

## Effect of Tannin Supplementation from Gambier Leaf Powder (*Uncaria gambir* Roxb) on Digestibility, Rumen Fermentation, Microbial Protein Synthesis and Performance of Bali Cattle (*In Vivo*)

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### ABSTRACT

This study aimed to analyze the *in vivo* use of gambier tannins in beef cattle supplements. The study used a 4 x 4 Latin Square design, namely as four rows of the research period and as columns of four types of treatment, namely (a) 100% fermented straw (control), (b) 70% fermented straw + 30% concentrate, (c) Fermented straw 70% + concentrate 20% + supplement 10%, (d) Fermented straw 70% + concentrate 15% + supplement 15%. The addition of supplements can improve the rumen ecosystem in the form of increasing 16.16% VFA and NH<sub>3</sub> concentrations as well as decreasing the rumen protozoa population ( $P < 0.05$ ), which occurs due to the supply of energy sources, nitrogen, minerals, and condensed tannins in the supplement as an effort to manipulate rumen fermentation, this has a positive influence on increasing 39.9% microbial biomass and protein concentration microbes. The protein-binding properties of tannins cause a 220% increase in non-degradable protein (RUDP) in rumen fluid. All of these parameters are positively correlated ( $P < 0.05$ ) with microbial protein metabolism (purine derivatives), thus reflecting increased cattle weight gain. In conclusion, the best results in terms of livestock performance and profitability are achieved with a ration containing 70% forage, 15% concentrate, and 15% supplements.

**Keywords:** Digestibility, Straw, Beef Cattle, Gambier Leaf Powder, *In vivo*, Tannin.

### INTRODUCTION

The need for meat to meet the nutritional needs of the Indonesian people is increasing along with the condition of the population, which continues to grow. However, the condition of the cattle population for meat production is decreasing yearly. Based on data from the Central Statistics Agency for 2023, the national beef cattle population in 2021 was 17,977,214 head and decreased in 2022 to 17,602,538 head (BPS 2023). Meanwhile, the availability of local beef only meets 68% of national beef demand (Smith et al. 2024). That is a matter of concern for the government to address to meet national meat needs immediately.

The local beef supply mainly comes from smallholder

livestock businesses with local cattle breeds (82.73%), including Bali, PO, Madura, Aceh, and Pesisir cattle (Abadi et al. 2025). Bali cattle play an essential role in providing national beef and are famous for farming in Indonesia because they have advantages in reproductive power, adaptability, and high carcass percentage (BSN 2017). Bali cattle are a breed of native Indonesian cattle originating from the domestication of bulls as determined by Minister of Agriculture Decree No. 325/kpts/O.T. 1/140/2010. The average body weight gain achieved nationally for Bali cattle is only 0.37kg/day, still far from ideal, namely 0.8-0.9kg/day (Achadri et al. 2021).

The low increase in body weight is due to inadequate rations in terms of quality and quantity. The ration relies more on the provision of rice straw or is accompanied by

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the provision of concentrate from local ingredients widely available in the farmer's environment, such as bran, sago, cassava, and coconut dregs. The concentrates provided are generally composed of energy-source feed ingredients because they are expensive and limited protein-source feed ingredients (Oematan 2023). As a result, the protein content in the concentrate does not meet the SNI requirements for fattening cattle concentrate because it is less than 13%, but the energy content can meet the SNI requirements because it contains more than 70% TDN (SNI 2017).

Therefore, it is necessary to improve the quality of raw materials, especially straw, which is commonly available and used by breeders. One improvement can be made by processing straw fermentation using the Silage method. Silage is a method of processing feed using anaerobic bacteria, namely lactic acid bacteria (Zong et al. 2024). Straw fermentation is carried out to increase digestibility in livestock (Ramaiyulis et al. 2021). On the other hand, there needs to be protection, especially protein nutrients, so that rumen microbes cannot wholly degrade them (Ramaiyulis 2021). That is to provide bypass protein to be maximally absorbed in the post-rumen. One of the potential protein protection compounds is gambier leaf powder (Ramaiyulis et al. 2019).

The gambier plant (*Uncaria gambir* Roxb) is a plant source of tannin. Tannin is a polyphenolic compound with a high molecular weight that can function as a defaunation agent (Ramaiyulis et al. 2025). It also protects the protein from rumen degradation at specific concentrations (Xie et al. 2021). The protozoa population decreased significantly due to the addition of condensed tannin. The reaction of tannins with protozoan cell walls damages cell wall permeability, which can kill protozoa (Ningrat et al. 2017). Tannins in the rumen will form complex compounds with proteins resistant to rumen microbial proteolysis enzymes, thereby reducing protein degradation in the rumen (Ramaiyulis 2021).

Gambir processing waste in the form of gambier leaf pulp, which has been extracted, has not yet been utilized even though it contains 9.96% condensed tannin and has the potential to be used as a detonator for rumen protozoa (Ramaiyulis et al. 2025). Adding 10-15% gambier leaf powder to the ration can increase digestibility and body weight in beef cattle. Gambier leaf powder supplementation aims to suppress the rumen protozoa population and protect feed protein from rumen microbial degradation (Ningrat et al. 2018; Pazla et al. 2025).

Based on the description above, this study aims to evaluate the in vivo supplementation of gambier tannin in beef cattle rations. This study specifically analyzed the use of fermented rice straw basal rations supplemented with gambier tannin in stages. It measured its effects on in vivo nutrient digestibility, specifically protein, NPU, and BV. This study also measured rumen fermentation characteristics and microbial protein synthesis, as well as the correlation between variables that influence performance in Bali cattle.

## MATERIALS AND METHODS

### Sample collection and chemical composition analysis

The research was conducted for six months at Asyfa Farm, located in the Tandikat district, Patamuan sub-

district, and Padang Pariaman district. In vivo research used four male Bali cattle aged  $\pm$  18 months with an initial body weight of 234 – 242kg. The study used a 4 x 4 Latin Square design (Gomez and Gomez 1981), with four cattle as replications, each with a different period receiving four ration treatments:

A: 100% fermented straw (control)

B: Fermented straw 70% + concentrate 30%

C: Fermented straw 70%+concentrate 20%+supplement 10%

D: Fermented straw 70%+concentrate 15%+supplement 15%

There are four periods of cattle maintenance, each lasting 20 days. Each period consists of 15 days of prelim and five days of collection.

The concentrates used are listed in Table 2, while the supplements used are listed in Table 1. The samples were then subjected to chemical composition analysis, i.e., Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF), and ash content (ICARDA 2011).

**Table 1:** Supplement formula for beef cattle

Materials	% DM
Ingredient composition	
Brown sugar	15
Bran	27
Coconut cake	12
Soybean Meal	15
Tapioca	15
Urea	5
Salt	3
Mineral	3
Gambier leaf powder	5
Chemical composition	
Crude Protein (CP)	23.68
Organic Matter (OM)	85.95
Crude Fiber (CF)	10.31
Fat	4.59
Extract ingredients without Nitrogen	52.77
Tannin	1.17
Tannin: PK non urea Ratio (g)	31.21

**Table 2:** Chemical composition of in vivo research rations (%)

Feed Ingredients	DM	Ash	OM	CP	CF	Fat
Fermented straw	96.27	9.67	90.33	5.41	22.56	3.02
Concentrate	88.44	5.88	93.45	7.49	10.90	4.00
Rice bran	90.96	9.86	89.16	13.37	13.29	2.14
Sago pith	89.03	8.17	90.82	3.28	13.88	1.43
Cassava cassava	90.91	1.47	98.38	3.50	0.87	1.59
Coconut pulp	81.31	0.89	98.91	9.01	12.91	13.06
Supplement feed	96.41	11.74	85.95	23.68	10.31	4.59

### Research procedure

In vivo research used four male Bali cattle aged 18 months with an initial body weight of 234-242kg. Cows were placed in individual pens measuring 1.25mx2m, equipped with a feeding and drinking area. The external and internal anti-parasitic drug Wormectin® (dihydro avermectin B16) was given subcutaneously at 1mL/100kg BW The cows were then given seven days to adapt and determine their consumption ability and dry matter requirements.

Prelimynari is given for 15 days to eliminate the influence of previous rations. Cows are given a treatment ration, where concentrate and supplements according to dry matter requirements are given twice daily at 07.30 and 17.00. At the same time, fermented straw and drinking water are provided ad libitum.

After completing the prelim period, the sample was collected using a total collection technique for seven days. Every 24 hours, the amount of consumption and excretion of feces and urine is weighed, and a 10% sample is taken to be dried and analyzed. Urine collection was carried out using a harness connected by a hose to a collection bottle filled with 20mL of 20% H<sub>2</sub>SO<sub>4</sub> to prevent nitrogen evaporation during collection.

Rumen searches were taken on the 7th day of collection at 3 hours after giving 100mL of ration. Rumen fluid was collected using a stomach tube connected to a vacuum Erlenmeyer flask and sucked using a Resun@ ACO-006 vacuum pump made in China. The rumen fluid was filtered with four layers of gauze and then taken to the laboratory.

### Characteristics of rumen fermentation

pH rumen fluid measurements were taken using a pH meter. The pH meter should be standardized before use with a buffer solution at a pH of 7. VFA production and NH<sub>3</sub> rumen fluid were measured according to the procedures outlined in General Laboratory Procedures (1966) and Conway and O'Malley (1942), respectively. Rumen microbial biomass was analyzed using the approach described by Griswold et al. (2003); the protozoa population was investigated according to the approach of Ogimoto and Imai (1981).

### Total digestibility of feed substances

Dry ration and feces samples were analyzed for feed substances, including water content, ash, crude protein, and crude fiber (ICARDA 2011). Next, explore the fiber fractions acid detergent fiber (ADF), acid detergent lignin (ADL), neutral detergent fiber (NDF), hemicellulose (NDF-ADF), and cellulose (ADF-ADL) (Van Soest 1994).

Digested feed substances = consumption of feed substances – remaining feed substances in feces.

### Nitrogen balance

The nitrogen balance uses total collections (Cole and Ronning 1974). The amount of nitrogen contained in rations, feces, and urine are analyzed using the Kjeldahl method (ICARDA 2011) and then used to express nitrogen retention, net protein utilization (NPU), biological value (BV) as follows :

Nitrogen retention (g/d) = N consumption – fecal N – urine N

$$NPU (\%) = \frac{N \text{ retention}}{N \text{ consumption}}$$

$$BV (\%) = \frac{N \text{ retention}}{N \text{ digested}}$$

### Microbial protein synthesis

Microbial protein synthesis was performed by analyzing allantoin excretion in urine using the method of Chen and Gomes (1992) with the following equation:

$$PDe = \frac{Ae}{0.85}$$

$$Pa = \frac{PDe - 0.385 \times W0.75}{0.85}$$

MN = Pa x 0.727

UAe = PDe x 0.15

Ae = Allantoin excretion via urine (mmol/day)

PDe = Purine derivative excretion via urine (mmol/day)

Pa = Purine absorption (mmol/day)

MN = Rumen microbial nitrogen (g/day)

UAe = Uric acid excretion in urine (mmol/day)

### Statistical Analysis

The research data obtained were subjected to analysis of variance (ANOVA) (Gomez and Gomez 1981) using a Latin square design. Significant differences among treatments were analyzed using Duncan's multiple-range test (DMRT) at the 5% level, and correlations among variables were analyzed using regression analysis using SPSS Software.

## RESULTS

### Ration consumption and digestibility

Table 3 shows that the addition of concentrate to the control ration increased dry matter intake (P<0.05). In contrast, supplement addition had no significant effect on dry matter intake (P>0.05). Dry matter intake of Bali cattle in the control ratio was 2.17% of body weight, while in the treatment ration it ranged from 2.66 to 2.77%, resulting in a 23.6% increase.

Dry matter digestibility increased with the addition of concentrate (P<0.05) and further with the addition of supplements (P<0.05). Meanwhile, the digestibility of organic matter, crude fiber, NDF, cellulose, and hemicellulose increased (P<0.05) only due to the addition of concentrate and was not affected by the addition of supplements. The addition of concentrate increased crude protein consumption by 54% and digestible protein by 140% compared to the control. In comparison, supplement addition increased crude protein consumption by 17% and digestible protein by 16%. Nitrogen retention in the control was 7.29g/d, significantly increased (P<0.01) by treatment, with a range of 25.70-30.38g/d, while there was no significant difference between treatments (P>0.05).

**Table 3:** Chemical composition of in vivo research rations (%)

Feed Ingredients	NDF	ADF	Cellulose	Hemi-cellulose	BETN	TDN	Tannin
Fermented straw	58.66	37.85	22.28	20.81	59.34	58.03	-
Concentrate	36.55	22.10	19.63	14.45	69.20	71.25	-
Rice bran	31.50	21.97	11.49	9.53	61.34	66.29	-
Sago pith	42.68	26.30	20.86	16.38	67.46	62.22	-
Cassava cassava	18.20	4.27	2.51	13.93	88.71	72.07	-
Coconut pulp	53.32	33.83	47.15	19.49	64.13	91.45	-
Supplement feed	27.16	13.56	9.44	13.60	52.77	73.85	1.17

NPU and BV reflect protein utilization in livestock. This study found the lowest NPU ( $P<0.01$ ) in the control ration, namely 30.48%, compared to the treatment ration of 52.19-54.30%. Likewise, the BV value was lowest ( $P<0.05$ ) in the control ration (56.95%) compared to the treatment ration (64.58-65.70%).

Regression analysis (Fig. 1a and 1b) showed that NPU correlated with body weight gain ( $P<0.01$ ;  $r=0.635$ ,  $n=16$ ) but BV did not correlate with body weight gain ( $P=0.37$ ;  $r=0.22$ ,  $n=16$ ). This means that nitrogen retention from consumption and protein digestibility with the addition of concentrate and supplements correlated with the rate of livestock body weight gain.

**Characteristics of rumen fermentation**

Table 4 shows that the addition of 30% concentrate did not affect rumen pH, but the mixture of concentrate and

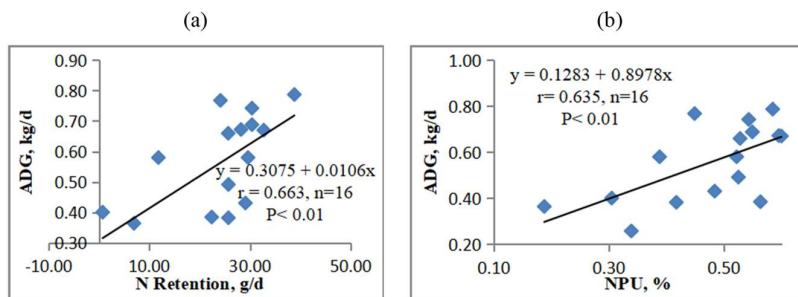
supplement significantly decreased rumen pH ( $P<0.05$ ). The decrease in rumen pH occurred due to a 16.15% increase in total VFA concentration in the rumen fluid after supplement addition. Supplement administration significantly increased rumen fluid NH<sub>3</sub> concentration ( $P<0.05$ ), while concentrate had no effect. NH<sub>3</sub> is the primary nitrogen source for rumen microbes in microbial protein synthesis, as evidenced by the correlation between NH<sub>3</sub> concentration and microbial protein concentration in the rumen fluid shown in Fig. 2a.

The highest VFA: NH<sub>3</sub> balance (53.07) was found in the ration with concentrate addition due to faster carbohydrate fermentation than ammonia release from protein degradation. The results of the regression analysis (Fig. 3a) showed a correlation between the VFA: NH<sub>3</sub> balance and microbial protein synthesis in the rumen ( $P<0.01$ ,  $r=0.653$ ,  $n=16$ ).

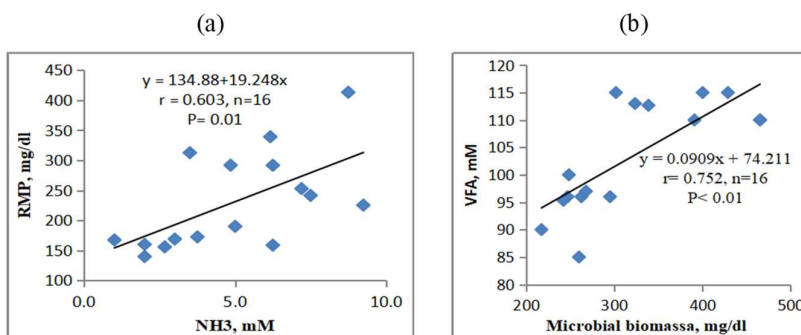
**Table 4:** Protein digestibility and rumen microbial protein production

Parameters	A	B	C	D	SEM	P-value
Characteristics of rumen fermentation						
pH	7.60 <sup>a</sup>	7.43 <sup>ab</sup>	7.33 <sup>b</sup>	7.20 <sup>b</sup>	0.06	0.03
NH <sub>3</sub> (mM)	3.48 <sup>b</sup>	2.94 <sup>b</sup>	7.20 <sup>a</sup>	6.17 <sup>a</sup>	0.90	0.04
Total VFA (mM)	95.33 <sup>b</sup>	97.00 <sup>b</sup>	112.67 <sup>a</sup>	110.00 <sup>a</sup>	3.25	0.03
Total VFA: NH <sub>3</sub>	31.23 <sup>b</sup>	53.07 <sup>a</sup>	16.73 <sup>c</sup>	19.47 <sup>c</sup>	6.64	0.04
Microbial proteins in the rumen						
Protozoan population (cell.10 <sup>5</sup> /mL)	2.088 <sup>b</sup>	3.420 <sup>a</sup>	3.834 <sup>a</sup>	2.311 <sup>b</sup>	0.27	0.02
Microbial biomass (mg/dl)	242.13 <sup>c</sup>	267.71 <sup>c</sup>	338.58 <sup>b</sup>	465.13 <sup>a</sup>	17.02	<0.01
Microbial proteins (mg/dl)	155.78 <sup>c</sup>	172.45 <sup>c</sup>	252.90 <sup>b</sup>	308.78 <sup>a</sup>	10.23	<0.01
TCA-soluble protein (mg/dl)	293.13 <sup>c</sup>	345.63 <sup>bc</sup>	555.39 <sup>ab</sup>	598.25 <sup>a</sup>	54.70	0.03
RUDP (mg/dl)	137.34 <sup>b</sup>	173.18 <sup>b</sup>	302.49 <sup>a</sup>	311.76 <sup>a</sup>	38.77	0.04
Microbial protein (MP) synthesis						
Urinary allantoin (mmol/d)	31.53 <sup>b</sup>	32.93 <sup>b</sup>	46.21 <sup>a</sup>	48.78 <sup>a</sup>	3.05	0.03
Uric acids (mmol/d)	5.56 <sup>b</sup>	5.81 <sup>b</sup>	8.15 <sup>a</sup>	8.61 <sup>a</sup>	0.54	0.03
Purine derivatives (mmol/d)	37.09 <sup>b</sup>	38.74 <sup>b</sup>	54.37 <sup>a</sup>	57.39 <sup>a</sup>	3.59	0.03
Microbial proteins (g/d)	90.98 <sup>c</sup>	98.33 <sup>c</sup>	163.94 <sup>b</sup>	203.61 <sup>a</sup>	11.58	<0.01
EMPS (gPM/gDOMR)	8.19 <sup>b</sup>	7.58 <sup>b</sup>	14.12 <sup>a</sup>	15.89 <sup>a</sup>	1.43	0.03

Numbers with different lowercase letters on the same row are significantly different ( $P<0.05$ ). Ration A = control (100% Fermented straw); B 70% Fermented straw + 30% concentrate; C = 70% Fermented straw + 20% concentrate + 10% supplement; D = 70% Fermented straw + 15% concentrate + 15% supplement. RUDP (rumen undegraded dietary protein) = TCA soluble protein - MP; EMPS = efficiency of microbial protein synthesis (gMP/gDOMR) assuming rumen digestibility = 65% of total digestibility; DOMR = digested organic matter in the rumen.



**Fig. 1:** (a) Correlation of N retention with body weight gain and (b) NPU with cow body weight gain.



**Fig. 2:** A. Correlation of NH<sub>3</sub> with rumen microbial proteins (RMP); b. correlation of VFA with rumen microbial biomass.

**Microbial proteins in the rumen**

The highest protozoa population (3.420 and 3.834 cells.10<sup>5</sup>/mL) was found in the ration with the addition of concentrate and supplement at 10% level (Table 4). In contrast, the supplement at the 15% level decreased the protozoa population to an approach to the control ration population, namely 2.088-2.311 cells.10<sup>5</sup>/mL (P=0.02). Microbial biomass and protein in the rumen fluid were not affected by the addition of concentrate (P>0.05), but increased significantly with the addition of supplements (P<0.01). The concentration of microbial protein in rumen fluid (mg/dL rumen fluid) correlated (P<0.01) with the supply of microbial protein, as measured by urinary allantoin concentration (Fig. 3b).

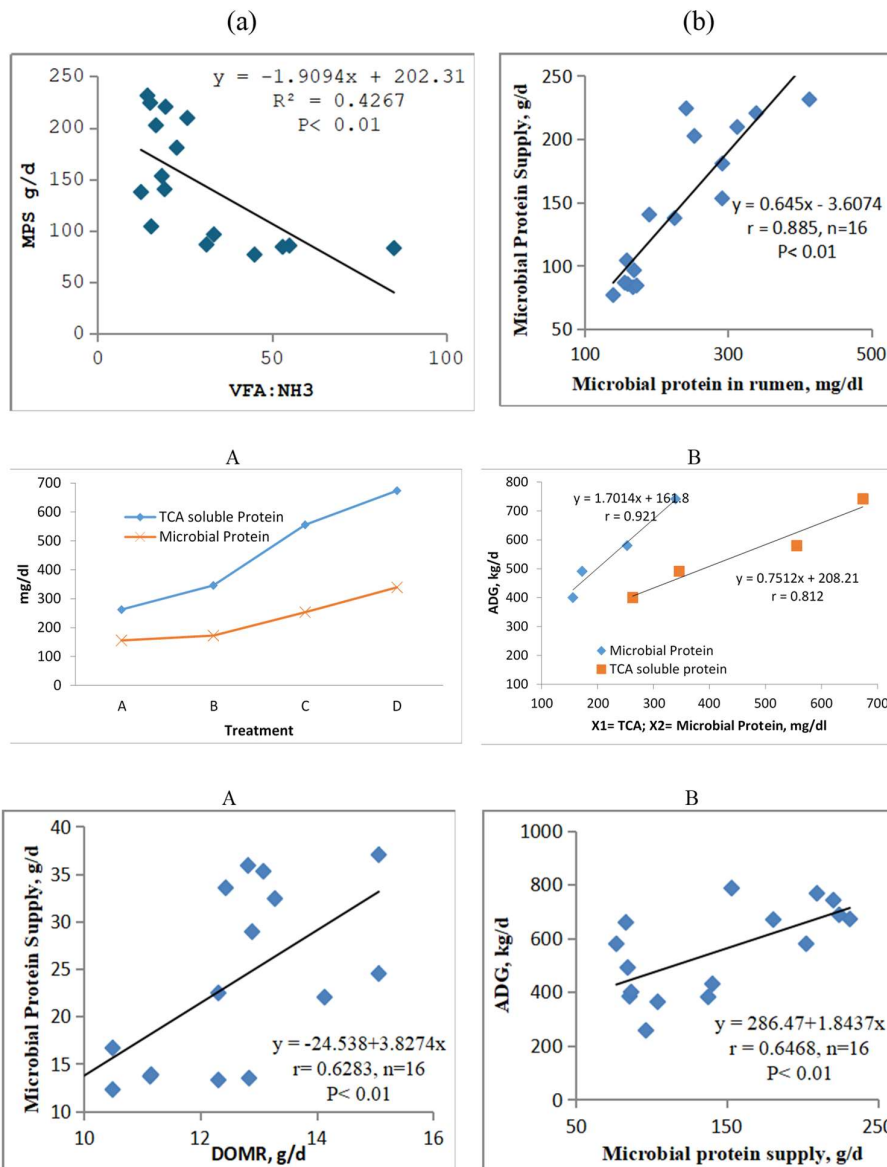
**Microbial protein synthesis**

The efficiency of microbial protein synthesis (g microbial protein/gDOMR) showed that the addition of supplements increased (P<0.05) the efficiency of microbial protein synthesis from 8.19gPM/gDOMR in the control to 14.12gPM/gDOMR (Fig. 4a). At the same time, the

addition of concentrate had no significant effect on the efficiency of microbial protein synthesis, with a value of 7.58gPM/gDOMR (Fig. 4b). It has been shown in Fig. 5a that the efficiency of microbial protein synthesis correlated (P<0.01) with digested organic matter in the rumen with  $Y = 3.8274X - 24.538$ ;  $R^2 = 0.3948$ . The correlation between microbial protein synthesis and cow body weight gain has been shown in Fig. 5b. This study found that microbial protein synthesis ranged between 90.98-203.61g/day and resulted in an increase in body weight of 0.400-0.742kg/day in Bali cattle.

**Livestock performance**

The performance of the research animals is shown in Table 5, which shows that the initial and final body weights of the Bali cattle used in this study were not significantly different (P>0.05). The control body weight gain was 0.400kg/day. It was not influenced by the addition of concentrate (P>0.05) but increased with the addition of 10% supplement to 0.580kg/day, and the highest was with 15% supplement, namely 0.742kg/day (P<0.01).



**Fig. 3:** a) Correlation of VFA:NH3 with microbial protein synthesis; b) correlation of microbial protein in the rumen with the rate of microbial protein synthesis.

**Fig. 4:** A) Effect of treatment on microbial proteins. TCA soluble protein and RUDP; B) Regression of microbial protein and TCA soluble protein with body weight gain.

**Fig. 5:** a. Correlation of digested organic matter in the rumen (DOMR) with microbial protein synthesis. b. Correlation of microbial protein synthesis with cow body weight gain.

**Table 5:** Livestock performance on forage rations, concentrates and supplements

Parameter	A	B	C	D	SEM	P-value
Initial body weight (kg)	242	241	236	234	3.98	0.25
Final body weight (kg)	246	248	245	247	4.55	2.37
Weight gain (kg/d)	0.400 <sup>c</sup>	0.491 <sup>b</sup>	0.580 <sup>b</sup>	0.742 <sup>a</sup>	0.04	<0.01
FCR	14.38 <sup>a</sup>	13.65 <sup>a</sup>	11.85 <sup>a</sup>	8.56 <sup>b</sup>	0.86	0.03
Ration costs (\$/d)	0.55 <sup>c</sup>	0.71 <sup>b</sup>	0.78 <sup>a</sup>	0.80 <sup>a</sup>	0.01	<0.01
Income (\$/d)	1.16 <sup>c</sup>	1.43 <sup>bc</sup>	1.68 <sup>b</sup>	2.15 <sup>a</sup>	0.12	<0.01
Income from feed costs (\$/d)	0.61 <sup>b</sup>	0.71 <sup>b</sup>	0.90 <sup>b</sup>	1.36 <sup>a</sup>	0.11	0.03

Numbers with different lowercase letters on the same row are significantly different ( $P < 0.05$ ). Ration A = control (100% Fermented straw); B 70% Fermented straw + 30% concentrate; C = 70% Fermented straw + 20% concentrate + 10% supplement; D = 70% Fermented straw + 15% concentrate + 15% supplement; FCR = feed conversion ratio.

Feed conversion ratio (FCR) describes the amount of dry matter consumed in the ratio that can be converted into body weight gain. Showed that livestock with supplements was 15% lower than other rations ( $P < 0.05$ ), namely FCR = 8.56, while for other rations, the FCR range was 11.85–14.38. The addition of concentrate increased ration costs by 29.3%, resulting in a 22.8% increase in income and a 16.9% increase in IOFC. At the same time, the addition of 15% supplements, as the best result in this study, increased the additional ration costs by 44.5% and resulted in an increase in income of 83.4% and an increase in IOFC of 122.3%.

## DISCUSSION

### Ration consumption and digestibility

The increase in dry matter consumption due to the addition of concentrate occurred due to the rise in feed digestibility in almost all variables. Increasing the digestibility of feed in the digestive tract causes faster emptying of the digestive tract so that livestock can consume more feed (Hu et al. 2020). The increase in dry matter and organic matter digestibility by the addition of concentrates and supplements was due to an increase in soluble carbohydrates/starch/BETN and crude protein in the ration (Table 2), as also reported by (Souza et al. 2017) that starch and nitrogen supplementation each caused an increase in dry matter digestibility: organic materials and NDF without any interaction. Organic matter and NDF are the main components of rations for beef cattle, whereas organic matter is an organic component of protein, Carbohydrate, Fats and vitamins, while NDF is a cell wall component consisting of cellulose, Hemicellulose and lignin.

### Characteristics of crude protein digestibility of rations

The increase in protein consumed was caused by an increase in dry matter consumed due to the increased digestibility of the ration. The addition of concentrate causes an increase in the amount of crude protein consumed, followed by an almost threefold increase in the amount of digested protein. However, with the addition of supplements, the amount of protein consumed increases in proportion to the increase in the amount of digested protein. This is caused by the condensed tannin content in the supplement, which causes obstacles to protein digestibility in the rumen.

A low protein ration (less than 5%) will result in low N retention due to the degradation of muscle protein to produce amino acids for hepatic urea production to support ammonia recycling in the rumen (Batista et al. 2016). The

increase in nitrogen retention with the addition of concentrates and supplements is due to the more effective use of digested nitrogen in the body to form livestock body tissue. Net protein utilization (NPU) and biological value (BV) describe the use of protein in the animal's body as a ratio of nitrogen retention to the total nitrogen consumed and digested.

### Characteristics of rumen fermentation

The highest VFA: NH<sub>3</sub> balance (53.07) was obtained in the ration with added concentrate because carbohydrate fermentation occurred faster than releasing ammonia from protein degradation. The addition of supplements can reduce the VFA: NH<sub>3</sub> balance to 16.73-19.47 because the urea content in the supplement can be hydrolyzed quickly and supplies ammonia in the rumen (Nayohan et al. 2022). The balance of VFA:NH<sub>3</sub> is very necessary for rumen microbes in microbial protein synthesis (Ramaiyulis et al. 2025).

### Microbial proteins in the rumen

The addition of concentrate increased the protozoa population by 64% of the control due to the increased nutrients easily dissolved in the rumen. The addition of a 10% level supplement with a tannin content of 0.12% from the dry matter of the ration did not affect protozoa, thereby increasing the protozoa population to 83% of the control. Increasing the supplement level to 15% (tannin = 0.18 BK ration) caused a decrease in the protozoa population of 65.90%. Other researchers also reported that condensed tannins reduced rumen protozoa populations (Junior et al. 2017).

Adding supplements increases microbial biomass and protein, improving the rumen ecosystem through the supply of soluble nutrients and suppressing protozoan populations. Supplements containing easily soluble carbohydrates, easily degradable proteins, and macro and micro minerals are essential nutrients for the growth of rumen microbes (Cammack et al. 2018).

### Microbial protein synthesis

The supply of nitrogen and soluble carbohydrates from supplements and the depression of protozoa populations due to gambier pulp tannins in supplements have implications for microbial protein synthesis by increasing microbial biomass growth. Polyorach et al. (2016) reported that adding condensed tannin from mangosteen flour caused a decrease in protozoa as bacterial predators, increasing total bacteria from 1.0 to 2.2 × 10<sup>10</sup> cells/mL.

Increased synthesis of microbial protein absorbed in the intestine and metabolized in the animal's body is

detected from increased absorption of purine derivatives used in the animal's body to form body tissue. In Bali cattle with a lower body weight than in this study (129kg), microbial protein synthesis was higher, 273-589g/day, this results in lower body weight gain, 0.31-0.65kg/day (Sio et al. 2018).

### Livestock performance

The increase in body weight manifests several previous parameters showing the positive influence of adding concentrates and supplements to the control ratio (100% fermented straw). This research informs that the relatively low rate of body weight gain on the control ration can be increased by adding concentrates and supplements with the highest body weight gain of 0.742kg/day obtained on a ration of 70% fermented straw + 15% concentrate + 15% supplements. This is the best treatment in this research. A ratio with a balance of forage and concentrate of 60:40% produces an FCR of 11.63-13.43 (Oematan 2023). It approached the value obtained in this study with a balance of forage and concentrate of 70:30%. While adding a 15% supplement can optimize the FCR to 8.56. The addition of concentrates and supplements causes an increase in ration costs. However, it also provides higher income, so the income obtained from over-feed cost (IOFC) is much higher.

### Conclusion

This study shows that tannin supplementation from gambir leaf powder in beef cattle rations can improve nutrient digestibility and rumen fermentation efficiency, suppress protozoa populations, increase rumen microbial biomass, and supply microbial protein to livestock, resulting in increased cattle weight gain and ration efficiency. The best results in terms of livestock performance and profitability were achieved with a ration containing 70% forage, 15% concentrate, and 15% supplements.

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