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Research Article

Performance of Male Bali Cattle Fattened by Complete Feed which Fish Meal Containing as a Protein Source

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Abstract | This study aimed to determine the effect of using a complete feed containing fish meal as a protein source on the performance of fattened male Bali cattle. Cattle used were 15 heads, in the age range of 2 – 2.5 years with an initial body weight range of 158.333±31.565 - 195.333±22.189 kg. Cattle were divided into three ration treatment, where each treatment group consisted of 5 cattle. Ration formulations of T1, T2 and T3 contained fish meal levels of 4%, 8% and 12%, respectively. The observed research variables included consumption of nutrients and digestibility of feed, as well as cattle growth performance which includes daily body weight gain, conversion and feed efficiency. The results of this study showed that the consumption (kg/head/day) of DM, OM,, CP, CF and energy consumption (Kcal/g/DM) were relatively the same between treatment. Digestibility (%) of DM, OM, CP, CF and energy were relatively the same between treatment. The T3 treatment showed higher daily body weight gain (ADG) (P<0.05) with optimal feed conversion and efficiency than T1 and T2 treatment. Therefore, it can be concluded that the use of fish meal levels of 12% in a complete feed improves the growth performance of fattened male Bali cattle.

Keywords | Complete feed, Consumption and digestibility of feed, Growth performance, Bali cattle, Fish meal.

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INTRODUCTION

Fattening is one of cattle rearing activities in the final phase of growth whose goal is to produce optimal carcasses and high-quality meat. To produce high-quality meat, the synthesis of body tissue during cattle fattening activities needs to be maximized by providing the high-quality feed.

Bali cattle fattening has become one of the activities carried out by farmers/breeders in North Central Timor Regency, East Nusa Tenggara. In this area, cattle rearing activities have been carried out for generations. Nevertheless, cattle rearing by farmers/breeders are still faced with classic problems that continue to haunt cattle rearing activities, such as the lack of feed in the dry season which must be immediately found solution (Tahuk and Dethan, 2010).

Due to the lack of feed, both in quality and quantity, there are differences in the performance of fattened cattle in the rainy and dry seasons. In the rainy season, cattle growth is positive—which is indicated by higher body weight gain. On the other hand, in the dry season, cattle growth is negative, sometimes even causing death. The report of Tahuk et al. (2018) showed that the daily body weight gain (ADG) of fattened male Bali cattle on smallholder farms in West Timor during the rainy season reached 0.51±0.16 kg/head/day; on the other hand, during the dry season, it decreased to 0.30±0.16 kg/head/day. This data illustrate that the effect of the season is real in determining the positive or negative performance of Bali cattle reared by farmers/breeders.

In addition to the suboptimal cattle performance problem, another consequence of the lack of feed in the dry season is the cattle fattening cycle carried out by farmers/breeders which is not continuous throughout the year. This is done by farmers/breeders to avoid the risk of weight loss of cattle which will have an effect on the low selling value of cattle.

Complete feed production can be an alternative technology to provide feed with sufficient nutrition to meet the needs of cattle so that cattle fattening activities can be carried out throughout the year. The development of a complete feed is also expected to minimize the negative effect of fluctuations in cattle feed due to the effect of the season in the tropics, besides contributing to the improvement of cattle performance, which in turn will increase the income of farmers/breeders.

According to Tahuk and Bira (2020), the application of complete feed for cattle fattening is one of the solutions offered to overcome the problem of the lack of feed in the dry season due to the availability of sufficient stock of feed ingredients to meet the needs of cattle. In fattened male Bali cattle, an experimental test of using a complete feed containing plant protein sources made a positive contribution in improving performance. This is in accordance with the report of Tahuk et al. (2022) which stated that the use of *Gliricidia sepium* leaf meal as a protein source in a complete feed could increase the weight gain of fattened male Bali cattle in the range of 0.775±0.066 – 0.985±0.071 kg/head/day; and the percentage of carcass produced was in the range of 50.61±1.595% - 51.140±0.512 %.

Protein is one of the nutrients that have a very important role in the synthesis of body tissues, especially muscle tissue. Therefore, the sufficiency of protein in the ration given to cattle greatly determines the growth of their muscle tissue.

Although protein is a very important building block for livestock, the availability of protein feed sources in the tropics is not continuous throughout the year, especially during the dry season. The discontinuity of the availability of protein source feed can be seen from the low body weight gain produced (Tahuk and Dethan, 2010). Therefore, to ensure the performance of Bali Cattle which are fattened throughout the year, one alternative that needs to be done by farmers is to use other protein sources, such as fish meal which is a source of animal protein feed.

Fish meal is an animal protein source that can meet the protein needs of fattened cattle. According to Hartadi et al. (1980), the CP (Crude protein) content of fish meal can range from 52.6 - 72%. A similar opinion was also expressed by Windsor (2001), who stated that fish meal contains 66% protein, 5% fat, 8% water and 21% minerals.

The CP content and high palatability have made the fish meal one of the animal feed ingredients that can be used as a potential complete ration mixing feed ingredient. Therefore, the application of using fish meal in a complete feed is expected to improve the performance of fattened male Bali cattle when compared to using vegetable protein sources. Although it is very potential as a protein source feed to meet the needs of cattle, the use of fish meal in a complete feed to improve the performance of fattened male Bali cattle is still lacking in scientific information. Therefore, this study needed to be done to explore and obtain this scientific information.

MATERIALS AND METHODS

Ethical approval

This study did not require approval from the ethics committee because the treatment did not harm the livestock used.

Time and location

This study was carried out at the Experimental Cage, Faculty of Agriculture, Universitas Timor from April to October 2021. Analysis of the samples of feed, feces and urine were carried out at the Feed Chemistry Laboratory, Faculty of Animal Husbandry, Universitas Nusa Cendana, Kupang.

Cattle, Feed and Research Design

Cattle: There were 15 male Bali cattle used in this study with an age range of 2 – 2.5 years according to the estimated teeth. Cattle had an initial body weight range of 158.333±31.565 - 195.333±22.189 kg. The expected daily body weight gain (ADG) during the observation was 0.75 kg/head/day.

Feed: The complete ration used consisted of fish meal as a protein source; field grass as a fiber source; milled corn, pollard bran and rice bran as easily digestible carbohydrates sources (Table 1 and 2).

Research design: This study used a completely randomized design (CRD) with a unidirectional pattern. 15 male Bali cattle used were divided into three ration treatment groups. The number of cattle in each treatment group was 5 heads. The ration formulation for each treatment group was T1 with 4% fish meal levels, T2 with 8% fish meal levels and T3 with 12% fish meal levels. Each treatment group had different CP content and energy (TDN); where T1 treatment group had a CP content of 11%, TDN of 72%; T2 treatment group had a CP content of 13%, TDN of 72%;

Table 1: Proportion Feed ingredients (%) and Composition nutrient of complete feed

Feed Ingredients	Proportion feed ingredients (%)	Composition nutrient of complete feed	
		CP (%)	TDN Content (%)
T1			
Field grass	30	2.1	17.4
Milled corn	89	4.6	37.8
Rice bran	13	0.9	6.6
Pollard bran	11	1.8	8.1
Fish meal	4	2.1	2.0
Total	100	11.5	72.0
T2			
Field grass	30	2.1	17.4
Milled corn	42	4.6	37.8
Rice bran	9	0.6	4.6
Pollard bran	11	1.8	8.1
Fish meal	8	4.2	4.1
Total	100	13.3	72.0
T3			
Field grass	30	2.1	17.4
Milled corn	42	4.6	37.8
Rice bran	5	0.3	2.5
Pollard bran	11	1.8	8.1
Fish flour	12	6.3	6.1
Total	100	15.1	**72.0**

Table 2: Nutrient contents of feed ingredients and complete ration for male Bali cattle fattening

Feed Ingredients	Nutrient Content										
	DM (%)	OM (% DM)	CP	EE	CF	CHO	NFE	TDN (%)	GE		ME
									MJ/ kg.DM	Kcal/ kg.DM	Kcal/ kg.DM
Field grass	88.986	77.388	5.318	0.805	28.221	71.266	43.045	51.086*	13.892	3307.69	2123.13
Fish meal	85.260	76.397	21.377	3.403	11.137	51.617	40.479	64.655*	15.272	3636.16	2848.33
Milled corn	85.950	83.012	9.609	8.967	3.059	64.437	61.378	94.992*	16.535	3937.01	3750.37
Pollard bran	87.165	82.663	16.648	3.329	6.902	62.685	55.784	83.339*	16.015	3813.19	3302.04
Rice bran	89.691	77.062	10.444	8.181	15.103	58.436	43.334	91.183*	15432	3674.28	2960.72
Ration											
T1	88.047	80.466	14.866	5.542	14.070	60.058	45.988	78.934**	15.884	3781.88	3014.04
T2	87.355	79.633	15.589	5.058	14.167	58.986	44.820	77.841**	15.709	3740.13	2951.32
T3	87.464	70.582	16.671	3.397	14.863	59.514	44.651	76.747**	15.495	3689.39	2843.36

Note: DM=dry mater; OM=organic matter; CP=crude protein; EE=extract eter; CF=crude fiber; CHO=carbohydrates; NFE=nitrogen free extract, calculated by the equation: NFE=[100 – (ash content + CF content + EE content + CP content)] %; TDN*= Total digestible nutrients, calculated by the equation of Hartadi *et al.* (1990); GE = gross energy; ME= energy metabolism; T1= Complete ration with CP content of 11%, TDN of 72%; T2= Complete ration with CP content of 13% and TDN of 72%; T3= Complete ration with CP content of 15% and TDN of 72%.

and T3 treatment group had a CP content of 15%, TDN of 72%. To meet the mineral needs of cattle, mineral premix was added to the ration. The mineral composition given to cattle consisted of Calcium Carbonate 50%, Phosphorus 25%, Manganese 0.35%, Iodine 0.20%, Potassium 0.10%, Cuprum 0.15%, Sodium Chlorine 15.00%, Iron 0, 80%, 0.20% Zinc and 0.15% Magnesium.

Research variables and data collection

Research variables: The variables measured in this study included: 1) Consumption of nutrients and digestibility of feed; 2) Cattle growth performance which includes daily body weight gain, conversion and feed efficiency.

Data collection: The data collection lasted for 14 weeks, which was divided into 2 stages, the adaptation stage for 2 weeks (14 days) and the data collection stage for 12 weeks. Provision of ration during data collection was provided twice a day, namely in the morning at 08.00 WITA (local time) and in the afternoon at 16.00 WITA (local time). Drinking water was provided ad libitum.

Feed consumption: Feed consumption was calculated from the difference between the amount of feed given and the remaining feed for 24 hours. The calculation was done using the following equations:
a. Consumption of DM (dry matter) (g): {feed given (g) x (% DM)} – {remaining feed (g) x % DM)}
b. Consumption of OM (g) = {feed given (g) x %OM) x (%OM)} – {remaining feed (g) x %DM) x (%OM)}
c. Consumption of CP (g) = {feed given (g) x %DM) x (%CP)} – {remaining feed (g) x %DM) x (%CP)}
f. Consumption of CF (g) = {feed given (g) x %DM) x (%CF)} – {remaining feed (g) x %DM) x (%CF)}

Digestibility of feed nutrients: The digestibility of feed nutrients was measured using the total collection method (Harris, 1970). The digestibility of feed nutrients measured included DM, OM, CF, CP and TDN. The measurement of dry matter digestibility (%) was done using the following equation (Cullison, 1979):

Digestibility of DM (%)= (A-B)/A x 100%

Where: A: average dry matter of feed consumed (g) and B: average dry matter of excreted feces (g). Digestibility of feed nutrients was calculated using the following equation:

Digestibility of nutrients (ND,%)=(A x a (%)-B x b (%))/ (A x a (%)) x 100%

Where: a = nutrient contents in feed A (%); b = nutrient contents in feces B (%)
Digestible Nutrients (%) = ND (%) x Feed Ingredients Nutrients (%). Total digestible nutrients was calculated using the following equation:
TDN (%) = digested CP + digested CF + digested NFE + (digested EE x 2.25)

Daily weight gain (ADG) was calculated from the difference between the final body weight and the initial body weight divided by the length of rearing. The equation used was: ADG (kg) = final weight (kg) – initial weight (kg)/ rearing time (days).

Feed conversion ratio/ rate (FCR): was calculated from the comparison of dry matter consumption (kg) per day with daily body weight gain (kg) of cattle.

Feed efficiency: was calculated from the comparison of daily body weight gain (kg) of cattle with dry matter consumption (kg) per day. The equations used to calculate these two variables was:
Feed conversion = DM Consumption (kg)/ADG; and feed efficiency = ADG (kg)/ DM Consumption (kg) x 100%.

Data analysis

Data were analyzed using analysis of variance according to the Completely Randomized Design (CRD) procedure. To simplify and speed up the analysis, the SPSS 19 software tool was used (Steel and Torrie, 1995).

RESULTS AND DISCUSSION

Feed Consumption

Consumption of Dry Matter (DM) and Organic Matter (OM): The results of this study showed that the consumption of dry matter (DM), organic matter (OM) was relatively the same (P>0.05) between treatment groups (Table 3). The consumption of dry matter (DM) and organic matter (OM) of fattened male Bali cattle in this study was generally sufficient for the needs of cattle to improve growth performance. This was indicated by a fairly high daily body weight gain. The consumption of DM and OM, which were not much different between treatment groups in this study, showed that a complete feed containing fish meal at levels of 4%, 8% and 12% with CP ration of 11%, 13% and 15% had high palatability so that the cattle response in the three treatment groups to consume it was also relatively the same. In addition, the consumption of OM that was relatively the same is influenced by the consumption of DM, where the relatively equal consumption of DM in the three treatment groups of cattle also contributed to the relatively equal consumption of OM.

The increased response of cattle in the three treatment groups to increase the consumption of a complete feed was influenced by the feed ingredients that make up the ration, which were quite palatable and contained sufficient nutrients, especially energy and protein. If the feed consumed by cattle contains sufficient energy and protein, the rumen microbial activity to digest feed is higher. As a result, the rate of emptying is faster, which stimulates cattle to consume more feed to meet their needs.

Table 3: Consumption feed for fattened male Bali cattle fed a complete feed containing fish meal as a protein source[1]

Variable	Treatment		
Dry matter (DM)	T1[2]	T2[2]	T3[2]
Consumption (kg/day)[ns]	3.989±0.770	3.650±0.613	4.524±0.434
Consumption (g/BW^0.75)[3ns]	69.420±5.923	66.684±6.856	71.909±2.185
Consumption/BW (%)[ns]	2.220±0.068	2.209±0.374	2.382±0.115
Organic matter (OM):			
Consumption of OM (kg/day)[ns]	3.262±0.627	2.992±0.503	3.702±0.354
Consumption of OM (g/BW^0.75)[3ns]	56.779±4.838	54.676±5.619	58.801±1.787
Consumption of OM/DM (%)	81.790±0.016[a]	81.993±0.007[b]	81.772±0.022[a]
Crude Protein (CP):			
Consumption of CP(kg/day)[ns]	0.506±0.106	0.460±0.083	0.564±0.059
Consumption of CP(g/BW^0.75)3ns	8.799±0.884	8.36740±0.940	8.955±0.378
Consumption of CP/DM (%)[ns]	12.662±0.307	12.540±0.221	12.453±0.387
Crude Fiber (CF):			
Consumption of CF (kg/day)ns	0.436±0.084	0.392±0.066	0.554±0.054
Consumption of CF (g/BW^0.75)[3]	11.401±0.775[a]	11.033±1.033[a]	13.217±0.648[b]
Consumption of CF/DM (%)	16.450±0.589[a]	16.560±0.432[a]	18.379±0.691[b]
Gross Energy :			
- MJ/KgDM (dry matter)/day[ns]	62.916±12.246	57.736±9.746	70.968±6.840
- Kcal/kgDM (dry matter)/day[ns]	14979.526±2915.230	13746.152±2320.489	16861.052±1617.329
Metabolic Energy: (Kcal/KgDM (dry matter)/day[ns]	11689.592±2330.739	10673.898±1835.641	12768.236±1261.254

1Data served in mean ± SD;
2T1= Complete ration with CP content of 11%, TDN of 72%; T2= Complete ration with CP content of 13% and TDN of 72%; T3= Complete ration with CP content of 15% and TDN of 72%;
3BW$^{0.75}$= metabolic body weight;
a, bdifferent superscripts on the same line showed differences (P<0.05)

ns = *non-significant*

Table 4: Consumption of ADF, NDF and Lignin of feed for fattened male Bali cattle fed a complete feed containing fish meal as a protein source[1]

Variable	T1[2]	T2[2]	T3[2]
Consumption of ADF (kg/day)	0.538±0.072[a]	0.522±0.074[a]	0.701±0.089[b]
Consumption of NDF (kg/day)	0.968±0.129[a]	0.950±0.135[a]	1.274±0.162[b]
Consumption of Lignin (kg/day)	0.164±0.0224[b]	0.162±0.023[b]	0.07680±0.017[a]
Consumption of Cellulose (kg/day)	0.272±0.0.365[a]	0.269±0.038[a]	0.38080±0.048[b]
Consumption of Hemicellulose (kg/day)	0.431±0.058[a]	0.428±0.061[a]	0.57140±0.073[b]

1Data served in mean ± SD;
2T1= Complete ration with CP content of 11%, TDN of 72%; T2= Complete ration with CP content of 13% and TDN of 72%; T3= Complete ration with CP content of 15% and TDN of 72%;
3BW$^{0.75}$= metabolic body weight;
a, bdifferent superscripts on the same line showed differences (P<0.05)

The use of fish meal at a level of 12% has not had a negative effect such as decreasing the palatability of the ration. In addition, the combination of fish meal as a protein source and concentrates of easily digestible energy sources such as milled corn, rice bran and pollard bran has provided balanced nutrition to meet the needs of cattle. As a result, the palatability of the ration increased so that the cattle preferred to eat up the feed given. The level of feed consumption of the three treatment groups contributed to the sufficient nutrient needs of cattle for basic living activities and growth.

Table 5: Fiber fraction content of feed ingredients for a complete ration containing fish meal as a protein source

Feed Ingredients	NDF	ADF	Cellulose	Lignin	Hemicellulose
Field grass	44.614	66.063	24.28	14.21	21.449
Concentrate 1	16.934	44.81	6.860	4.60	27.877
Concentrate 2	17.489	46.98	7.734	5.00	29.494
Concentrate 3	18.533	48.44	9.925	5.44	29.908
Ration 1	25.058	54.99	14.31	7.92	29.939
Ration 2	24.074	53.06	13.80	6.98	28.995
Ration 3	23.781	52.65	12.24	6.29	28.870

*The results of the analysis of the Feed Chemistry Laboratory, Faculty of Animal Husbandry, Universitas Nusa Cendana, Kupang, 2021

Table 6: Digestibility of feed for fattened male Bali cattle fed a complete feed containing fish meal as a protein source[1]

Digestibility	T1	T2	T3
Dry matter (DM, %)[ns]	53.487±3.131	52.586±8.242	55.574±6.335
Organic matter (OM,%)ns	54.638±3.099	54.179±7.886	57.617±6.457
Crude Protein (CP, %)[ns]	80.387±1.184	77.602±7.641	80.413±6.753
Crude Fiber (CF, %)[ns]	25.3798±4.931	23.988±11.808	27.957±15.378
Gross Energy (%)[ns]	56.212±3.046	55.647±7.983	59.435±6.502

1Data served in mean ± SD;
2T1= Complete ration with CP content of 11%, TDN of 72%; T2= Complete ration with CP content of 13% and TDN of 72%; T3= Complete ration with CP content of 15% and TDN of 72%;
ns = non-significant

Table 7: Growth performance of fattened male Bali cattle fed a complete feed containing fish meal as a protein source[1]

Variable	T1[2]	T2[2]	T3[2]
Initial weight (kg)[ns]	189.000±24.637	158.333±31.565	195.333±22.189
Final weight (kg)[ns]	236.667±38.083	220.40±30.930	261.667±25.027
Weight gain (BWG) (kg)	47.667±9.292[a]	49.000±10.536[a]	66.333±5.033[b]
Daily weight gain (ADG) (kg/head/day)	0.757±0.148[a]	0.778±0.168[a]	1.053±0.080[b]
Feed conversion	5.707±0.939	5.103±0.815	4.529±0.262
Feed efficiency (%)[ns]	17.819±2.702	19.962±3.454	22.129±1.270

1Data served in mean ± SD;
2T1= Complete ration with CP content of 11%, TDN of 72%; T2= Complete ration with CP content of 13% and TDN of 72%; T3= Complete ration with CP content of 15% and TDN of 72%;
a, bdifferent superscripts on the same line showed differences (P<0.05)
ns = *non-significant*

The need for DM for young male cattle weighing 200 kg with an expected daily weight gain target of 0.75 kg/day reaches 5.4 kg or 2.7% of body weigh (Kearl, 1982). In this study, the consumption of DM of cattle in the three treatment groups was relatively lower than the standard above. This condition illustrates that increasing feed quality has an effect on decreasing feed consumption due to sufficient nutrition, especially energy. It is proven in this study, that the use of a complete feed rich in protein and energy can meet the nutritional needs, especially energy, thereby limiting cattle to continue to increase feed consumption. According to Cooke (2018), energy is the main component in cattle nutrition that must be fulfilled; and to meet their energy needs, cattle need to get an energetic feed intake. Energy requirements of cattle depend on their age, gender, body size, physiological state and environment. Therefore, in cattle ration that lack energy, energy supplementation in cattle ration is carried out to optimize the appearance (performance) of cattle. According to Valento et al. (2013), the need for net energy for maintenance is influenced by the body weight of cattle. Lower body weight will reduce energy requirements for basic living.

Sufficient consumption of DM (dry matter) and nutrients in the three groups of experimental cattle was evidenced by the achievement of growth performance (daily weight gain), namely, in T1 treatment group was 0.757±0.148 kg/head/day; T2 treatment group was 0.778±.167574 kg/

head/day; and T3 treatment group was 1.053 ± 0.080 kg/head/day (Table 7).

In general, the average consumption of DM (%BW) in the three treatment groups had reached 2% of BW. Consumption of such DM feed is sufficient to meet basic living needs and production needs of cattle. The need for dry matter (DM) in growing beef cattle is in the range of 2 – 2.5% of body weight (Vickers, 2019). In line with that, according to Aregheore and Yahaya (2001), the ability of ruminants to consume feed ranges from 40 - 90 g/kg.$BW^{0.75}$/day or 1 - 2.8% of their live body weight. Referring to these recommendations, the achievement of consumption of DM in this study was within the normal range to meet the needs of cattle.

Feed consumption in cattle varies and is influenced by factors such as cattle species, body weight, body size, age and condition, physiological status, digestive tract condition and capacity; also level of feed palatability, type and physical properties of feed, the energy content of feed and availability of drinking water and the environment (Vickers, 2019; Mayulu et al., 2021). Different types of cattle, for example, small cattle with a small body will also have different feed requirements from cattle with a large body. Besides, other factors that are quite influential are the genetic potential and gender of cattle (Vickers, 2019).

The consumption of DM (dry matter) in the results of this study was lower than what was reported by Tahuk et al. (2017) who obtained consumption of DM (kg/head/day) of 4.60 ± 0.60 in fattened Bali cattle according to rearing habits on smallholder farms; and consumption of DM of 7.76±0.28 kg/head/day and 6.60±0.24 kg/head/day in male Bali cattle on ration containing different CP levels of 12% and 15% (Tahuk et al., 2017). On the other hand, the consumption of DM (dry matter) in the results of this study was higher than what was reported by Tahuk and Dethan (2010) who obtained consumption of DM of 3.88 kg/head/day for Bali cattle reared during the rainy season on smallholder farms. Also, the consumption of DM in the results of this study was almost the same as what was reported by Tahuk et al. (2018) who obtained consumption of DM of 4.29±0.76 kg/head/day in male Bali cattle reared during the dry season but higher than what was reported by Tahuk et al. (2018) who obtained consumption of DM of 3.33±0.55 kg/head/day in male Bali cattle reared during the rainy season.

Consumption of crude protein and crude fiber: The average consumption of crude protein (CP) in male Bali cattle fed a complete feed containing fish meal as a protein source was relatively the same between treatment groups. The consumption of crude fiber (CF) (kg/day) was also not much different, where the cattle in T1 - T3 treatment groups had relatively the same CF consumption (P> 0.05). The consumption of dry matter (DM) which was quite high and relatively the same in the results of this study was directly proportional to the consumption of crude protein (CP) which was also not much different between treatment groups. It can be seen that the consumption of CP in the results of this study met the basic needs of life, so the excess was used to meet the production needs of cattle, where the percentage of the needs of CP from DM consumed by each cattle, namely, T1 treatment group was 12.662±0.307%, T2 treatment group was 12.540±0.221% and T3 treatment group was 12.453±0.387%. Sufficient needs for CP in cattle can be seen from the increase in cattle performance which is indicated by the increase in daily body weight gain obtained by cattle (Table 7).

The consumption of crude fiber (CF) in the results of this study also illustrates the quality of the feed used when it is associated with the palatability of the ration. Besides, the proportion of feed ingredients that made up the ration, especially field grass, which was the same between treatment groups contributed to the consumption of CF, which was not much different between treatment groups.

In general, field grass which is a fiber source for cattle, when the proportion of its use in the ration is the same, contributes to consumption that is not much different between treatment groups. In accordance with the results of the proximate analysis, the CF content used in this study reached 35.659%. The high CF content with the proportion of use reaching 30% in each treatment ration contributed to the increase in the consumption of CF ration by experimental cattle in each treatment group which was not much different. In addition to field grass, the increase in consumption of CF in this study came from rice bran which has an CF content of 18.290%. Crude fiber is a structural carbohydrate source for cattle.

The consumption of CF in the results of in this study was different from what was reported by Tahuk et al. (2022) who obtained consumption of CF (kg/day) ranging from 0.679±0.054 - 0.840±0.113 kg/head/day in male Bali cattle fed a complete feed containing *Gliricidia sepium* leaves as a protein source. The difference in the consumption of CF is influenced by the high and low consumption of DM, cattle body weight—and the type and chemical composition of feed ingredients that make up the ration. Therefore, the consumption of DM in the results of this study was lower than the consumption of DM of male Bali cattle reared on smallholder farms during the rainy season of 0.67±0.12 kg/head/day (20.04±1.50%) and during the dry season of 0.96±0.20 (22.23±1.82%) (Tahuk et al., 2018).

Energy Consumption: The consumption of gross energy (GE) (Kcal/kg.DM) of male Bali cattle in the three treatment groups was relatively the same (P>0.05) (Table 4). The results of this study described the response of cattle in the three treatment groups to a complete feed containing fish meal as a high enough protein source. This has an effect on increasing cattle energy consumption to meet basic living and production needs.

Energy is a very important component that needs to be met by cattle in their feed consumption. Sufficient energy needs can support normal body activities, rumen microbial activity in digesting feed and play an important role in supporting the maximum utilization of feed protein to meet the needs of cattle. According to Chooke (2018), beef cattle need energy to meet basic living needs, grow and maintain the body's immune system so that cattle remain healthy, as well as for lactation, reproduction and pregnancy.

Energy is the main indicator in determining the need for ruminant feed. Energy can come from various sources of feed organic matter, including fiber, carbohydrates, fats and proteins. The potential of each source of organic matter as an energy provider varies according to the level of degradability and fermentability (Haryanto, 2012). Energy is needed for every function of the body, especially those related to cattle production. Without proper energy nutrition, cattle's health, growth, reproduction and lactation are severely compromised (Vickers, 2019). In cattle rearing, giving forage alone does not provide sufficient energy for cattle. Therefore, a well-planned energy supplementation program is very important to keep cattle in sufficient levels of nutrients to improve cattle performance (Vickers, 2019).
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The high energy consumption of cattle in this study contributed to increasing cattle productivity, especially the daily body weight gain (ADG) of cattle, where cattle in T1 treatment group had ADG of 0.757±0.148 kg/head/day; T2 treatment group had ADG of 0.778±0.167574 kg/head/day, and T3 treatment group had ADG of 1.053±0.080 kg/head/day (Table 6). The increase in daily body weight gain which was quite high in cattle in T3 treatment group illustrates that the use of fish meal of 14% of the dry matter (DM) ration is sufficient for protein needs for maximum body tissue synthesis if supported by sufficient energy consumption. Therefore, synchronizing the availability of energy and protein is considered a strategy that can affect the effectiveness of fermentative microbes in the rumen which in turn will affect cattle productivity (Haryanto, 2012).

Consumption of ADF, NDF, Lignin, Cellulose, and Hemicellulose: The results of this study showed that the consumption of fiber fraction (ADF, NDF, Cellulose and Hemicellulose) (Table 4) of cattle in T3 treatment group was higher (P<0.05) than in T1 and T2 treatment groups; while between T1 - T2 treatment groups, it showed relatively the same results. On the other hand, the consumption of lignin of cattle in T1 and T2 treatment groups was relatively the same and higher (P<0.05) than in T3 treatment group.

The increase in consumption of ADF, NDF, cellulose and hemicellulose (kg/day) of cattle in T3 treatment group which received a protein level of 12% in this study was directly proportional to the consumption of DM. This condition explains that an increase in the proportion of fish meal in a complete feed stimulates the rumen microbial activity to digest crude fiber optimally. As a result, the rate of emptying is faster, which eventually has an effect on increasing feed consumption by cattle. According to Vickers (2019), increasing feed consumption is very vital for cattle because it determines optimal cattle performance during the growth phase and in the fattening phase.

Cattle in T1 and T2 treatment groups had a lower fiber fraction consumption than those in T3 treatment group, except for lignin. It can be seen that the use of fish meal at levels of 4% and 8% in a complete feed has not been optimal in its contribution to increasing the rumen microbial activity in degrading crude fiber. The high consumption of lignin in T1 and T2 treatment group when compared to T3 treatment group illustrates the condition when microbes obtain sufficient feed protein and are supported by sufficient energy.

According to Van Soest (2006), Acid Detergent Fiber (ADF) is a food substance that is insoluble in acidic detergents. The components of this nutrient consist of cellulose, lignin and silica. Cellulose is an easily digestible component of ADF; while lignin is a component that is difficult to digest because it has double bonds. Feed ingredients that have a high lignin content will have a low digestibility coefficient (Minson,1993). Neutral Detergent Fiber (NDF) is the largest part of plant cell walls. According to Belyea et al. (2022), NDF reflects the amount of forage obtained by cattle. Because forage fiber is large, there is a limit to the amount of NDF that can enter cattle's rumen, when that limit is reached, cattle will stop eating.

Digestibility of feed

Digestibility of dry matter and organic matter (DMD and OMD): Digestibility of dry matter and organic matter (DMD; OMD, %) of a complete feed containing fish meal as a protein source for male Bali cattle in the three treatment groups was relatively the same (Table 6). The digestibility of DM which ranged from 52.59±8.24 - 55.57±6.34% and OM which ranged from 54.79±7.89 –

57.62±6.46% were suboptimal (not optimal).

One important factor that needs to be considered because it ensures sufficient nutrients intake in cattle is an optimal digestion process. Feed that has a high level of digestibility will provide sufficient nutrients to meet the needs of cattle. Digestibility of dry matter and organic matter (DMD; OMD, %) of a complete feed containing fish meal as a protein source for male Bali cattle in the three treatment groups was relatively the same between treatment groups (Table 6).

This condition indicated that the use of fish meal at levels of 4%, 8% and 12% resulted in optimal nutritional content of feed, especially protein and energy to increase rumen microbial activity in digesting feed. Thus, the results showed that the complete feed quality in T1, T2 and T3 treatment groups was not much different so that the rumen microbial response to degrade DM and OM was relatively the same as well. It can be seen that the DMD and OMD scores in this fattened male Bali cattle are suboptimal, although they are sufficient to contribute to the supply of nutrients needed by cattle, both to meet basic living needs and for production needs.

The digestibility of DM which ranged from 52.59±8.24 - 55.57±6.34% and OM which ranged from 54.79±7.89 – 57.62±6.46% were suboptimal. This is due to the high content of plant cell walls (NDF, ADF, lignin, cellulose and hemicellulose) in the complete feed used. As a result, it limits the microbes in the rumen to digest the feed consumed (Table 6). In addition, the incomplete digestibility of DM and OM complete feed in the three treatment groups was thought to be related to nutrient imbalance, especially protein and energy. As a result, rumen microbial activity to digest feed is suboptimal. The digestibility of DM and OM in the results of this study was lower than what was reported by Kongphitee et al. (2018) who obtained digestibility of DM ranging from 56.4% - 74.7% and OM ranging from 60.9% - 77.5% in Thai native beef cattle given different levels of cassava. The difference in the digestibility of DM and OM is influenced by the difference in cattle species, feed ingredients and treatments given.

According to various studies, there is a negative correlation between lignin content in plants and their digestibility. The higher the lignin content in the plant, the lower the digestibility produced. Thus, an increase in plant cell walls results in a decrease in digestibility (Minson, 1993).

Digestibility of feed (especially forage digestibility) in cattle is influenced by many factors such as plant species/varieties, plant growth phase, plant fertility and plant growth temperature (Hartadi, 1990). In this study, the cause of the incomplete digestibility of the complete feed consumed by cattle was the variation in the type of feed and its composition.

The chemical and physical composition of feed which includes CP, CF, NFE and minerals as well as the length of stay of feed in the rumen can determine the digestibility of a feed ingredient in the rumen (McDonald et al., 2002). Different types of feed, besides affecting digestibility, also affect the condition of the rumen (Van Soest, 2006). The rate of digestibility of fibrous feed consumed by cattle is low because the breakdown/degradation by the microbes in the rumen is slow. This is due to the slow first physical contact which results in delayed digestive enzyme activity, causing food retention in the rumen (McDonald et al., 2002).

The digestibility of DM obtained in the results of this study was lower than what was reported by Tahuk et al. (2022) who obtained consumption of DM ranging from 53.518±2.455 – 56.528±2.275% in male Bali cattle fed a complete feed containing *Gliricidia sepium* leaves as a protein source. Furthermore, the digestibility of DM obtained in the results of this study was also lower than what was reported by Koddang (2008) who obtained a range of 59.63 – 64.11% in male Bali cattle fed a concentrate of 1.5 – 2.0% with *Pennisetum purpuroides* 100% ad libitum; and what was reported by Tahuk et al. (2017) who obtained a digestibility of DM of 62 – 76% in male Bali cattle fed a ration with different CP levels reared on smallholder farms. However, the digestibility of DM obtained in the results of this study was higher than what was reported by Koddang (2008) who obtained a range of 51.92% in male Bali cattle fed 100% *ad libitum Pennisetum purpuroides* grass without concentrate. The digestibility of OM obtained in the results of this study is lower than what was reported by Tahuk et al. (2022) who obtained a renge of 56.050±2.329 - 9.605±2.232% in male Bali cattle fed *Gliricidia sepium* leaves as a protein source. The differences in the digestibility of DM and OM from several studies and this study are caused by the differences in the type of feed and the nutritional content given to cattle.

Crude protein digestibility (CP): Digestibility crude protein (%) in male Bali cattle fed a complete feed containing fish meal as a protein source was quite high but relatively the same between treatment groups (Table 6). The average digestible crude protein (CP) obtained in each treatment in this study, namely, T1 treatment group was 0.4072±0.08833 kg/head/day; T2 treatment group was 0.3576±0.08747 kg/head/day; and T3 treatment group was 0.4520 ± 0.04664 kg/head/day.

Crude protein digestibility (%) in male Bali cattle fed a

complete feed containing fish meal as a protein source was quite high but relatively the same between treatment groups (Table 6). The relatively same digestibility of CP between treatment groups indicated that the quality of a complete feed used for fattening, containing fish meal at levels of 4% (T1), 8% (T2) and 12% (T3), was sufficient and not much different between the three treatment groups. Such feed quality can increase rumen microbial activity in degrading feed protein in the rumen.

Sufficient protein and energy content in the ration can support and increase the ability of the microbes in the rumen to digest feed. This condition indicates that the digestibility score is not constant for every food or, every cattle because it is influenced by other factors such as chemical composition, feed processing, the amount of food given and the type of animal (Kongphitee et al., 2018; McDonald et al., 2002). In this study, the CP and energy contents were sufficient to stimulate rumen microbial activity in digesting feed.

Factors that also affect digestibility of feed in cattle are the amount of feed consumed by cattle, the chemical composition of the feed including the content of feed fiber fraction, digestive disorders, feeding frequency and feed processing (Kongphitee et al., 2018). The feed obtained by cattle, if it has a high CF content it can have an effect on the lower digestibility score of the feed ingredients (Utomo, 2004).

The increase in the digestibility score of CP in this study can provide sufficient protein to meet basic living needs and production needs of cattle. Sufficient protein obtained by cattle contributes to the increase in body tissue synthesis as indicated by the increase in daily body weight gain and the production of fattened male Bali cattle.

The average digestible crude protein (CP) obtained in each treatment in this study, namely, T1 treatment group was 0.4072±0.08833 kg/head/day; T2 treatment group was 0.3576±0.08747 kg/head/day; and T3 treatment group was 0.4520 ± 0.04664 kg/head/day. This digestibility score of CP is almost equal to—or, exceeds the crude protein requirement according to the recommendation of Kearl (1982) for male cattle weighing 150 kg at a target ADG of 0.75 kg/day, whose requirements of crude protein is 0.589 kg/day or digestible protein is 361 kg/day.

The digestibility score of CP in this study was higher than what was reported by Tahuk et al. (2018) who obtained digestibility score of CP ranging from 64 – 74% in fattened male Bali cattle with different CP levels; and what was reported by Tahuk et al. (2017) who obtained a range of 68.89 – 74.64% in fattened male Bali cattle on smallholder farms. The digestibility score of CP in this study was also higher than what was reported by Koddang (2008) who obtained a digestibility score of CP of 58.58% in male Bali cattle fed 100% of *Pennisetum purpuroides* grass *ad libitum*; and 72.48 – 74.66% in male Bali cattle fed a concentrate of 1.5 – 2.0% of body weight on administration of *Pennisetum purpuroides* 100% ad libitum. The differences in the digestibility of CP among the results of the above studies are caused by the influence of genetic factors, cattle physiological status and the difference in feed ingredients.

Digestibility of crude fiber (CF): The digestibility score of crude fiber (%) of male Bali cattle fed a complete feed containing fish meal as a protein source for each treatment, namely, T1 treatment group was 25.3798±4.93066; T2 treatment group was 23.9884±11.80768; and T3 treatment group was 27.9566±15.37826% (Table 6).

The digestibility score of crude fiber (%) of male Bali cattle fed a complete feed containing fish meal as a protein source for each treatment, namely, T1 treatment group was 25.3798±4.93066; T2 treatment group was 23.9884±11.80768; and T3 treatment group was 27.9566±15.37826% (Table 4). The digestibility of CF obtained in this study was low because it was related to the use of field grass forage which has a fairly high fiber fraction with NDF 66.063%, ADF 44.614%, cellulose 24.286%, lignin 14.212% and hemicellulose 21.449%, respectively. The increase in fiber fraction illustrates that field grass as a forage material that made up a complete feed is difficult to degrade by the microbes in the rumen, which is indicated by the low digestibility of crude fiber in cattle in the three treatment groups. The fiber fraction of feed greatly determines digestibility, both in terms of quantity and chemical composition of the fiber itself (McDonald et al., 2002). According to Riaz et al. (2014), digestibility is strongly influenced by the content of ADF and NDF of feed, where an increase in both fiber fractions has a negative effect because it can reduce digestibility of feed in ruminants.

In addition to field grass, the results of the proximate analysis showed that T1 – T3 ration also contained high levels of CF, NDF, ADF, lignin, cellulose and hemicellulose (Table 3). This high content of cell walls is a limiting factor for the microbes in the rumen to digest CF consumed by cattle. The increase in the content of fiber fraction in T1 – T3 ration was caused by the feed ingredients that made up the ration, especially field grass, which had reached the flowering phasesome even surpassed the flowering phase, which resulted in an increase in plant cell walls. According to Vickers (2019), supplementation of fibrous feed in the ration has an effect on decreasing the efficiency of nutrients utilization, resulting in decreased cattle performance. Cellulose and hemicellulose are included in the structural carbohydrate fraction (fiber fraction), which is the main component of plant cell walls. These two fiber fractions

often bind to lignin, making it difficult for the microbes in the rumen to digest (Minson, 1993). Leaves can be digested and consumed at a higher rate than stems, because the cell walls in leaves are easier to destroy than in stems. Cattle fed with leaves can consume more than 40% of DM per day when compared to cattle fed with stems (McDonald et al., 2002).

The low supply of protein and energy for rumen microbial activity is thought to be one of the factors causing the low digestibility score of CF in this study. According to Tahuk et al. (2017), high consumption of CP in Bali cattle will not be efficient and beneficial for cattle to improve their performance if it is not balanced with sufficient energy sourced from easily digestible carbohydrates.

The sufficient nitrogen (N) content of feed has a positive effect on increasing fiber degradation, where the sources of N for the microbes in the rumen are feed, saliva and blood urea. The minimum N required for the microbes in the rumen to degrade feed is 0.6 - 0.8%. If the available N of feed reaches 1%, it is optimum for the microbes in the rumen to degrade fiber (Orkov, 1992).

Factors affecting fiber degradation in cattle include feed particle size, N content of feed, carbohydrate solubility and lignin content. For starch, its degradation or digestibility by the microbes in the rumen is influenced by factors, including the type of grain, processing, mix of grain, as well as mix of grains and fiber (Minson, 1993). Feed given to cattle, if it contains high lignin it can have an effect an effect on decreasing fiber degradation by the microbes in the rumen if there is not sufficient energy source (McDonald et al., 2002). The percentage of digestibility and the level of feed consumption by cattle are not only influenced by the proportion of the cell wall, but also by the physical shape of the cell wall.

The digestibility of cf in fattened Bali cattle fed a complete feed containing fish meal as a protein source in this study was lower than the digestibility of cf in male Bali cattle that were reported by Tahuk et al. (2022) who obtained (%) ranging from 22.420±6.031-24.665±5.793% in male Bali cattle fed *Gliricidia sepium* leaves as a protein source; by Tahuk et al. (2022) who obtained a range of 70 – 81%; and by da Cruz de Carvalho et al. (2010) on male PO and SimPO fed different concentrates in feedlot rearing who obtained a digestibility score of CF (crude fiber) of 58.82 and 57.06%, respectively. The difference in the digestibility score of CF is influenced by the difference in the type and physical form of the feed, its nutritional content and cattle genetics.

Growth Performance

Daily weight gain: The results of this study showed that the use of fish meal as a protein source in a complete feed could improve the growth performance of fattened male Bali cattle. T3 treatment group fed a complete ration with fish meal content of 12% had higher weight gain (BWG) and daily weight gain (ADG) than T2 and T1 treatment groups fed a complete ration with fish meal content of 8% and 4% (Table 7).

The increase in daily body weight gain (ADG) of cattle is an illustration of the effective management of cattle rearing, especially the quality of nutrition obtained by cattle. The results of this study showed that the use of fish meal as a protein source in a complete feed could improve the growth performance of fattened male Bali cattle. The T3 treatment group fed a complete ration with fish meal content of 12% had higher weight gain (BWG) and daily weight gain (ADG) than T2 and T1 treatment groups fed a complete ration with fish meal content of 8% and 4% (Table 7).

In general, the results of this study showed that the use of animal protein sources in Bali cattle fattening contributed positively to increased growth. The existence of variations in weight gain (BWG) and daily weight gain (ADG) shown by cattle in the three treatment groups are caused by variations in individual cattle responses to the treatment given. The performance in the results of this study was higher than the performance of Bali cattle fed a complete feed with a protein source based on *Gliricidia sepium* leaf forage, where T1 treatment group showed ADG of 0.775±0.066, T2 treatment group showed ADG of 0.985±0.071 and T3 treatment group showed ADG of 0.805±0.169 (Tahuk et al., 2022). It can be seen from the results of this study that increasing the level of fish meal at 12% in the complete feed still contributes to an optimal increase in BWG and ADG. On the other hand, the use of *Gliricidia sepium* leaves as a protein source in a complete feed, an increase in the level of use tends to decrease the BWG and ADG of cattle. Thus, it can be said that the use of animal protein sources from fish meal has a positive effect on improving cattle performance. The difference in the use of these two energy source feed ingredients lies in their palatability. An increase in the level of use of *Gliricidia sepium* leaves decreased the palatability of a complete ration in cattle. This condition is different from fish meal where an increase in the level of its use can also increase the palatability of the ration.

The significant increase in ADG of cattle in T1, T2 and T3 treatment groups illustrates that Bali cattle fattening on smallholder farms using a complete feed is quite promising to be applied because it contributes to improving cattle performance. This is because fish meal is a good source of amino acids for cattle. Giving it to cattle can stimulate cat-

tle growth because it increases the synthesis of body tissue in cattle. According to Spain et al. (1995), fish meal is one of the feed ingredients that has the potential as a protein and fat source, especially for long-chain polyunsaturated fatty acids (PUFA). The potential of fish meal is proven in this study, where the synthesis of body tissue of cattle can be increased as evidenced by the high ADG of cattle in the three treatment groups.

Feed conversion and efficiency: The results of this study, as shown in Table 7, showed that male Bali cattle in the three treatment groups had lower (better) feed conversion rates. The achievement of high feed conversion rates in the three treatment groups proved that the quality of the complete feed used in the study was sufficient to stimulate cattle growth. The three treatment groups required a fewer complete ration to increase one kilogram of daily weight gain, where the feed conversion of each treatment, namely, T1 treatment group was 5.707±0.939; T2 treatment group was 5.103±0.815 and T3 treatment group was 4.529±0.262. Feed efficiency generated in this study also had a pattern that was not far different from feed conversion, where the three treatment groups of cattle had relatively the same efficiency score improvement.

The feed conversion ratio/rate is an illustration of cattle performance associated with the quality of feed consumed and the resulting daily weight gain. In its application, the feed conversion rate is used to monitor and measure cattle performance in the fattening phase because it is associated with growth rates (Martawidjaja et al., 1999). The results of this study, as shown in Table 7, showed that male Bali cattle in the three treatment groups had lower (better) feed conversion rates.

The achievement of high feed conversion rates in the three treatment groups proved that the quality of the complete feed used in the study was sufficient to stimulate cattle growth. The three treatment groups required a fewer complete ration to increase one kilogram of daily weight gain, where the feed conversion of each treatment, namely, T1 treatment group was 5.707±0.939; T2 treatment group was 5.103±0.815 and T3 treatment group was 4.529±0.262. The use of fish meal as a protein source in a complete ration increases the efficiency of feed utilization to improve growth performance. In addition, the feed conversion rates of cattle in the three treatment groups indicated high consumption of DM followed by high body weight gain. Feed conversion rate is low (optimal) when the consumption of DM is high, followed by high ADG as well. In rearing cattle, the lower the feed conversion rate, the better. The best feed conversion rate is 4.5 – 7.5 (Shike, 2013).

These not so far different of feed conversion rates are influenced by the type and age of cattle reared, adaptation ability to feed, as well as the method used to give the feed (Tahuk et al., 2022). On this study, the type of cattle was the same and the age of cattle was also not far different so the cattle responses to a *complete feed* given also were also not far different between treatment groups. High and low feed conversion rates on cattle ruminants are influenced by factors, including feed quality, the magnitude of increase in daily body weight and digestibility score of feed (Jaurini et al., 1995). Cattle fed a high-quality feed have higher growth rates, which in turn have better feed conversion rates (Kuswandi et al., 2000; Jaurini et al., 1995).

Feed conversion rates in the results of this study were lower (better) if compared to what was reported by Tahuk et al. (2022) who obtained feed conversion rates of 5.835±0.369 - 7,193±1,210; by Tahuk and Dethan (2010) who obtained feed conversion rates of 7.55 on male Bali cattle, aged 2 - 2.5 years, fed with forage; as well as by Hafid and Rugayah (2009) who obtained feed conversion rates of 9.89 - 10,40 on male Bali cattle, aged 2 year, with thin body condition and fed with ration concentrates made from local ingredients. Furthermore feed conversion rates in the results of this study were also lower than what was reported by Tahuk et al. (2017) who obtained feed conversion rates of 11.50 – 16.57 on fattened male Bali cattle fed with different level of CP using *Gliricidia sepium* leaves as a source protein.

Feed efficiency generated in this study also had a pattern that was not far different from feed conversion, where the three treatment groups of cattle had relatively the same efficiency score improvement. A high feed efficiency score describes the use-value of the feed consumed by cattle for the synthesis of animal body tissues that is optimal. About 70% of the feed consumed by cattle is used for body maintenance and 30% is used to meet the production needs of cattle (Kuswandi et al., 2000). The feed efficiency score obtained in this study was greater than what was reported by Tahuk et al. (2022) who obtained a feed efficiency score of 14,178±2,201 -17,193±1,110%. This high feed efficiency score illustrates that the use of animal protein sources in a complete feed can increase feed efficiency. According to Vickers (2019), the increase in feed efficiency in beef cattle is strongly influenced by factors such as gender, body weight and growth performance, cattle genetics and health, stress, nutrition, and feeding management.

CONCLUSION

In accordance with the results of the study, it can be concluded that the use of fish meal as a protein source in a complete feed can improve the growth performance of fattened male Bali cattle. The use of fish meal at a level of

12% gave the best results in fattened male Bali cattle when compared to the use of fish meal at levels of 4% and 8%.

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CONFLICT OF INTEREST

We convey that there is no conflict of interest related to this published article, both in terms of article content, funding, or personal.

NOVELTY STATEMENT

Research contributes to the improvement of science and technology, especially the development of feed technology for beef cattle fattening by utilizing fish meal as a protein source feed in the tropics.

AUTHORS CONTRIBUTION

PKT, designed research, research process, statistical analysis and drafted the manuscript; ORN and GRB assisted in the research process and data collection, and drafted the manuscript. All authors contributed to the conduct of the study, as well as consented to this article being published.

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