The main SFA of goat meat in this study consisted of stearic and palmitic acid, while the main UFA was oleic acid. Previous studies also reported that the dominant fatty acids in goat meat are palmitic acids, stearic acids, and oleic acids (Kafle et al., 2021; Akbas et al., 2022), along with linoleic acid and arachidonic acids (Kim et al., 2019). According to Kafle et al. (2021), palmitic acids, stearic acids, and oleic acids contribute approximately 80-85% of the total fatty acids.

In this study, goat meat had a higher content of SFA and MUFA compared to PUFA, aligning with the findings reported by Dinh et al. (2021). The high presence of SFA in ruminants was attributed to the biohydrogenation process in their

Citation: Adiwinarti R, Kustantinah, Rusman, Rianto E, Purnomoadi A, Arifin M, Sutaryo, and Restitrisnani V (2025). Primal cuts of carcass and meat characteristics of Kacang goat fed total mixed ration containing different sources of ruminally undegraded protein. *Online J. Anim. Feed Res.*, 15(1): 33-40. DOI: https://dx.doi.org/10.51227/ojafr.2025.5

rumens. Slimeni et al. (2022) also reported that extensively raised goats had a higher proportion of SFA, while semi-intensively raised goats produced more MUFA in goat meat.

The SFA content in goat meat from the goats in control group was relatively similar to that in the TMR group (Table 3), although the SFA content in natural grass from rangeland (control) was higher than those in TMR diets (Table 1). The average SFA content in TMR goat meat was 42.83% that was lower than the findings in Bambou et al. (2021) or Slimeni et al. (2022), but comparable to Lee et al. (2023) and higher than in Akbas et al. (2022). Slimeni et al. (2022) reported that extensively raised goat had 50.3% SFA, while semi intensively raised goat had 44.6% SFA. Bambou et al. (2021) reported SFA content in Creole goat meat ranging from about 42.8% to 52.6%. Lee et al. (2023) reported an SFA concentration of 42.48%, while Akbas et al. (2022) reported around 38.9%. Akbas et al. (2022) stated that low concentration of lauric acids, miristic acids, palmitic acids, and stearic acids indicated better meat quality. The concentration of UFA in the TMR group was relatively similar to those reported by García et al. (2019) and Lee et al (2023). The MUFA concentration in this study was higher compared to the findings reported by García et al. (2019): 42.9%, Akbas et al. (2022): 43.53%, and Lee et al. (2023): 36.27%. Meanwhile, the concentration of PUFA was lower compared to the results of García et al. (2019), Akbas et al. (2022), and Lee et al. (2023). Akbas et al. (2022) reported a PUFA content of 14.85%, Lee et al. (2023) reported 21.25%, García et al. (2019) reported 6.57%.

In this study PUFA/SFA ratio of forage diet (NGFR) was similar to other treatments. However, Lee et al. (2023) mentioned that different diets can influence the fatty acid composition of native Korean black goats meat, and a forage-based diet can enhance the PUFA/SFA ratio. The PUFA/SFA ratio in this study was lower compared to other researchers (0.08 reported by Guzmàn et al. (2020) and between 0.1 to 0.15 reported by García et al. (2019).

The ratio of MUFA to SFA between treatments did not show significant differences. The MUFA/SFA ratio in goats fed with TMR (1.19 to 1.43) was higher compared to the findings of García et al. (2019), Guzmàn et al. (2020) and Akbas et al. (2022) who reported MUFA/SFA ratios ranging from 0.32 to 0.83 (Guzmàn et al., 2020), 0.81 to 0.92 (García et al., 2019), and 1.07 to 1.15 (Akbas et al., 2022).

CONCLUSION

In conclusion, improving feed quality by using TMR-SBM (total mixed ration containing soybean meal) resulted in higher primal cuts weight, while TMR-TSBM (total mixed ration containing formaldehyde treated soybean meal) displayed a better meat-to-bone ratio compared to the control. Goats fed with TMR-TSBM produced leaner meat compared to those fed with TMR-SBM. The fatty acid profiles were similar between the treatments.

DECLARATIONS

Corresponding author

Correspondence and requests for materials should be addressed to Retno ADIWINARTI; E-mails: retno_adi@yahoo.co.id; retnoadiwinarti@lecturer.undip.ac.id; ORCID: 0000-0003-0638-4220

Ethical considerations

This experiment procedures related to the use of animals have been approved by the committee of animal ethics in the Animal and Agricultural Science, Universitas Diponegoro (59-04/A-08/KEP-FPP) and the authors have complied with the ARRIVE guidelines.

Acknowledgements

The authors are gratefully thanks to Prof. Ir. I Gede S. Budisatria, M.Sc., Ph.D. (RIP) for supervising the research, “Kacang goat” team and Meat Science Laboratory assistants for helping the data collection.

Authors’ contribution

R.Adiwinarti designed the research, supervised the fieldwork, analyzed the data, prepared and wrote the manuscript.
Kustantinah and Rusman participated in designing the research, reviewed and edited the manuscript.
E.Rianto and A.Purnomoadi participated in supervising the fieldwork, reviewed and edited the manuscript.
M.Arifin and Sutaryo contributed to review and edit the manuscript.
V.Restitrisnani supervised the fieldwork and lab work.
All authors have read and approved the final manuscript.

Competing interests

There are no competing interests regarding the publication of this article.

REFERENCES

Adiwinarti R, Kustantinah, Budisatria IGS, Rusman and Indarto E (2016). Improving the performance of local Kacang goats using ruminally undegradable protein feeds. Asian Journal of Animal Science, 10(4): 262-267. https://doi.org/10.3923/ajas.2016.262.267

Adiwinarti R, Budisatria IGS, Kustantinah K, Rusman R and Indarto E (2019). Effects of rations containing formaldehyde-protected soybean meal on meat production in Kacang goats. Veterinary World, 12(6):890-895. https://doi.org/10.14202/vetworld.2019.890-895

Aguerre MJ, Capozzolo MC, Lencioni P, Cabral C and Wattiaux MA (2016). Effect of quebracho-chestnut tannin extracts at 2 dietary crude protein levels on performance, rumen fermentation, and nitrogen partitioning in dairy cows. Journal of Dairy Science, 99:4476-4486. http://dx.doi.org/10.3168/jds.2015-10745

Akbas AA, Kuleasan Ş, Üstuner H, Elmaz O, Sari M and Saatci M (2022). Some meat quality traits and fatty acid composition of Saanen, Turkish Hair × Saanen (F1) and Honamlı × Saanen (F1) crossbreed kids in tropical region of Turkey. Research Square. https://doi.org/10.21203/rs.3.rs-1834997/v1

Bambou J-C, Cériac S, Liméa L, Arquet R, Bocage B and Alexandre G (2021). Impact of diet supplementation and age at slaughter on carcass characteristics of creole goats. Frontiers in Veterinary Science, 8, 671948. https://doi.org/10.3389/fvets.2021.671948

Chebli Y, El Otmani S, Hornick J-L, Keli A, Bindelle J, Cabaraux J-F and Chentouf M (2022). Forage availability and quality, and feeding behaviour of indigenous goats grazing in a Mediterranean Silvopastoral system. Ruminants. 2:74–89. https://doi.org/10.3390/ruminants2010004

Chen Y-A, Chen J-Y, Chen W-Q, Wang W-Y and Wu H-H (2022). Effects of castration age on the growth performance of Nubian crossbred male goats. Animals, 12:3516. https://doi.org/10.3390/ani12243516

Cruz GFL, Santos EM, Araújo GGL, Azevedo PS, de Albuquerque ÍRR, Panosso NM, Perazzo AF, Zanine AM, Ferreira DJ, Lima AGVO and Oliveira JS (2023). Carcass traits and meat quality of goats fed with cactus pear (*Opuntia ficus*-*indica* Mill) silage subjected to an intermittent water supply. Scientific Reports, 13: 855. https://doi.org/10.1038/s41598-022-25923-7

Dinh TTN, To KV and Schilling MW (2021). Fatty acid composition of meat animals as flavor precursors. Meat and Muscle Biology, 5(1):34. https://doi.org/10.22175/mmb.12251

Falahatizow J, Danesh Mesgaran M, Vakili AR, Tahmasbi AM and Nazari MR (2015). The estimation of ruminal protein degradation parameters of various feeds using in vitro modified gas production technique. Iranian Journal of Veterinary Research, 16(1):47-52. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4789239/pdf/ijvr-16-047.pdf

Fluharty FL, Zerby HN, Lowe GD, Clevenger DD and Relling AE (2017). Effects of feeding corn silage, pelleted, ensiled, or pelleted and ensiled alfalfa on growth and carcass characteristics of lamb. South African Journal of Animal Science, 47(5):704-711. http://dx.doi.org/10.4314/sajas.v47i5.14

García EM, López A, Zimerman M, Hernández O, Arroquy JI and Nazareno MA (2019). Enhanced oxidative stability of meat by including tannin-rich leaves of woody plants in goat diet. Asian-Australasian Journal of Animal Sciences, 32(9):1439-1447. https://doi.org/10.5713/ajas.18.0537

Gawat M, Boland M, Singh J and Kaur L (2023). Goat meat: production and quality attributes. Foods, 12:3130. https://doi.org/10.3390/foods12163130

Guzmàn JL, Delgado-Pertíñez M, Beriáin MJ, Pino R, Zarazaga LA and Horcada A (2020). The use of concentrates rich in orange by-products in goat feed and its effects on physico-chemical, textural, fatty acids, volatile compounds and sensory characteristics of the meat of suckling kids. Animals, 10:766. https://doi.org/10.3390/ani10050766

Kafle D, Lee JH, Min BR and Kouakou B (2021). Carcass and meat quality of goats supplemented with tannin-rich peanut skin. Journal of Agriculture and Food Research, 5:100159. https://doi.org/10.1016/j.jafr.2021.100159

Kim H-J, Kim H-J and Jang A (2019). Nutritional and antioxidative properties of black goat meat cuts. Asian-Australasian Journal of Animal Sciences, 32(9):1423-1429. https://doi.org/10.5713/ajas.18.0951

Lee S-H, Lee J, Chowdhury MMR, Jeon D, Lee S-S, Kim S, Kim D H and Kim K-W (2019). Grazing Behavior and Forage Selection of Goats (*Capra hircus*). Journal of the Korean Society of Grassland and Forage Science, 39(3):189-194. https://doi.org/10.5333/KGFS.2019.39.3.189

Lee J, Kim H-J, Lee S-S, Kim K-W, Kim D-K, Lee S-H, et al. (2023). Effects of diet and castration on fatty acid composition and volatile compounds in the meat of Korean native black goats. Animal Bioscience, 36(6):962-972. https://doi.org/10.5713/ab.22.0378

Makmur M, Zain M, Marlinda Y, Khasrad K and Jayanegara A (2020). *In vitro* ruminal biohydrogenation of C18 fatty acids in mixtures of *Indigofera zollingeriana* and *Brachiaria decumbens*. Journal of the Indonesian Tropical Animal Agriculture, 45(2):124-135. https://doi.org/10.14710/jitaa.45.2.124-135

Phesatcha K, Phesatcha B and Wanapat M (2022). Mangosteen peel liquid-protected soybean meal can shift rumen microbiome and rumen fermentation end-products in lactating crossbred Holstein Friesian cows. Frontiers in Veterinary Science, 8:772043. https://doi.org/10.3389/fvets.2021.772043

Rezende MPG, Figueiredo GC, Araujo JIM, Campos BM, Moretti R, Bozzi R, Malhado CHM, de Souza Jr AAO and Carneiro PLS (2020). Growth curve, carcass traits and kleiber ratio of Dorper crossbreed with hairless native Brazilian sheep breeds. Small Ruminant Research, 192(2020):106190. https://doi.org/10.1016/j.smallrumres.2020.106190

Rooke J, Brookes I and Armstrong D (1983). The digestion of untreated and formaldehyde-treated soya-bean and rapeseed meals by cattle fed a basal silage diet. The Journal of Agricultural Science, 100(2):329-342. https://doi.org/10.1017/S0021859600033487

Santana A, Cajarville C, Mendoza A and Repetto JL (2017). Combination of legume-based herbage and total mixed ration (TMR) maintains intake and nutrient utilization of TMR and improves nitrogen utilization of herbage in heifers. Animal, 11(4):616-624. https://doi.org/10.1017/S1751731116001956

Slimeni O, Hajji H, Mekki I, Smeti S, Mahouachi M, Saidani F, et al. (2022). Is it possible to increase goat meat production under Mediterranean forest conditions using small amounts of concentrate without deterioration of its quality? Animal Science Papers and Reports, 40(3):335-350. Institute of Genetics and Animal Biotechnology of the Polish Academy of Sciences, Jastrzębiec, Poland. https://www.igbzpan.pl/uploaded/FSiBundleContentBlockBundleModelTranslatableBlockTranslatableFilesElement/filePath/2206/str335-350.pdf

Stashenko E and Martínez JR (2014). Gas Chromatography - Mass Spectrometry. Available at: https://www.intechopen.com/chapters/46209

Steel RGD and Torrie JH (1980). Principles and Procedures of Statistics. McGraw-Hill Book Co. Inc. New York.

Wang Z, Yu Y, Li X, Xiao H, Zhang P, Shen W, Wan F, He J, Tang S, Tan Z, Wu D and Yao H (2021). Fermented soybean meal replacement in the diet of lactating Holstein dairy cows: modulated rumen fermentation and ruminal microflora. Frontiers in Microbiology, 12:625857. https://doi.org/10.3389/fmicb.2021.625857 .

Widyobroto BP, Budhi SPS and Agus A (2010). Effect of protein undegraded supplementation on production and composition of milk in dairy cows. Journal of the Indonesian Tropical Animal Agriculture, 35 (1): 27 - 33. DOI: https://doi.org/10.14710/jitaa.35.1.27-33