Research Article

Effects of Fish Meal and Soluble Carbohydrate Supplementation in Complete Silage on the Performance of Fattened Kacang Goats

Paulus Klau Tahuk*, Marselinus Banu, Yuliana Kolo

Departement of Animal Science, Faculty of Agriculture, Science and Health, University of Timor.

Abstract | The study aimed to determine the impact of fish meal and soluble carbohydrates supplementation in complete silage on the performance of young male Kacang goats. The study was conducted in Kefamenanu Selatan, Timor Tengah Utara, East Nusa Tenggara, Indonesia from May to November 2024. The study used 15 young male Kacang goats aged 12–18 months, with initial body weights ranging from 12.7 to 13 kg (average 13.206 ± 0.577 kg). The treatment feed was complete silage supplemented with fish meal and soluble carbohydrates. A completely randomized design (CRD) was used with three ration treatments and five replications: T1 (45% complete silage + 50% soluble carbohydrates + 5% fish meal), T2 (45% complete silage + 45% soluble carbohydrates + 10% fish meal), and T3 (45% complete silage + 40% soluble carbohydrates + 15% fish meal). Data were analyzed using ANOVA. Results showed that dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), carbohydrate (CHO), nitrogen free extract (NFE) and energy intake in T3 were significantly higher ($P<0.05$) than in T1 and T2. The digestibility of OM, CP, and CF was also significantly higher in T3 ($P<0.05$), while DM, CHO, NFE, and energy digestibility did not differ significantly among treatments. Daily weight gain in T3 was significantly higher ($P<0.05$) than in T1 and T2, although feed conversion ratio and feed efficiency were relatively similar across treatments. It can be concluded that increasing levels of fish meal and soluble carbohydrates in complete silage diets improves feed intake, nutrient digestibility, and growth performance of young Male Kacang goats during the fattening phase.

Keywords | Complete silage, Fish meal, Intake, Digestibility, Performance, Kacang goat, Soluble carbohydrate, Supplementation

Received | April 30, 2025; **Accepted** | July 06, 2025; **Published** | November 07, 2025
***Correspondence** | Paulus Klau Tahuk, Program Departement of Animal Science, Faculty of Agriculture, Science and Health, University of Timor; **Email:** paulklau@yahoo.co.id
Citation | Tahuk PK, Banu M, Kolo Y (2025). Effects of fish meal and soluble carbohydrate supplementation in complete silage on the performance of fattened Kacang goats. J. Anim. Health Prod. 13(4): 1176-1187.
DOI | https://dx.doi.org/10.17582/journal.jahp/2025/13.4.1176.1187
ISSN (Online) | 2308-2801

INTRODUCTION

Feed is the largest component of livestock that affects goat productivity, in addition to management factors and livestock genetics. Therefore, the feed factor is the focus of farmers' attention when improving the performance of their fattened goats. According to various research reports, adequate feed quality, both forage and concentrate, is the key to success in raising livestock because it can spur growth, which in turn can increase carcass production and meat quality of goats (Hardcastle and Lear, 2020; Hess and Griffler, 2022).

Despite determining the performance of livestock, the availability of feed in the tropics is a limiting factor in the maintenance of goats. The reality faced by farmers in the field is the high fluctuation of feed between the rainy and dry seasons (Ruvuga, 2016). During the rainy season, forage availability is abundant, which has a positive impact on increasing livestock performance. Conversely, during the dry season, forage is limited in availability. As a result, there are not enough nutrients to meet the needs

of livestock, which is indicated by low/negative livestock growth (Tahuk and Dethan, 2010).

To anticipate the problem of feed limitation, one solution is the development of feed preservation technology through the manufacture of complete silage. Complete feed silage is one of the solutions that can be taken to meet the needs of livestock. Apart from its complete nutritional content to meet the needs of livestock, complete silage is also a feed technology that can be taken to overcome the scarcity of feed during the dry season (Tahuk *et al*., 2021).

According to various sources, the prospect of using the complete feed in goats is quite promising both in terms of metabolic aspects and in terms of potential and optimization of the utilization of feed resources based on agricultural and agro-industrial residues. This is because metabolically, the energy needs and capacity of the digestive organs of goats require a type of feed with a high concentration of nutrients as characteristic of complete feed (Ginting, 2009).

According to the report of Tahuk *et al*. (2021), the application of complete silage made from natural grass, *Sorghum bicolor* (L.) Moench, and *Pennisetum purpupoides* on Kacang goats fattened has not shown maximum results; the daily body weight gain (ADG) (g/head/day) produced was 14.71 ± 2.91; 44.19 ± 26.50; and 20.98 ± 11.69, respectively; with feed conversion of 37.79 ± 12.33; 18.45 ± 9.88; and 53.38 ± 59.76, respectively. Meanwhile, the percentage of carcass produced ranged from 32-36% (Tahuk and Bira, 2020). This data shows that although complete silage technology can provide a solution to overcoming feed shortages in the dry season; however, it has not maximally supported the performance of goats when only given as a single feed. The lack of performance of goats is thought to be caused by the degradation of nutrients in the ensilage process which has an impact on the low nutrients that can be utilized by livestock to improve their performance (Campbell *et al*., 2020)

Therefore, the application of complete silage in goat rearing needs to be supplemented with feed sources of protein and easily digestible carbohydrates to maximize animal performance. This study aims to determine the impact of protein supplementation and easily digestible carbohydrates on the productivity of Kacang goats.

MATERIALS AND METHODS

Location and time of research

The research was conducted in Kefamenanu Selatan Urban Village, Kefamenanu City Sub-District, Timor Tengah Utara Regency, East Nusa Tenggara Province, Indonesia. The implementation time was from May to October 2024 with the stages of implementation including preparation, data collection, analysis, and reporting. Analysis of feed samples and feces samples was carried out at the Feed Chemistry Laboratory, Faculty of Animal Husbandry, Fisheries and Marine Sciences, Nusa Cendana University, Kupang.

Research material

The livestock used in this study were 15 young male Kacang goats 12-18 months according to the change of fixed incisor teeth. The initial body weight of the animals used was 12.7-3.5 kg with an average of 13.206 ± 0.577 kg.

The feed used in this study was complete silage composed of *Pennisetum purpuphoides*, *Gliricidia sepium* leaves bran pollard, and palm sugar. The ration was prepared based on the needs of young goats with a body weight of 10 kg (Kearl, 1982). The expected daily body weight gain (ADG) was 75 g/head/day. Feed ingredients used for supplementation included fish meal as a protein source; while feed sources of easily digestible carbohydrates consisted of ground corn, rice bran, and bran pollard. The animals were also given a mineral premix to avoid mineral deficiencies. The composition of the complete silage, as well as the concentrate used for supplementation (DM basis) are listed in Tables 1 and 2. While the composition of ration is outlined in Table 3.

The cages used were individual cages of 15 plots with a size of 70 x 150 cm equipped with separate feed and drinking water containers. In addition, roug weight digital livestock scales with a sensitivity of 0.1 kg to weigh goats, feed scales with a capacity of 2 kg with a sensitivity of 10 g, feces, and urine collection equipment, machetes, knives, concentrate buckets, Wiley mill milling machine with a sieve diameter of 1 mm to grind feed and feces samples and one unit of proximate analysis equipment.

The chemicals used in this study were 10% H_2SO_4 solution to bind N in urine and 10% formalin solution to spray the feces to avoid decomposition and changes in fecal nutrients during the drying process.

Experimental design

The study used a completely randomized design (CRD), with 3 groups of ration treatments. There were 15 Kacang goats used, and each treatment consisted of 5 goats. The treatment arrangement given to the goats was as follows:

- T1: 45% complete silage + 50% soluble carbohydrates + 5% fish meal.
- T2: 45% complete silage + 45% soluble carbohydrates + 10% fish meal
- T3: 45% complete silage + 40% soluble carbohydrates + 15% fish meal.

Table 1: Nutrient content of feed ingredients used in the research.

Nutrient content of feed ingredients	Feed ingredients				
	Complete silage*	Ground corn**	Bran pollard**	Rice bran*	Fish meal*
Dry matter (DM,%)	93.575	88.001	86.595	91.169	92.116
Ash (%)	9.851	1.678	0.855	16.732	18.142
Organic matter (OM,%)	90.149	98.322	99.145	83.268	81.858
Crude protein (CP,%)	11.047	10.428	16.457	10.051	53.166
Crude fat/(ether extract (EE,%)	6.078	6.934	3.344	7.863	6.516
Crude fiber (CF,%)	26.342	1.894	8.461	18.324	3.797
Carbohydrate (CHO,%)	73.024	80.960	79.345	65.354	22.176
NFE (%)	55.667	79.066	70.884	47.031	18.379
GE:-(MJ/kg.DM)	17.384	18.899	18.856	16.425	18.945
-(Kcal/kg.DM)	4139.110	4499.810	4489.530	3910.680	4510.790
EM (Kcal/kg.DM)	3319.360	4347.090	3927.190	2788.120	3166.680

Note: *,** Analysis results of Feed Chemistry Laboratory, Faculty of Animal Husbandry, Fisheries and Marine, Nusa Cendana University (2024, 2023); NFE: nitrogen-free extract, GE: Gross energy; EM: Metabolic energy.

Table 2: Nutrient content of concentrates used in the research*.

Nutrient composition of concentrate	Treatment		
	T1	T2	T3
Dry matter (DM,%)	89.300	90.147	89.904
Ash (%)	7.041	8.320	8.815
Organic matter (OM,%)	92.959	91.680	91.185
Crude protein (CP,%)	12.440	11.952	11.520
Crude fat/ether extract (EE,%)	5.997	6.678	6.631
Crude fiber (CF,%)	10.526	12.711	13.702
Carbohydrate (CHO,%)	74.522	73.050	73.033
NFE (%)	63.996	60.339	59.331
GE:-(MJ/kg.DM)	17.953	17.813	17.689
-(Kcal/kg.DM)	4274.580	4241.140	4211.720
EM (Kcal/kg.DM)	3347.310	3251.600	3194.400

Note: *Analysis results of Feed Chemistry Laboratory, Faculty of Animal Husbandry, Animal Husbandry and Marine, Nusa Cendana University (2024); NFE: Nitrogen free extract, GE: Gross energy; EM: Metabolic energy.

Preparation of complete silage

The *Pennisetum purpuphoides* was harvested during the pre-flowering period and fresh *Gliricidia sepium* leaves were chopped. Both forages that have been chopped are then spread on a tarpaulin. Additive material in the form of bran pollard is then sprinkled evenly over the chopped forage (*Pennisetum purpuphoides* and *Gliricidia sepium* leaves). Stir the chopped forage of *Pennisetum purpuphoides* and *Gliricidia sepium* leaves with additives until evenly mixed. The homogeneous mixture of feed and additives is then gradually entered into the silo fermentor (plastic drum), dripped with palm sugar solution as a source of soluble carbohydrates, and compacted to remove as much oxygen as possible. Silos (plastic drums) that have been filled with silage are stored (ensilage) in the room at room temperature for 21 days before being given to goats.

Feeding trial and data collection

Goats were adapted to complete silage and concentrate for 14 days (2 weeks) before data collection. The purpose of the adaptation stage was to obtain a stable body condition of the goats during the study; as well as to eliminate the effects of the previous feed. To avoid goats infected with skin diseases such as scabies and internal parasites such as worms, Wormectin was given at a dose of 0.5 ml/25 kg BW subcutaneously. In addition, goats are also given intramuscular injections of vitamin B Complex at a dose of 0.5 ml/10 kg BW to maintain endurance and increase appetite. The goats were fed twice a day at 8:00 am and 4:00 pm local time. Drinking water was given ad libitum during the study.

The study ran for 90 days including the complete silage preparation, adjustment, and data collection phases. Feeding was adjusted to the body weight of the goats. The collection of research data was carried out for 3 (three) months according to the length of the research time. Observation of the physical and chemical quality of complete silage was carried out after 21 days of the fermentation process in the silo. Observation of physical and chemical quality is to prove that the fermented silage meets the requirements of quality silage.

The feed given was weighed and recorded, as well as the remaining feed to determine the amount of feed consumption. The nutrient composition of the complete silage was determined by taking 500 g of feed samples, sun-dried to constant weight, and ground with a Willey mill with a 1 mm sieve hole to be analyzed for nutrient content in the laboratory.

Table 3: Ration composition of the study.

Feed ingredients	Proportion utilisation of feed (kg, DM)	Dry matter (%)	Organic matter (%)	Crude protein (%)	Extract ether (%)	Ash (%)	Crude fiber (%)	NFE (%)	CHO (%)	TDN (%)	GE (MJ/kg.DM	GE (Mcal/kg)	ME (Mcal/kg.DM)
Ration of T1 treatment													
Complete silage	45.00	29.36	40.57	4.97	0.27	4.43	7.81	25.05	32.86	35.76	7.82	1862.60	1493.71
Fish meal	5.00	91.03	3.51	2.78	0.04	1.49	0.24	0.03	0.28	3.23	0.88	208.31	147.95
Ground maize	25.00	88.00	21.36	2.61	0.17	3.64	0.47	19.77	20.24	20.07	4.72	1124.95	1086.77
Bran pollard	15.00	86.60	12.45	2.47	0.05	2.55	1.27	10.63	11.90	12.60	2.83	673.43	589.08
Rice bran	10.00	90.26	7.31	1.00	0.03	2.69	2.85	4.40	7.25	6.21	1.61	341.75	256.21
Total	100.00		85.20	13.83	0.57	14.80	12.65	59.88	72.53	77.88	17.86	4211.04	3573.72
Ration of T2 treatment													
Complete silage	45.00	29.36	40.57	4.97	2.74	4.43	7.81	25.05	32.86	35.76	7.82	1862.60	1493.71
Fish meal	10.00	91.03	7.02	5.57	0.89	2.99	0.49	0.07	0.56	6.47	1.75	416.62	295.89
Ground maize	25.00	88.00	21.36	2.61	1.73	3.64	0.47	19.77	20.24	20.07	4.72	1124.95	1086.77
Bran pollard	10.00	86.60	8.30	1.65	0.33	1.70	0.85	7.09	7.93	8.40	1.89	448.95	392.72
Rice bran	10.00	90.26	7.31	1.00	0.34	2.69	2.85	4.40	7.25	6.21	1.61	341.75	256.21
Total	100.00	-	84.55	15.79	6.04	15.45	12.47	56.37	68.84	76.91	17.79	4194.87	3525.31
Ration of T3 treatment													
Complete silage	45.00	29.36	40.57	4.97	2.74	4.43	7.81	25.05	32.86	35.76	7.82	1862.60	1493.71
Fish meal	15.00	91.03	10.52	8.35	1.34	4.48	0.73	0.10	0.83	9.70	2.63	624.93	443.84
Ground maize	25.00	88.00	21.36	2.61	1.73	3.64	0.47	19.77	20.24	20.07	4.72	1124.95	1086.77
Bran pollard	10.00	86.60	8.30	1.65	0.33	1.70	0.85	7.09	7.93	8.40	1.89	448.95	392.72
Rice bran	5.00	90.26	3.66	0.50	0.17	1.34	1.42	2.20	3.62	3.11	0.81	170.87	196.36
Total	100.00	-	84.41	18.07	6.31	15.59	11.29	54.20	65.49	77.04	17.86	4232.31	3613.40

Note: NFE= Nitrogen free extract; CHO = Carbohydrates; TDN= Total digestible nutrients; GE = Gross energy; ME= Metabolic energy

Collection of feces from each goat was done by total collection for 10 days to determine the feed digestibility value (Harris, 1970). Prior to fecal collection, goats were placed in metabolic cages equipped with different feed and drink containers, which had been equipped with fecal and urine collection devices. Every day feces were collected and weighed fresh weight, then a 20% sample was taken, and sprayed with 10% formalin solution to avoid fecal decomposition and loss of fecal N. The collected feces were then sun-dried to a constant weight. For chemical analysis, dried goat feces collected for 10 days were mixed evenly, taken as much as 20%, ground with a 1 mm diameter Willey mill, and taken to the laboratory for proximate analysis.

Weighing of animals to obtain body weight was done per individual goat at the beginning of the study. Subsequent weighing was carried out every week to adjust the amount of feed given, in addition to obtaining daily body weight gain and growth patterns of goats.

Analytical procedures

Feed intake measured included consumption of dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), nitrogen free extract (NFE), carbohydrate (CHO), and energy. The DM intake of feed was calculated by separating the amount of feed given from the remaining feed intake and then multiplying by the DM content of the feed. The OM, CP, CF, NFE, and CHO intake were calculated by multiplying DM intake by the nutrient content (%) of each nutrient.

Feed nutrient digestibility was calculated by separating feed nutrient intake (DM, OM, CP, CF, CHO, NFE and energy) from fecal nutrient content (DM, OM, CP, CF, CHO, NFE, and energy). The equation is:

$$\text{DM digestibility/DMD (g)} = \text{DM intake (g)} - \text{DM of feces (g)}$$

$$\text{DM digestibility (\%)} = \frac{\text{DM Digested (g)}}{\text{DM intake (g)}} \times 100\ \%$$

Where; DM intake (g) = DM Content (%) x Total fresh feed consumption (g), DM of Fecal (g) = The DM content of fecal (%) x total fecal excretion (g).

The same calculation also applies to the digestibility of other feed nutrients.

Daily body weight gain (DWG) was calculated by setting aside the results of weighing livestock (final body weight) with the previous body weight (initial body weight) divided by the length of time of the study. The equation is as follows:

$$\text{ADG (kg)} = \frac{\text{Final Body Weight (kg)} - \text{Initial Body Weight (kg)}}{\text{Observation Time (days)}}$$

Feed conversion was calculated by comparing dry matter consumption with daily body weight gain of livestock.

$$\text{Feed Conversion} = \frac{\text{DM intake (g)}}{\text{ADG (g)}}$$

Feed utilization efficiency was measured by comparing daily body weight gain with dry matter consumption multiplied by 100%.

$$\text{Feed efficiency (\%)} = \frac{\text{ADG (g)}}{\text{DM intake (g)}} \times 100\ \%$$

Data analysis

Data were processed and analyzed by Analysis of Variance (ANOVA) procedure with the help of Statistical Product and Service Solution (SPSS) Version 26 followed by Duncan's multiple test (Steel and Torrie, 1995; Sorzano, 2025).

RESULTS AND DISCUSSION

Dry matter (DM) intake

Dry matter intake (DM) in goats is the amount of dry matter consumed from feed in one day. Dry matter consists of all feed components that do not contain water, such as protein, carbohydrates, fat, vitamins, and minerals. The level of dry matter consumption is very important in goat rearing because it determines the intake of nutrients obtained by goats to support body activity, milk production, growth, and reproduction (Singh *et al*., 2025).

The results showed that the average dry matter (DM) intake of male Kacang goats increased significantly ($P < 0.05$) when fed silage composites supplemented with soluble carbohydrates and fish meal at levels of 5% (T1), 10% (T2), and 15% (T3) (Table 4). The average dry matter (DM) intake of goats was 344.57±27.66 g for treatment T1, 344.83±66.35 g for T2, and 532.47±196.25 g for T3. Goats in the T3 group, which received complete silage supplemented with 15% fish meal and 40% soluble carbohydrates, had significantly higher DM intake 54.53% higher than T1 and 54.42% higher than T2 (Table 4).

The increase in DM intake at 15% fishmeal supplementation compared to 5% and 10% levels is due to increased feed palatability. Fishmeal contains essential amino acids and organic compounds such as peptides that provide a distinctive and attractive flavour for livestock, thus increasing appetite (Adiwinarti *et al*., 2016). At the 15% level, the fishmeal content is high enough to provide a more prominent aroma and flavour than the 5% or 10% level, which encourages goats to consume.

In addition, feed nutrition can also be improved by supplementing fish meal at 15% in complete silage because of the higher content of essential amino acids obtained by livestock. Increased protein consumption will increase the activity of rumen microbes in digesting feed which results in a fast rumen emptying rate; ultimately increasing feed consumption (Tahuk *et al*., 2016). According to Kiura *et al*. (2024), increased consumption of protein and soluble carbohydrates will provide organic material that is easily fermented, thus increasing feed degradation in the rumen to provide energy for livestock; as well as increasing the efficiency of microbial protein synthesis in the rumen. Adiwinarti *et al*. (2016) reported that the use of fishmeal as a source of protein that is not degraded in the rumen can increase dry matter intake; consequently, productivity and carcass products of Kacang goats can be maximally improved.

Organic matter (OM) intake

Organic matter (OM) intake refers to the amount of carbon-containing feedstuffs (such as carbohydrates, protein and fat) eaten and utilised by livestock (Suwignyo *et al*., 2017). The OM intake in Kacang goats is influenced by several factors, such as feed quality, physiological condition of the animals, and the environment. As with dry matter intake, organic matter (OM) intake in this study also showed significant differences ($P<0.05$) between treatments (Table 4). It can be seen that animals that received 45% complete silage with 15% fish meal supplementation and 40% soluble carbohydrates (T3) showed higher organic matter intake ($P<0.05$) than the other two treatments. According to Kawas *et al*. (1999), increasing the supplementation level of energy from grains to 1.8% of body weight in the ration can increase organic matter intake in female goats during the rainy and dry seasons.

The higher organic matter (OM) intake in goats fed 45% complete silage with 15% fishmeal supplementation and 40% soluble carbohydrates (T3) compared to other treatments (10% and 5% fishmeal) was due to the higher and balanced content of nutrients such as protein and energy. As a result, the balance of protein and energy has an

impact on rumen microbial activity which is more optimal in degrading feed so that the rate of rumen emptying is faster which ultimately stimulates livestock to consume feed. According to Suwignyo *et al*. (2017), feed sufficiency in goats will increase organic matter intake, on the contrary goats that are restricted in feed will have lower organic matter intake, which has an impact on the decline in the performance of the livestock concerned.

Crude protein (CP) intake

Crude protein (CP) is one of the main nutrients that are very important in livestock rearing. In goats, protein is the basic material for the formation of body tissues, such as muscles, skin, and organs, and also plays an important role in livestock reproduction. Goats that get enough crude protein will have optimal growth, especially during the early growth phase or during the recovery period after illness (Pugh, 2024). Conversely, goats that lack feed cause the protein obtained for body tissue synthesis to also decrease, which is indicated by the low body weight gain produced (Suwignyo *et al*., 2017).

Table 4: Feed intake (g/head/day) of male Kacang goats fed with complete silage supplemented with fish meal and soluble carbohydrates[1]

Parameter	Treatments			P
	T1	T2	T3	
Dry matter (DM)				
Intake (g)	344.057±27.660[a]	344.830±66.352[a]	532.469±196.245[b]	0.045
Intake (g/kgBW$^{0.75}$)	49.951±2.849	48.780±1.993	67.807±23.567	0.244
Intake (% of BW)	2.588±0.194	2.437±0.106	3.335±1.102	0.269
Organic matter (OM)				
Intake (g)	315.882±25.182[a]	314.048±60.210[a]	482.366±176.987[b]	0.048
Intake (g/kgBW$^{0.75}$)	39.662±11.979	43.967±2.613	61.447±21.226	0.217
Intake (% of DM)	91.772±0.125	91.035±0.078	90.660±0.174	0.000
Crude protein (CP)				
Intake (g)	40.842±3.182[a]	39.977±7.565[a]	59.895±21.713[b]	0.062
Intake (g/kgBW$^{0.75}$)	5.919±0.309	5.616±0.301	7.637±2.595	0.288
Intake (% of DM)	11.852±0.062	11.571±0.047	11.280±0.079	0.000
Crude fiber (CF)				
Intake (g)	45.819±4.298[a]	50.180±10.363[a]	84.129±33.838[b]	0.024
Intake (g/kgBW$^{0.75}$)	6.704±0.527	6.881±0.653	10.642±4.160	0.165
Intake (% of DM)	13.411±0.303	14.669±0.236	15.553±0.612	0.002
Carbohydrate (CHO)				
Intake (g)	254.293±20.330[a]	251.863±48.459[a]	388.850±143,307[b]	0.048
Intake (g/kgBW$^{0.75}$)	36.908±2.074	35.308±2.011	49.518±17.209	0.246
Intake (% of DM)	73.889±0.067	73.039±0.001	73.028±0.001	0.000
NFE (g)				
Intake (g)	208.474±16.156[a]	201.683±5.877[a]	304.723±109.514[b]	0.058
Intake (g/kgBW$^{0.75}$)	30.203±1.552	28.427±1.359	38.877±13.045	0.275
Intake (% of DM)	60.478±0.369	58.370±0.238	57.475±0.614	0.000
Gross energy				
Intake (MJ/kg.DM)	6.097±0.486[a]	6.084±1.165[a]	9.326±3.414[b]	0.048
Intake (MJ/kgBW$^{0.75}$)	884.729±49.299	850.773±52.354	1188.171±409.109	0.244
Intake (Kcal/kg.DM)	1451.567±115.674[a]	1448.531±277.270[a]	2220.421±812.801[b]	0.048
Intake (Kcal/kgBW$^{0.75}$)	210639.935±11738.167	202562.288±12469.598	282901.710±97408.532	0.244
Metabolic energy				
Intake (Kcal/kg.DM)	1147.737±92.057[a]	1130.510±218.507[a]	1739.103±650.544[b]	0.054
Intake (Kcal/kgBW$^{0.75}$)	166611.007±9447.413	158782.709±8486.549	221221.044±78463.935	0.269

[1]Data are presented as Mean±SD; T1 = Male Kacang goat given 45% complete silage with 5% fish meal supplementation and 50% soluble carbohydrate, T2 = Male Kacang goat given 45% complete silage with 10% fish meal supplementation and 45% soluble carbohydrate, T3 = Male Kacang goat given 45% complete silage with 15% fish meal supplementation and 40% soluble carbohydrate; [a,b] different superscripts in the same row indicate significant differences (P<0.05); NFE = nitrogen free extract, GE= gross energy, ME= metabolic energy.

According to the results of the study (Table 4), it can be seen that CP intake in T3 treated goats is higher than T2 and T1 treated goats. The high CP intake illustrates that fish meal supplementation as a source of animal protein and soluble carbohydrates in goats given complete silage has a positive effect. Protein supplementation of low quality forage can have a positive impact on goats as indicated by the increase in daily body weight gain (Rashid, 2008). In addition, increased protein supplementation combined with soluble carbohydrates can improve rumen microbial development, which has a positive impact on increasing fibre digestibility and forage intake, as well as maximum growth of goats (Kawas *et al*., 2010).

If the protein and energy obtained by livestock are high enough and complementary, it will have a positive impact on feed metabolism in the rumen, which in turn supports optimal livestock growth performance (Tahuk *et al*., 2016). According to various research reports, female goats that receive energy level supplementation from grains up to 1.8% of body weight in the ration can increase crude protein consumption in the rainy season and dry season (Kawas *et al*., 1999). Lutfi *et al*. (2024) reported that increasing protein and energy levels in the ration can increase nutrient intake including protein intake in goats.

Crude fibre (CF), carbohydrate (CHO), NFE and energy intake

The results (Table 4) showed that the intake of CF, CHO, NFE and energy increased significantly (P<0.05) in animals treated with 15% fishmeal and 40% soluble carbohydrates (T3) when compared to treatments T1 and T2. This condition shows that energy sufficiency alone is not sufficient as in treatments T1 and T2 (soluble carbohydrates 50 and 45% respectively; and fish meal 5 and 10%) to improve the performance of fattened goats. The ration of fattened goats needs to be balanced with sufficient protein content so as to increase the balance of protein and energy in supporting muscle tissue synthesis to produce optimal growth.

Crude fibre intake of T3 treated goats increased 68% higher than T2 treated goats and 86.67% from T1 treated goats; CHO intake of T3 increased higher 54.58% from T2 and 52.76% from T1; NFE intake of T3 goats was higher 51.24% from T2 goats, and 46.15% from T1 goats. Meanwhile, in terms of energy intake (gross energy), the T3 treatment was higher 53.33% for T2, and 52.99% for T1; and for the metabolic energy of the livestock, the T3 treatment was higher 53.89% from T2 and 51.61% from the T1 treatment.

This increase in crude fibre, carbohydrate, NFE and energy intake illustrates that the supplementation of fish meal up to 15% and soluble carbohydrate 40% contributed positively to increasing the productivity of goats. According to Luginbuhl (2020), carbohydrates (sugar, starch, fibre) and fat from feed are the main sources of energy in goats. If carbohydrate intake is sufficient as needed, it will have a positive impact on increasing the energy intake obtained by goats. Yuniarti *et al*. (2016) reported that improving feed quality contributed positively to increasing energy intake and productivity of goats.

In general, energy intake in the T3 treatment animals in this study was sufficient to meet the basic needs of life and production. According to Spencer (2018), energy is the most common limiting factor found in the nutrition of small ruminants. Energy sufficiency supports livestock productivity; however, energy-deficient livestock will experience reduced production, reproductive failure, increased mortality, and increased susceptibility to disease and parasites. Tahuk *et al*. (2024) reported that increasing the content of soluble carbohydrates as an energy source in the ration contributed positively to the increase in energy intake, thus supporting the productivity of goats.

Nutrients digestibility of feed

The results in Table 5 indicate that increasing levels of fish meal supplementation (5%, 10%, and 15%) as a protein source had no significant effect (P > 0.05) on dry matter digestibility (DMD), carbohydrate digestibility, or energy digestibility. In contrast, organic matter (OM) and crude protein (CP) digestibility were significantly affected (P < 0.05). As the level of fish meal supplementation increased, both OM and CP digestibility also increased.

Relatively the same DM digestibility between treatments in this study indicates a fairly balanced nutrient ration obtained by goats. Where rations that have a good balance between protein and energy can create optimal conditions to support rumen microbial activity, as a result the digestibility of dry matter produced is maximum. The DM digestibility of the results of this study is not much different from the report of Tahuk *et al*. (2024) who obtained DM digestibility ranging from 69% to 79% in young male Kacang goats that received feed with different energy levels. However. This DM digestibility is higher than the report of Islamiyati *et al*. (2013) who obtained DM digestibility ranging from 56.41-57.22% in local goats.

Carbohydrate (CHO) and NFE digestibility values obtained in the study were quite high but relatively similar among treatments T1, T2, and T3 (Table 5). The high digestibility of CHO and NFE illustrates the rumen microbial activity of the three groups of goats in digesting carbohydrates obtained is not much different due to the

Table 5: Feed nutrient digestibility (%) of male Kacang goats fed complete silage with supplementation of fish meal and soluble carbohydrates[1].

Parameters	Treatment			P
	T1	T2	T3	
Dry matter digestibility (%)[ns]	72.813±5.167	70.827±6.945	73.051±5.966	0.820
Organic matter digestibility (%)	75.627±4.290[a]	86.476±2.707[b]	87.935±2.560[b]	0.000
Crude protein digestibility (%)	84.373±2.287[a]	90.719±2.139[b]	92.238±1.561[b]	0.000
Carbohydrate digestibility (%)[ns]	73.089±4.908	70.829±6.552	73.427±5.843	0.749
NFE digestibility (%)[ns]	78.531±4.622	77.752±4.769	79.360±4.770	0.862
Crude fibre digestibility (%)	45.004±10.526[a]	73.708±5.371[b]	77.348±4.895[b]	0.000
Gross energy digestibility (%)[ns]	76.830±4.003	74.585±6.262	76.686±5.016	0.750
Metabolic energy digestibility (%)[ns]	82.430±2.966	78.828±3.922	81.965±3.841	0.266

[1]Data are presented as ±SD; T1 = Male goat given 45% complete silage with 5% fish meal supplementation and 50% soluble carbohydrate, T2 = Male goat given 45% complete silage with 10% fish meal supplementation and 45% soluble carbohydrate, T3 = Male goat given 45% complete silage with 15% fish meal supplementation and 40% soluble carbohydrate; NFE = nitrogen free extract; [a,b] different superscripts in the same row indicate significant differences (P<0.05).

relatively similar feed quality. In addition, the digestibility of CHO and NFE is influenced by the digestibility of dry matter. Carbohydrate and NFE are the largest components of dry matter. If dry matter digestibility increases, so will carbohydrate digestibility. Carbohydrates are biochemical compounds consisting only of the elements carbon, hydrogen and oxygen, and are the main source of energy for livestock. Livestock get most of their required energy from carbohydrates in feed (Saha *et al.*, 2023). Similarly, the high digestibility of NFE which is a soluble carbohydrate component contributes positively to goats; where energy availability is fulfilled thus contributing to improved performance of Kacang goats fattened.

The increase in organic matter (OM) digestibility and crude protein (CP) digestibility, and crude fibre (CF) digestibility (Table 5) in this study illustrates that increasing the level of fishmeal to 10 and 15% and soluble carbohydrates contributes positively to the availability of nutrients that will be used by goats to meet basic needs and production. Increased crude protein digestibility has the effect of increasing muscle tissue deposits, while increased crude fibre digestibility allows the availability of carbohydrates as an energy source for goats growth. Kawas *et al.* (1999) reported that grain supplementation up to 1.8% of BW increased the digestibility of organic matter in goats both in the rainy and dry seasons. Jelantik *et al.* (2012) reported that the use of sun-dried fish and fish meal had a positive and significant impact on the digestibility of dry matter, organic matter, and crude protein digestibility and balance in goats.

The high digestibility of both gross energy and metabolic energy (Table 5) illustrates that the feed energy consumed by goats has a high use value; so that it can be utilised to improve their performance to the maximum. Various research reports show that energy and protein are the two main components that need to be considered in the provision and feeding of goats. Energy deficiency can generally limit goat productivity, while protein is an important nutrient that must be fulfilled for growth, pregnancy and milk production (Sow *et al.*, 2020).

In general, the results of this study made a positive contribution to increasing the digestibility of dry matter and nutrient digestibility of organic matter, crude protein, crude fibre and energy. As a result, the nutrients obtained by goats are fulfilled both for basic life and for growth (Table 5). The digestibility values of dry matter, organic matter, crude protein, and crude fibre of the results of this study are lower when compared to the report of Tahuk *et al.* (2021) on young male Kacang goats that received complete silage without supplementation of feed sources of protein and soluble carbohydrates. The difference in digestibility value is thought to be caused by differences in the feed ingredients that make up the ration so that it has an impact on the response and ability of rumen microbes to digest feed consumed by livestock. According to Trisnadewi *et al.* (2012), soluble carbohydrate supplementation in rations can increase the digestibility of dry matter, organic matter, crude protein, and the number of rumen fluid protozoa. But on the other hand, the addition of soluble carbohydrates in feed can reduce rumen pH. As a result, it can inhibit the activity of fibre-digesting microbes, thus reducing crude fibre digestibility. Luthfi *et al.* (2024) reported that increasing protein and energy levels in young and adult Kacang goats can increase the digestibility of dry matter, organic matter, crude protein, crude fibre and energy.

Body weight changes of Kacang goats

Determination of body weight gain (BWG) in goats is very important because it can provide relevant information

related to the effectiveness of livestock maintenance in terms of feed provision, potential for livestock growth, housing, genetic and health status of livestock. In addition, weight gain data reflects the level of productivity of goats in producing meat, and can be used to assess the quality and efficiency of feeding, the suitability of the environment where livestock are kept, and to adjust the amount and quality of rations according to the growth potential of livestock. The determination of BGW also aims to determine the target final body weight of livestock to be sold (Litzow, 2020), estimate the target market, and determine the economic value (selling price) of goats (Kinder, 2016).

The results showed that although the initial body weight values of the animals used in the study were relatively the same (P=0.180) (Table 6), there were significant differences between the final body weight of the animals (P<0.05), body weight gain and daily body weight gain (P=0.060) of Kacang goats in the T3 treatment with the T2 and T1 treatments. The final body weight value of T3 animals was 20.879% higher than T1 treatment animals, and 5.059% higher than T2 treatment animals. Meanwhile, in terms of body weight gain (BWG) and average daily body weight gain (ADG), the T3 animals had higher BWG and ADG than the T1 animals by 173.639% and 173.686, respectively; and the T2 animals by 34.903% and 34.890%, respectively.

The body weight gain of animals that received 15% fishmeal, with 40% soluble carbohydrates (SC) (T3) was higher than the T2 and T1 treatments that had 10 and 5% protein, respectively. This is because fishmeal is a source of high-quality animal protein with complete essential amino acids, such as lysine and methionine, which are essential for muscle growth and tissue synthesis in goats. The 15% fishmeal concentration thus provides a higher amount of protein than the T2 and T1 treatments that received 10% or 5% fishmeal. As a result, the nutritional needs of goats are met to support optimal growth (Tahuk *et al*., 2024). In addition, the use of SC reaches 40% in the form of ground corn, bran pollard and rice bran which are energy sources that are very easily fermented in the rumen so that they can be maximally utilised for rumen microbial protein synthesis. The combination of high energy from SC and protein from fishmeal contributes to increasing the efficiency of energy and protein metabolism so as to support the growth of body tissues.

According to the results of this study, it appears that a more balanced ratio of protein and energy as in the T3 treatment helps fulfil the needs of goats to produce maximum growth. The body weight gain of the study results was lower when compared to the report of Kustantinah *et al*. (2017) who obtained ADG in Kacang goats of 72.75 ± 4.93 g/day who received fishmeal as a source of protein; and the report of Tahuk *et al*. (2024) who obtained feed with a protein content of 13% and TDN 73%. However, the ADG of these Kacang goats was higher than the report of Tahuk *et al*. (2021) who obtained ADG of 14.71 - 44.19 g/day in Kacang goats that received complete silage.

Feed conversion

Feed conversion describes the use value of feed consumed by livestock and utilised to increase their body weight gain. According to the results of the study, the feed conversion of Kacang goats that received complete silage with fishmeal supplementation of 5, 10, and 15%, respectively had feed conversion values that were not much different. However, quantitatively, the feed conversion values of the T3 and T2 treatments were better (optimal) (P=0.083) than the T1 treatment (Table 6).

Table 6: Changes in body weight, conversion and feed efficiency of male Kacang goats fed with complete silage supplemented with fish meal and soluble carbohydrates[1]

Parameter	Treatment			P
	T1	T2	T3	
Initial Body Weight (kg)^{ns}	12.700±0.757	13.500±0.200	13.417±0.375	0.180
Initial Body Weight ($BW^{0.75}$)^{ns}	6.726±0.299	7.043±0.079	7.010±0.147	0.179
Final Body Weight (kg)	13.967±1.427^{a}	16.070±0.185^{ab}	16.883±1.138^{b}	0.036
Final Body Weight ($BW^{0.75}$)	7.220±0.551^{a}	8.026±0.069^{ab}	8.327±0.421^{b}	0.036
Body Weight Gain (kg)	1.267±0.671^{a}	2.570±0.329^{ab}	3.467±1.343^{b}	0.060
Daily Weight Gain (g)	22.619±11.982^{a}	45.893±5.877^{ab}	61.905±23.978^{b}	0.060
Feed Conversion^{ns}	18.567±7.895	8.640±1.299	9.526±2.431	0.083
Feed Efficiency (%)^{ns}	6.201±2.957	11.768±1.937	11.019±3.084	0.089

[1]Data are presented as ±SD; T1 = Male goat given 45% complete silage with 5% fish meal supplementation and 50% soluble carbohydrate, T2 = Male goat given 45% complete silage with 5% fish meal supplementation and 45% soluble carbohydrate, T3 = Male goat given 45% complete silage with 5% fish meal supplementation and 40% soluble carbohydrate; ^{a,b} different superscripts in the same row indicate significant differences (P<0.05).

The feed conversion value of each goats treatment group was T1 at 18.567±7.895; T2 at 8.640±1.299, and T3 treatment at 9.526±2.431. Theoretically, the smaller the feed conversion value, the more efficient the animal is in utilising feed to maximise its growth (Nuraini *et al.*, 2014). Thus, the results of this study showed that the T2 and T3 treatment goats were more efficient in utilising feed to increase body weight when compared to the T1 treatment goats. Feed nutrient content, especially the increase in ration energy content, has a major effect on feed conversion. If the feed obtained by goats contains complete nutrients and as needed, the body weight gain of goats will be higher. The higher feed quality will result in more optimal conversion to support livestock growth (Tahuk and Bira, 2020). Mutimura *et al.* (2021) reported that livestock growth and feed conversion are largely determined by the type of feed consumed by livestock. The higher the quality of the feed used, the better the feed conversion value, thus spurring livestock growth. As a result, feed conversion and growth of Kacang Goats in the T3 treatment can be maximised.

In this study, the T3 treatment ration (Table 3) provided a well-balanced nutrient composition, particularly in terms of protein and energy, sufficient to meet the maintenance and production requirements of Kacang goats. As a result, feed conversion efficiency and growth performance were optimized in goats receiving the T3 treatment.

Feed efficiency

Feed efficiency is the ratio between the amount of daily body weight gain (ADG)) and feed dry matter intake (DMI) in livestock. Feed efficiency values indicate how optimally goats utilise feed to produce body weight gain. High feed efficiency is very important in the farming system because it can reduce production costs and increase the profitability of livestock rearing.

The feed utilisation efficiency values for each treatment were T1 treatment of 6.201±2.957%, T2 treatment of 11.768±1.937 and T3 treatment of 11.019±3.084 (Table 6). The results of statistical analysis showed that the treatment did not significantly affect the feed efficiency value (P>0.05). The relatively equal value of feed efficiency is influenced by ADG and DM intake which is the basis for calculating feed efficiency is also not different between treatments. Although relatively the same, goats treated with T3 and T2 tended to have higher feed efficiency values (P=0.089) than goats treated with T1. This illustrates that the use value of the ration of T3 and T2 treatment animals is higher in increasing ADG of goats. This condition is also related to the value of feed conversion that is more optimal in the Kacang goats of T3 and T2 treatment. Feed conversion is an illustration of the efficiency of feed use in increasing animal weight gain (Tahuk and Bira, 2020). This study resulted in lower feed utilization efficiency when compared to the report of Islamiyati *et al.* (2013) which resulted in feed efficiency of 17-23% in local goats that received corn straw inoculated with fungi and enriched with *Gliricidia sepium*. This difference is due to differences in feed type and quality, different goat responses to feed, and genetic differences in the goats used.

The results of this study generally illustrate that feed efficiency in growing phase Kacang goats can be maximally improved by supplementing fish meal levels of 10 and 15% with a proportion of soluble carbohydrates ranging from 40 to 45% of the ration given to goats. Increased ration energy will streamline the utilisation of feed protein for maximum body tissue synthesis. Kustantinah *et al.* (2017) reported that fish meal supplementation in the ration can increase nutrient intake, digestibility, N retention and metabolism and increase growth (ADG) of Kacang goats.

CONCLUSION

Based on the results of this study, it can be concluded that supplementing the ration with 15% fish meal and 40% soluble carbohydrates in Kacang goat fattening diets increases the intake of dry matter, organic matter, crude protein, carbohydrates, and energy. The digestibility of organic matter and crude protein also increased with higher levels of fish meal supplementation. Although the digestibility of dry matter, carbohydrates, and energy showed slight increases, the differences among treatments were not statistically significant. Additionally, body weight gain improved with increasing fish meal supplementation, while feed conversion ratio and feed efficiency remained relatively unchanged across treatments.

ACKNOWLEDGEMENT

The authors would like to thank Timor University through LPPM for funding the implementation of this Scheme Centre of Dryland Studies Research with Contract Number: 138/UN60.6/PP/2024, dated 15 May 2024.

NOVELTY STATEMENT

Complete silage constitutes a feed technology designed to ensure continuous feed availability for Kacang goats during periods of forage scarcity. Nevertheless, the application of complete silage as a sole dietary component has not yielded a significant enhancement in the productive performance of Kacang goats. The findings of this study present novel insights regarding the utilization of complete silage for the fattening of Kacang goats. Supplementation with fish meal at a level of 15% alongside soluble carbohydrates markedly enhances the performance of Kacang

goats fed complete silage as their basal diet.

AUTHOR'S CONTRIBUTION

PKT was responsible for data processing and statistical analysis, discussion, and preparation of reports and scientific articles for publication. MB and YK assisted with data processing and discussion of draft scientific articles. All authors have read and approved the manuscript to be published.

Ethical approval of study

This study on the effects of supplementation of fish meal and soluble carbohydrates in complete silage on fattened Kacang goats was conducted in accordance with internationally recognised guidelines for the ethical treatment of experimental animals. Animals were treated ethically according to the principles of animal welfare.

Generative AI and AI-assisted technology statement

The authors declare that no Genrative AI was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Adiwinarti R, Kustantinah I, Gede S, Budisatria R, Indarto E (2016). Improving the performance of local Kacang goats using ruminally undegradable protein feeds. Asian J. Anim. Sci., 10: 262-267. https://doi.org/10.3923/ajas.2016.262.267

Campbell M, Ortuño J, Ford L, Davies DR, Koidis A, Walsh PJ, Theodoridou K (2020). The effect of ensiling on the nutritional composition and fermentation characteristics of brown seaweeds as a ruminant feed ingredient. Animals, 10(6): 1019. https://doi.org/10.3390/ani10061019

Ginting SP (2009). Prospek penggunaan pakan komplit pada kambing: tinjauan manfaat dan aspek bentuk fisik pakan serta respon ternak. Wartazoa, 19(2): 64–75.

Hardcastle A, Lear A (2020). Fundamentals of feeding goats (farm animal field services). Large Animal Clinical Sciences, Institute of Agriculture, University of Tennessee. Available at: https://vetmed.tennessee.edu/wp-content/uploads/sites/4/UTCVM_LACS-FeedingGoats.pdf. Accessed date 7 April 2025.

Harris LE (1970). Chemical and biological methods for feeds analysis. Center for tropical Agriculture Feed Composition Project, Livestock Pavilion University of Florida, Gainnesville Florida.

Hess T, Griffler M (2022). Daily diet, treats, and supplements for goats. Tersedia di: https://opensanctuary.org/daily-diet-treats-supplements-for-goats/?gad_source=1andprint=print.

Islamiyati R, Natsir A, Rasjid IS (2013). Productivity of local goat fed corn stover treated with fungi *Trichoderma* sp. and supplemented gliricidia. Int. J. Agric. Syst., 1(2): 128–134.

Jelantik I, Weibsjerg M, Madsen J (2012). Intake, rumen degradation and utilisation of urea-ammoniated grass hay by kacang goats as affected by supplementation of sun-dried fish or fishmeal. Anim. Prod., 14(2). Retrieved from http://animalproduction.net/index.php/JAP/article/view/366/347

Kawas JR, Andrade-Montemayor H, Lu CD (2010). Strategic nutrient supplementation of free-ranging goats. Small Rumin. Res., 89(2–3): 234-243. https://doi.org/10.1016/j.smallrumres.2009.12.050

Kawas JR, Schacht WH, Shelton JM, Olivares E, Lu CD (1999). Effects of grain supplementation on the intake and digestibility of range diets consumed by goats. Small Rumin. Res., 34(1): 49-56. https://doi.org/10.1016/S0921-4488(99)00040-1

Kearl LC (1982). Nutrient requirement of ruminants in developing countries. International Feedstuffs Institute, Utah Agricultural Experiment Station, Utah State University, Longman, USA.

Kinder CA (2016). Average daily gain (ADG). Available at: https://www.uidaho.edu/-/media/UIdaho-Responsive/Files/Extension/4-H/Animal-Science-Lesson-Plans/Nutrition-ADG-L1-ALL-CKinder.pdf?

Kiura JN, Ondiek JO, Migwi PK, Guliye AY (2024). Dry matter intake, digestibility and milk production of toggenburg dairy goats fed on Napier grass (*Pennisetum purpureum*) basal diet supplemented with a concentrate in Kenya, Preprint (Version 1) available at Research Square. https://doi.org/10.21203/rs.3.rs-4628567/v1

Kustantinah R Adiwinarti IGS, Budisatria R, Indarto E (2017). Improved productivity of kacang goats reared by farmers using balanced rations with different sources of protein. Pak. J. Nutr., 16: 672-677. https://doi.org/10.3923/pjn.2017.672.677

Litzow E (2020). Growth weight data providing valuable insights. Available at: https://www.mla.com.au/news-and-events/industry-news/growth-weight-data-providing-valuable-insights/. Accessed date 17 April 2205.

Luginbuhl JM (2020). Nutritional feeding management of meat goats. NC State Extension Publications. Available at: https://content.ces.ncsu.edu/nutritional-feeding-management-of-meat-goats. Akses 19 April 2025.

Luthfi N, Purnomoadi A, Rianto E, Mukminah N, Lestari CMS, Purbowati E (2024). The effect of feeding level on protein and energy utilization in young and mature Kacang goats. IOP Conf. Ser. Earth Environ. Sci., 1377 012076. https://doi.org/10.1088/1755-1315/1377/1/012076

Mutimura M, Celestin P, Hitimana, Shumbusho F, Manzi M (2021). Growth, feed intake and conversion ratio of improved goats fed brachiaria grass and napier grass mixed with or without leucaena leaf meal. Trop. Anim. Health Prod., Available from: https://www.researchgate.net/publication/353713403_Growth_Feed_Intake_And_Conversion_Ratio_of_Improved_Goats_Fed_Brachiaria_Grass_And_Napier_Grass_Mixed_With_or_Without_Leucaena_Leaf_Meal [accessed Mar 17 2025]. https://doi.org/10.21203/rs.3.rs-740086/v1

Nuraini IGS, Budisatria AA (2014). Pengaruh tingkat penggunaan pakan penguat terhadap performa induk kambing Bligon di peternak rakyat. Bulet. Peternakan. 38(1): 34-41. https://doi.org/10.21059/buletinpeternak.v38i1.4614

Pugh DG (2024). Nutritional requirements of goats. Auburn University. Tersedia. https://www.msdvetmanual.com/management-and-nutrition/nutrition-goats/nutritional-requirements-of-goats. Accessed date 17 April 2025.

Rashid M (2008). Goats and their nutrition. Manitoba Agriculture, Food and Rural Initiatives. https://www.gov.mb.ca/agriculture/livestock/goat/pubs/goats-and-their-nutrition.pdf

Ruvuga P (2016). Goat production in the tropics and mitigation to feed shortage in different production systems in Eastern, Tanzania. Master thesis. Swedish University of Agricultural Sciences, Faculty of Veterinary Medicine and Animal Science, Department of Animal Nutrition and Management.

Saha U, Leticia S, Dennis H, Nicholas H, Lawton S, Gary H, David EK (2023). Common terms used in animal feeding and nutrition. Bulletin, 1367: https://secure.caes.uga.edu/extension/publications/files/pdf/B%201367_6.PDF

Singh B, Das A, Bhakat C, Mishra B, Elangbam S, Sinver M, Ambili KS, Tarafdar A (2025). Prediction of dry matter intake in growing Black Bengal goats using artificial neural networks. Trop. Anim. Health Prod., 57(2): 42. https://doi.org/10.1007/s11250-025-04295-w

Sorzano COS 2025. Statistical experiment design for animal research. https://i2pc.es/coss/Articulos/Sorzano2023.pdf. https://doi.org/10.31219/osf.io/e9s25

Sow F, Niang K, Camara Y, Traoré EH, Moula N, Cabaraux JF, Missohou A, Hornick JL (2020). Comparative study of intake, apparent digestibility and energy and nitrogen uses in sahelian and majorera dairy goats fed hay of *Vigna unguiculata*. Anim Open Access J., 10(5): 861. https://doi.org/10.3390/ani10050861

Spencer R (2018). Nutrient requirements of sheep and goats. Alabama A and M University and Auburn University. https://www.aces.edu/wp-content/uploads/2018/11/ANR-0812.pdf. Accessed date 25 April 2025.

Steel RGD, dan Torrie JH (1995). Prinsip dan prosedur statistika. Edisi ke-4. Penerbit Gramedia Pustaka Utama, Jakarta.

Suwignyo B, Zein AB, Ristianto U, Sarmin, Irkham W (2017). Effects of different feed restrictions on kacang goats. Pak. J. Nutr., 16: 236-241. https://doi.org/10.3923/pjn.2017.236.241

Tahuk PK, Bira GF, Lopi KRM, Nenabu AB, Kolo N (2021). Nutrient intake, digestibility and performance of male Kacang goats fattened by complete silage. Adv. Anim. Vet. Sci., 9(12): 2147-2156. https://doi.org/10.17582/journal.aavs/2021/9.12.2147.2156

Tahuk PK, Bira GF (2020). Carcass and meat characteristics of male Kacang goat fattened by complete silage, Vet. World, 13(4): 706-715. https://doi.org/10.14202/vetworld.2020.706-715

Tahuk PK, Bira GF, Feka WV (2024). Feed intake, digestibility, and growth performance of young male kacang goats fed diets containing different energy levels. J. Anim. Health Prod., 12(3): 370-379. https://doi.org/10.17582/journal.jahp/2024/12.3.370.379

Tahuk PK, Budhi SPS, Panjono BE (2016). *In vitro* characteristics of rumen fermentation of fattening rations with different protein-energy levels fed to Bali cattle. Pak. J. Nutr., 15(10): 897-904. https://doi.org/10.3923/pjn.2016.897.904

Tahuk PK, Dethan AA (2010). Performance of bali bull in greenlot fattening by farmers when rainy season in Timor Island. J. Indonesian Trop. Anim. Agric., 35(4): 257-261. https://doi.org/10.14710/jitaa.35.4.257-261

Trisnadewi AAAS, Cakra IGLO, Wirawan IW (2012). Pengaruh karbohidrat mudah larut (Dedak Padi) Sebagai Pakan Tambahan Pada Kambing Pe Terhadap Kecernaan Bahan Kering Dan Nutrien Dengan Metode Indikator Internal. Majalah Ilmiah Peternakan, 12(3). Available at: https://ojs.unud.ac.id/index.php/mip/article/view/1736

Yuniarti E, Evvyernie D, Astuti DA (2017). Production and energy partition of lactating dairy goats fed rations containing date fruit waste. Media Peternakan, 39(1): 27-33. https://doi.org/10.5398/medpet.2016.39.1.27