Effects of Different Levels of Fish Meal in the Diet on Carcass Traits and Meat Quality of Bali Cattle

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ABSTRAK

Tahuk PK, Nahak OR, Bira GF. 2024. Pengaruh level tepung ikan yang berbeda terhadap sifat karkas dan kualitas daging Sapi Bali jantan. JITV 29(2):79-90. DOI: http://dx/doi.org/10.14334/jitv.v29i2.3431.

Penelitian ini bertujuan untuk mengetahui pengaruh penggunaan tepung ikan sebagai sumber protein dalam pakan komplit terhadap sifat-sifat karkas dan kualitas daging sapi bali jantan yang digemukkan. Ternak yang digunakan adalah 15 ekor sapi Bali jantan berumur 2-2,5 tahun dengan kisaran berat badan awal 180-200 kg. Ternak dibagi menjadi tiga kelompok dengan ulangan setiap perlakuan 5 ekor ternak. Ketiga perlakuan tersebut masing masing adalah T1 ternak mendapat pakan komplit dengan level tepung ikan 4%; T2 ternak mendapat pakan komplit dengan level tepung ikan 8%; dan T3 ternak mendapat pakan komplit dengan level tepung ikan 12%. Data dianalisis sesuai prosedur ANOVA. Hasil penelitian menunjukkan bahwa bobot potong, bobot karkas, dan bobot non karkas perlakuan T3 lebih tinggi (P<0,05) dibandingkan dengan T2, sedangkan T1 relatif sama dengan T2 dan T3. Persentase karkas dan non karkas, bobot dan persentase daging, serta kadar air dan protein daging relative sama diantara ketiga perlakuan. Kandungan lemak daging perlakuan T2 lebih tinggi dibandingkan dengan perlakuan T1, sedangkan kandungan lemak daging perlakuan T2 relatif sama dengan perlakuan T1 dan T3. Kandungan kolagen daging T1 lebih tinggi (P<0,05) dari T3, sebaliknya perlakuan T2 relatif sama dengan perlakuan T1 dan T3. Kolesterol daging perlakuan T1 dan T2 relatif sama dan lebih rendah (P<0,05) dari perlakuan T3; sedangkan nilai pH, susut masak, daya ikat air, dan keempukan daging relatif sama di antara perlakuan. Disimpulkan bahwa peningkatan level tepung ikan hingga 12% dalam pakan komplit memberikan kontribusi positif terhadap performans ternak yang ditunjukkan dengan tingginya bobot karkas yang dihasilkan dengan kualitas fisik dan kimiawi daging yang optimal.

Kata Kunci: Sapi Bali, Karkas, Pakan, Tepung Ikan, Kualitas Daging

ABSTRACT

Tahuk PK, Nahak OR, Bira GF. 2024. Effects of different levels of fish meal in the diet on carcass traits and meat quality of Bali cattle. JITV 29(2):79-90. DOI: http://dx/doi.org/10.14334/jitv.v29i2.3431.

This study aims to ascertain how fattened Bali bulls' carcass characteristics and meat quality are affected by using fishmeal as a protein source in full feed. Fifteen male Bali cattle, ages two to three and with beginning body weights ranging from 180 to 200 kg, were the animals employed. Livestock were divided into three groups, with 5 animals replicated in each treatment. The cattle were split into three groups: T1 cattle were fed a complete diet containing 4% fishmeal; T2 cattle were fed a complete diet containing 8% fishmeal; and T3 cattle were fed a complete diet containing 12% fishmeal. The ANOVA method was used to analyze the data. The findings demonstrated that compared to T2, the T3 treatment's slaughter weight, carcass weight, and non-carcass weight were higher (P<0.05), although T1 was essentially equal to T2 and T3. Across the three treatments, the percentages of meat and non-meat, weight and meat percentage, moisture content, and meat protein were all comparatively close. While the beef fat content of the T2 treatment was comparatively equivalent to that of the T1 and T3 treatments, it was higher than that of the T1 treatment. T1 meat had a higher (P<0.05) collagen concentration than T3. However, the T2 treatment was identical to the T1 and T3 treatments. While the pH, cooking shrinkage, water binding capacity, and meat softness were all somewhat consistent across treatments, the amount of cholesterol in the meat of treatments T1 and T2 was significantly lower (P<0.05) than that of treatment T3. Based on the high carcass weight generated with the best possible physical and chemical quality of meat, it can be determined that adding 12% more fishmeal to the entire feed improves animal performance.

Key Words: Bali Cattle, Carcass, Feed, Fish Meal, Meat Quality

INTRODUCTION

The demand for protein by the Indonesian people continues to increase every year, demanding the availability of adequate meat. Nationally, the domestic beef supply needs to be increased, as indicated by the high number of beef imports. According to (Agus & Widi 2018), the increasing demand for meat has not been matched by domestic beef production, the supply of which is less than 60% of the national demand for beef. The imbalance between supply and demand for beef has increased imports of live cattle and frozen meat to fulfill national demand in the short and medium term.

This condition illustrates that more than the domestic beef supply is needed to fulfill the community's needs. Bali cattle are superior local beef cattle that can provide meat to meet the demand for meat and other animal protein sources from poultry and other ruminants. Improving fattening management is one of the alternatives farmers can pursue to produce the maximum amount and quality of meat.

Cattle raising in East Nusa Tenggara play important role in the daily life of local people including to fulfill nutritional needs, to generate cash income, to develop social relationships, and to maintain religious activities (Firman & Nono 2021). Especially on Timor Island, farmers have been fattening beef cattle (Balinese cattle) for generations. The farmers depend on raising cattle, in addition to farming, to fulfil their family needs, so raising Balinese cattle has become an integral part of the local community's life (Saili 2020).

Despite being an integral part of the local community's life, cattle fattening by farmers is still faced with the problem of a lack of feed availability, both in quality and quantity, due to seasonal influences (Lamidi & Ologbose 2014). In the rainy season, livestock growth is positive, indicated by higher body weight gain due to sufficient feed obtained by livestock. Conversely, livestock growth is negative in the dry season, often resulting in death.

According to Ntakyo et al. (2020), prolonged drought in the dry season has adverse effects on cattle productivity, such as reduced growth and milk production (Lamidi and Ologbose 2014). Meanwhile, (Lamidi and Ologbose 2014) stated that a feed shortage in the dry season reduces livestock growth, lacks workforce livestock, and does not maximize livestock production and reproduction. As reported by (Rauf et al. 2015), grazed Balinese cattle produced a daily weight gain of 0.148 ± 0.069 g/head/day; while Balinese cattle that received rice bran and cocoa husk as supplementary feed produced a daily weight gain of 0.207±0.149, and 0.138±0.101 kg/head/day, respectively.

Feed availability that is not continuous throughout the year not only has a direct impact on feed availability and livestock productivity but also hurts livestock rearing activities carried out by farmers, where fattening activities are not carried out throughout the year due to limited feed given to livestock. Therefore, the problem of feed availability that is not continuous throughout the year needs to be solved so that the productivity of Bali cattle fattened by farmers can be increased, both in the rainy and dry seasons (Martojo 2012). In addition, farmers can carry out fattening activities throughout the year without worrying about a decline in animal performance. One of the solutions offered to overcome the problem of feed shortage is the production of complete feed by utilizing forage that is quite abundant in the rainy season. If complete feed production can be developed properly, there is a sufficient stock of feed ingredients available with adequate nutrition to meet the needs of livestock during feed shortages. According to (Beigh et al. 2017), the full feed consists of a quantitative mixture of all dietary constituents that have been thoroughly blended to prevent separation and selection. It is fed as the only source of nutrients, with the exception of water, and is designed in a specified proportion to meet the needs for each nutrient. In addition, the use of complete feed is advantageous because forage and concentrates are presented together to livestock to increase feed palatability and minimize the nature of feed selection by livestock (Tahuk et al. 2020). To ensure animal performance, the balance of nutrients, such as protein and energy, in complete feeds is important.

Protein is an essential nutrient because its sufficiency can ensure maximum muscle tissue synthesis. Fishmeal is a potential protein source for feed to fulfill livestock needs. It is a naturally balanced feed ingredient high in protein, energy, and minerals. In addition, fishmeal is a natural source of vitamins such as choline and biotin and vitamins B12, A, D, and E and includes trace elements such as selenium and iodine.

The quality of fishmeal depends on the raw materials used and the processing method. Fishmeal is a source of easily digestible protein, omega-3 long-chain fatty acids (EPA and DHA), and other essential vitamins and minerals. The quality of the nutrient composition found in fishmeal sets it apart from other dietary supplements, particularly the content of essential amino acids (Ween et al. 2017), long-chain polyunsaturated omega-3 fatty acids (Shahidi and Ambigaipalan, 2015), and mineral (calcium, phosphorus) (Canti et al., 2023).

Applying fishmeal in rations can improve the performance of buffalo and cattle (Kumar et al., 2018) because fishmeal is of better quality than other protein feed sources, such as soybean meal or a combination of soybean meal and urea. Applying fishmeal in the ration can also increase consumption and nutrient digestibility in late-gestational-phase Bali cows (Hartati et al., 2015). In fattened Bali bulls, the use of fishmeal and its impact on productivity has yet to be well informed. Therefore, this research is essential to obtain that information.

MATERIALS AND METHODS

Location, livestock, and feed

The research was conducted at the University of Timor Campus. In contrast, the research results were applied at the Nekmese Farmers Group, Usapinonot Village, West Insana District, North Central Timor, East Nusa Tenggara. Analysis of the physical and chemical quality of meat was conducted at the Meat Laboratory, Faculty of Animal Husbandry, Gadjah Mada University, Yogyakarta, while analysis of meat cholesterol content was conducted at the Feed Chemistry and Biochemistry Laboratory, Faculty of Animal Husbandry, Gadjah Mada University, Yogyakarta. The study used 15 Bali cattle aged 2–2.5 years. The initial body weight ranged from 180–200 kg, with an expected weight gain of 0.75 kg/head per day. Feed offered field grass, ground corn, bran pollard, rice bran, and fish meal, arranged as a complete ration. Fishmeal was purchased from a local feed shop.

The study used 15 Bali bulls in a complete randomized design (CRD) unidirectional pattern, divided into three treatment groups with five bulls each. The groups were: T1, receiving a ration with 11% CP, 72% TDN, and 4% fishmeal; T2, with 13% CP, 72% TDN, and 8% fishmeal; and T3, with 15% CP, 72% TDN, and 12% fishmeal. A mineral premix was added to meet the livestock's needs. The study had two stages: adaptation and data collection. The feed ingredients and nutrient content are detailed in Tables 1 and 2. The adaptation stage lasted 14 days (2 weeks), and the data collection stage lasted 12 weeks. Rations were given twice daily: 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*.

Parameters and their measurements

Variables and measurements included slaughter and empty body weights, carcass weights and percentages, and the amount of meat produced. Physical composition measured included meat pH, cooking loss, water holding capacity/water binding capacity (%), and meat tenderness. The chemical composition of meat measured

Table 1. Feed Ingredients (%) and Nutrient Composition in Complete Feed

Feed Ingredients	Proportion (%)	Nutrient content (%)	
		CP	TDN
T1			
Native grass	30.00	2.10	17.40
Milled corn	89.00	4.60	37.80
Rice bran	13.00	0.90	6.60
Pollard bran	11.00	1.80	8.10
Fish meal	4.00	2.10	2.00
Total	**100.00**	**11.50**	**72.00**
T2			
Native grass	30.00	2.10	17.40
Milled corn	42.00	4.60	37.80
Rice bran	9.00	0.60	4.60
Pollard bran	11.0	1.80	8.10
Fish meal	8.00	4.20	4.10
Total	**100.00**	**13.30**	**72.00**
T3			
Native grass	30.00	2.10	17.40
Milled corn	42.00	4.60	37.80
Rice bran	5.00	0.30	2.50
Pollard bran	11.00	1.80	8.10
Fish meal	12.00	6.30	6.10
Total	**100.00**	**15.10**	**72.00**

T1= complete diet containing 4% fishmeal, T2= full diet containing 8% fishmeal, T3= complete diet containing 12% fishmeal CP= crude protein, TDN= total digestible energy

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

Feed Ingredients	Nutrient Content										
	DM	OM	CP	EE	CF	CHO	NFE	TDN (%)	GE		ME
	(%)	(% DM)							MJ/kg.DM	Kcal/kg.DM	Kcal/kg.DM
Native grass	90.67	82.318.39	2.77	1.39	35.66	78.16	42.50	51.09*	14.67	3492.05	2053.42
Fish meal	91.03	70.15	55.67	8.92	4.89	5.55	0.66	64.66*	17.50	4166.17	2958.92
Milled corn	88.19	86.91	9.32	4.89	1.71	72.70	70.98	94.99*	16.53	3929.38	3792.41
Pollard bran	87.62	82.97	18.50	5.47	6.73	59.00	52.73	83.34*	16.56	3942.08	3408.55
Rice bran	90.05	76.32	8.60	9.68	18.29	58.04	39.75	91.18*	15.43	3673.09	2868.76
Ration											
T1	88.05	80.47	14.87	5.54	14.07	60.06	45.99	78.93**	15.88	3781.88	3014.04
T2	87.36	79.63	15.59	5.06	14.17	58.99	44.82	77.84**	15.71	3740.13	2951.32
T3	87.46	70.58	16.67	3.40	14.86	59.51	44.65	76.75**	15.50	3689.39	2843.36

DM=dry mater; OM=organic matter; CP=crude protein; EE=extract enter; 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; 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%. *= Total digestible nutrients, calculated by the equation of (Hartadi et al. 1980)**= Total digestible nutrients, calculated by the equation of (Wardeh 1981) included the percentage of protein, water, fat, collagen, and meat cholesterol (mg/100g).

The slaughter weight was determined by weighing the cattle just before slaughtering and feeding for ± 24 hours. Drinking water was provided ad libitum during the fasting period. Carcass weight (hot carcass) was determined (Tahuk et al. 2020; Tahuk et al. 2018) from the weighing of carcasses after slaughter, obtained from the difference between slaughter weight and non-carcass weight. The hot carcass percentage is calculated from the ratio of hot carcass weight to slaughter weight multiplied by 100 percent. The equation is carcass percentage (%) = hot carcass weight (kg)/cut weight (kg) x 100%. Meat weight (kg) is obtained after the decomposition of the carcass. The percentage of meat is obtained from the ratio of the weight of the meat to the weight of the hot carcass. The equation is meat percentage (%) = meat weight (kg)/carcass weight x 100% (Tahuk et al. 2020; Tahuk et al. 2018).

The physical composition of meat measured includes pH, water holding capacity, cooking loss, and tenderness. Determination of pH and water holding capacity and cooking shrinkage use according to the procedure of Povše et al. (2015). The equation for calculating cooking shrinkage (%) is A - B/A x 100%, where A = weight before heating (grams) and B = weight after heating (grams). The procedures Warner-Bratzler breaking power test, according to Povše et al. (2015), was used to determine meat tenderness.

The chemical composition of meat was measured, including moisture, fat, protein, and collagen content. The test method used was near-infrared spectroscopy according to Osborne's instructions (Prieto et al. 2017) by utilizing the Meat Analyzer Food Scan device, which reads at a wavelength of 800–1400 nm. The measurement of meat cholesterol used the Liebermann-Burchard method according to the instructions of (Keklik et al. 2018), where the readings used a spectrophotometer at a length of 680 nm.

Data analysis

Data were analyzed using the variance analysis procedure of a completely randomized design (CRD) (Drebee 2018). SPSS 26 software was used to simplify and accelerate the analysis.

RESULTS AND DISCUSSION

Slaughter weight and empty body weight

A high slaughter weight of livestock indicates effective management during fattening, but it does not guarantee the quality of carcasses. According to the study results (Table 3), animals in the T3 treatment had higher slaughter and empty body weights compared to the T2 treatment. In contrast, the T1 treatment was similar to the T3 treatment. Specifically, T3 treatment cattle had a 24.311% higher slaughter weight than T1 and 36.759% higher than T2 treatment cattle. Additionally, the empty body weight of T3-treated animals was 16.015% higher than T1-treated animals.

The results of this study illustrate that the use of fishmeal as a protein source up to 12% in complete feed still shows positive performance in livestock. There is a tendency to decrease the slaughter weight in T2 cattle due to variations in individual responses that still need to be optimal for the complete feed. However, increasing the level of fishmeal in the ration can increase the slaughter weight of Bali cattle. The slaughter weight of T3-treated animals was higher due to a significant increase in body tissue synthesis compared to the T1 and T2 (Table 3). The increase in slaughter weight is because livestock's protein and energy needs have been met, which contributes to the synthesis of body tissues, resulting in a high slaughter weight. The slaughter weight of the T1 and T2 was lower than the report of (Tahuk et al. 2020), who obtained the slaughter weight of Bali bulls fattened with complete feed containing *Gliricidia sepium* leaves ranging from 219,250±14,245 to 239,000±21,280 kg.

In contrast, T3 had a higher slaughter weight than the report of Tahuk et al. (2020). Similarly, the slaughter weight of T1 and T2 was lower than the report of (Tahuk et al. 2018b), who obtained a slaughter weight of 228.60-251.20 kg in Bali bulls received different CP levels. However, the cattle in T3 showed a higher slaughter weight than the report of Tahuk et al. (2018b). The initial live weight, time of rearing, the ADG, and feed quality influenced the difference in slaughter weight in this study.

Carcass yields

The carcass weight (Table 3) of animals in T3 was higher than those on T2 treatment (P<0.05) but relatively the same as T1. Similarly, the T1 showed results that were not much different from the T2 treatment. On the other hand, the carcass percentages of the three treatment groups showed relatively similar results. The non-carcass weight of T3 animals was higher (P<0.05) than that of T1 and T2; conversely, T1 and T2 produced relatively the same carcass weight. The increase in carcass and non-cass weight of T3 was 24.031% and 26.552% higher than that of T1 and 45.236% and 26.552% higher than that of T2. Although the three treatment groups were statistically similar, there was a tendency for the percentage of carcasses and non-carcasses of T3 to be 0.365% higher and 0.495% lower than T1, 5.977% higher, and 7.171% lower than T2.

Both slaughter weight and carcass weight influence the value of dressing percentage. A higher proportion of carcass weight to slaughter weight increases the dressing percentage. This study found that using fishmeal at levels of 4%, 8%, and 12% in complete feed had a similar effect on dressing percentage. The dressing percentages observed in this study were higher than those reported by Tahuk et al. (2020), who found dressing percentages ranging from 50.61±1.595% to 51.140±0.512% in young Bali cattle fed complete feed with *Gliricidia sepium* leaves as a protein source. Similarly, Tahuk et al. (2018b) reported dressing percentages ranging from 54.07±2.39% to 55.61±0.93% in Bali cattle reared on smallholder farms. These results indicate that high-quality feed can maximize carcass production in Bali bulls during the accelerated growth phase.

This study's non-carcass weight of T3 (Table 3) was relatively high due to the higher slaughter weight. An increase in slaughter weight not only contributes positively to the carcass produced but also impacts the development of the non-carcass component of the livestock. This study's weight and percentage of non-carcass produced were still relatively high. The livestock grazing for approximately 12 hours before slaughter has not significantly reduced animal tract contents. In addition, this condition is related to the development of non-carcass components during the rearing phase. Non-carcass weight is closely related to the feed ingredients obtained and their digestibility. When the digestibility of feed is low, it contributes to an increase in the contents of the digestive tract, resulting in higher non-carcass components. This study observed that the fiber fraction of the ration and its constituents was high, resulting in increased fiber fraction consumption (Table 1 and 2). As a result, the ability of rumen microbes to degrade was not maximized.

Meat weight and percentage

The results showed that the weight and meat percentage of the three treatment groups were relatively similar (P>0.05) among treatments. However, T3 had a higher carcass weight than the other two treatments. Each animal in the T3 treatment had a weight and percentage of meat that were 16.67% higher and 14.83% lower than those in T1, respectively. In contrast, T3 produced 17.67% more meat than T2, but its meat percentage was 17.87% lower.

The meat weight in this study was not influenced by fishmeal (P>0.05). The weight and percentage of meat produced in this study were lower than the report of Tahuk et al. (2020), who obtained the weight and percentage of meat ranging from 75.39±4.86 kg to 86.00±8.76 kg (68.62±0.62 to 71.72±1.47%), respectively, who obtained using complete feed containing *Gliricidia sepium* leaves as a protein source. The meat weight of this research report was also lower than that of Tahuk et al. (2018), who obtained a meat weight ranging from 84.98 to 93.16 kg and a meat percentage of slaughter weight ranging from 35.67 to 37.35% from Bali bulls fattened on smallholder farms.

Meat quality

Protein content

The results showed that the meat protein content (%) of Bali cattle given fishmeal as a protein source was relatively similar (P>0.05) (Table 4). The treatment cattle showed the highest meat protein, ranging from 22.71±0.23 to 22.97±0.73% (Table 4). The meat protein content of the three treatment groups was not significantly different. This condition illustrates that feed protein at the level of 11–15% of the ratio used is optimal to fulfill basic life so that it can be utilized for body tissue synthesis when the quality of nutrients obtained by livestock increases, the increase in nutrient quality has a positive impact on increasing energy utilization for fat and protein deposition (Park et al. 2018).

The meat protein content of Bali cattle in this study was within the normal range. Thus, the use of fishmeal as a source of protein in rations with 11–15 percent CP has a similar and insignificant effect on meat protein deposition. This condition illustrates that the animal feed protein obtained in the three treatments is optimal for maximum meat protein synthesis. In addition, the relatively same age impacts the rate of protein synthesis, which is not much different either. According to Bulkaini et al. (2020), the rate of protein synthesis in Bali cattle decreases with age. In growing cattle, the protein synthesis and degradation rate increases, and the protein synthesis rate often exceeds protein degradation. The rate of synthesis and degradation in animals diminishes as they get closer to maturity, eventually settling at a low and balanced rate Kutay et al. (2024).

The meat protein of these Bali bulls was lower than the report of Tahuk et al. (2020), who obtained meat protein ranging from 22.89±0.44 to 23.58±0.26% in Bali bulls that received *Gliricidia sepium* leaves as a protein source. Differences influence the content of meat protein levels in several research reports on animal genetics and differences in feed used. The results of this study indicate that fattening Bali bulls using fishmeal as a protein source produces relatively normal meat protein. Forage feed is generally high in fiber and low in energy, resulting in low carcass fat content but increased protein and water content in meat (Baik et al. 2023).

Moisture content

Moisture content determines the quality of beef, whereas fresh beef with a moisture content of 65–80% is highly perishable (Li et al. 2018). The meat moisture content (%) of male Bali cattle fed complete feed with fishmeal as a protein source was about the same across treatments, ranging from 72.51±0.54 to 72.79±0.56% (Table 4). The relatively low-fat meat content in T1, T2, and T3 closely correlates with the moisture content of meat in the three treatment groups. Despite the T3 having a higher fat content than the T1, the resulting fat content value did not significantly differ, impacting the water content of the produced meat and remaining relatively the same (P>0.05) among treatments.

The relatively similar moisture content of the meat in this study indicates that the quality of Bali beef produced was average. Generally, moisture content in meat has a negative relationship with fat content; as fat content increases, moisture content decreases. According to Geletu et al. (2021), moisture content in meat is an essential component because it determines the quality of the meat. Water makes up approximately 75% of the weight of beef, making it the component with the most significant quantitative impact on surface appearance, color, and texture. In cattle, meat moisture content typically ranges from 70.54 to 77.64, averaging 74.09% (Abdelwhab and Mohammed, 2019), and 72.76±0.47% to 73.32±0.64% in Bali cattle (Tahuk et al., 2020). The difference in moisture content from several

Table 3. Carcass characteristics of Bali cattle fattened with complete feed containing fish meal as a protein source[1]

Carcass characteristics	T1[2]	T2[2]	T3[2]	SEM	P Value
Initial body weight (kg)	189,00±24,64	158,33±31,56	195,33±22,19	9.53	0.263
Slaughter weight (kg)	208.75±41.40[ab]	189.75±18.46[a]	259.50±39.20[b]	12.67	0.048
Empty body weight (kg)	187.26±39.18[ab]	163.61±14.06[a]	217.25±33.98[b]	10.46	0.100
Carcass weight (kg)	121.30±31.39[ab]	103.59±11.49[a]	150.45±26.19[b]	8.66	0.066
Non-carcass weight (kg)	87.45±10.09[a]	86.16±7.26[a]	109.05±13.59[b]	4.21	0.024
Dressing percentage	57.59±3.60	54.54±1.04	57.80±2.05	0.78	0.167
Percentage of non-carcasses	42.41±3.60	45.46±1.04	42.20±2.05	0.78	0.167
Meat weight (kg)ns	57.00±13.98	56.500±10.85	66.50±7.724	3.22	0.398
Meat percentage (%)ns	47.14±3.32	54.62±9.19	44.86±6.01	2.14	0.148

[1]Data are presented as mean±SD; [2]T1= Complete ration with 11% crude protein, 72% total digestible nutrient; T2= complete ration with 13% crude protein and 72% total digestible nutrient; T3= complete ration with 15% CP and 72% TDN. Different superscripts on the same line indicate differences (P<0.05); [ns] = nonsignificant

Table 4. Chemical and physical composition of meat of male Bali cattle fed with complete diets containing fishmeal as a protein source[1]

Meat Chemical Composition	T1[2]	T2[2]	T3[2]	SEM	P Value
Protein (%)ns	22.97±0.73	22.77±0.23	22.71±0.23	0.13	0.72
Water (%)ns	72.50±0.54	72.79±0.56	72.78±1.16	0.21	0.85
Intramuscular fat (%)	3.42±0.53b	3.98±0.41ab	4.24±0.35a	0.15	0.07
Collagen (%)	1.91±0.06b	1.59±0.06ab	1.64±0.27a	0.14	0.05
Cholesterol (mg/100g)	52.34±4.36a	54.33±6.22a	62.74±2.71b	0.82	0.03
Physical Composition of Meat					
pH of means	5.55±0.13	5.45±0.13	5.57±0.07	0.03	0.17
Cooking loss (%)ns	27.39±1.24	26.49±0.45	26.92±1,67	0.34	0.61
Water holding capacity (WHC,%)ns	34.42±6.29	38.75±3.89	37.50±2.24	1.29	0.41
Breakability (tenderness)ns	8.60±0.81	8.26±0.61	8.13±0.49	0.18	0.59

[1]Data are presented as mean±SD; [2]T1= Complete ration with 11% crude protein, 72% total digestible nutrient; T2= complete ration with 13% crude protein and 72% total digestible nutrient; T3= complete ration with 15% CP and 72% TDN. Different superscripts on the same line indicate differences (P<0.05); [ns] = nonsignificant

research reports is due to differences in animal genetics and feed used and variations in fat deposits from each animal. Differences in moisture content across studies are due to variations in animal genetics, feed, and fat deposits.

Intramuscular fat content

The deposition of meat fat demonstrates that the body uses the excess nutrients to meet basic life needs, particularly energy. Meat fat content (%) in Bali cattle fed complete feed containing fish meal as a protein source showed that T3 was higher than T1 (P<0.05) but relatively the same as T2 (P>0.05). The intramuscular fat content of T3 was 24.05% higher than T1 and 6.57% higher than T2 (Table 4). Intramuscular fat content (Table 4) illustrates that using fish meals in complete rations positively affects fat tissue synthesis due to the sufficient energy obtained by livestock. The complete ration formulation in this study contains enough protein and energy to fulfill basic living and production needs. Once basic living needs have been met, the excess energy is utilized to increase production, including muscle and fat tissue synthesis.

Fat deposits in cattle are determined by whether or not livestock obtains enough feed. Feeding with high energy content can increase fat deposits. Livestock with limited feed impacts the low-fat deposits produced (Schumacher et al. 2022). Using high-concentrate feed in livestock in the finishing phase can shorten the production cycle and increase fat deposition (Patino et al. 2015). Dietary energy levels increase intermuscular fat, reducing the amount of heat-resistant connective tissue. In addition, increased intramuscular fat results in increased juiciness, tenderness, and aroma characteristics of meat (Kutay et al. 2024).

Carcass fat content in this study was lower than the report of (Tahuk et al. 2020), who obtained carcass fat levels ranging from 4.77±0.65 to 5.61±0.47% in Bali bulls fed complete feed containing *Gliricidia sepium* leaves as a protein source. Fat deposition in livestock is influenced by various factors, including the amount and type of feed given to livestock, genetics, gender, and environment (Schumacher et al. 2022). In addition, Piao and Baik (2015) reported that the season significantly affects fat deposition in cattle. Heat stress (HS) or cold stress can affect food intake, heat production, and nutrient partitioning priorities, reducing animal performance. According to (Patino et al. 2015), the intramuscular fat content of bulls reared on pasture with energy supplementation is lower when compared to cattle reared in confinement with forage and concentrate feeding ratio of 50:50. The intermuscular fat content of meat is influenced by nutritional factors including metabolism, digestibility and absorption of fat, and availability of glucose or soluble sugars (Park et al. 2018). It was also explained that triglyceride synthesis is a critical factor for IMF deposition, while triglyceride hydrolysis decreases IMF deposition; in addition, manipulation of digestion and absorption of dietary fat in the small intestine can increase IMF deposition; similarly, maximum starch utilization is essential for IMF deposition and can be achieved by optimal starch fermentation in the rumen and maximum starch digestion and absorption in the small intestine.

Collagen

The collagen levels can affect the value of meat by limiting its tenderness and cooking convenience (Bruce and Roy 2019). The collagen content affects meat's tenderness and cooking convenience. The collagen levels in the study were 1.91±0.06% for T1, 1.58±0.06% for T2, and 1.64±0.29% for T3. T3's meat collagen was 14.271% lower than T1's but 4.127% higher than T2's. Statistically, T1 had more collagen than T2 (P<0.05), but T2 was not significantly different from T1 or T3 (P>0.05). Variations in collagen distribution in Bali beef were observed, with T1 having higher collagen due to lower fat content.

Collagen content varies by sex, age, and meat type within the same carcass and is influenced by fat content. The collagen levels were lower than Tahuk et al. (2020) reported, who found 2.40±0.21% to 2.53±0.44% in Bali bulls fed with *Gliricidia sepium* leaves. Differences in intramuscular fat are influenced by cattle age and feed quality. According to Bruce and Roy (2019), factors such as the age at slaughter, use of growth steroids, and cattle breed affect collagen quality. Collagen plays a crucial role in cooked beef; when heated, it shrinks and causes fluid loss, making it less tender (Wiśniewski et al., 2021).

Cholesterol

The impact of cholesterol content on consumer health is a severe issue in beef production. Therefore, beef's high-fat content has become a discussion topic for beef consumers due to its associated health effects, such as cardiovascular disease (Troy et al. 2016). According to Bronzato and Durante (2017), red meat consumption is considered a dietary risk factor for cardiovascular diseases (CVD). Most of the risk of red meat intake has been related to saturated fat and cholesterol content. As shown in Table 4, adding 12% more fishmeal raised the cholesterol level in beef (P<0.05) to 62.74±2.71 mg/100g, compared to 4% and 8% fishmeal levels, which raised the cholesterol levels to 52.34±4.36 mg/100g and 54.33±6.22 mg/100g, respectively. The increase in cholesterol level of T3 was 19.89% compared to T1 and 15.48% compared to T2. This condition illustrates that increasing the level of fishmeal not only increases muscle tissue synthesis, spurring livestock growth but also contributes to an increase in the proportion of fat, including meat cholesterol.

The cholesterol content of meat produced in this study is higher than the cholesterol content of Bali beef reported by (Suryanto et al. 2014), ranging from 38.75 ± 4.27 to 38.75±2.63 to 42.00±4.97 mg/100g, and the report of (Tahuk et al. 2020), who obtained Bali beef cholesterol, ranging from 28.79±4.42 to 29.77±3.16 to 33.69±1.21 mg/100g. However, the cholesterol content of the results of this study is lower than that of (Abdelwhab & Mohammed 2019), who obtained a cholesterol content in beef of 74.50±6.73 mg/100g. The livestock's type of feed, age, and genetics influence the difference in meat cholesterol content.

Physical quality of meat

Cooking loss

Cooking loss is one of the parameters that determines the meat quality, which is related to consumer acceptance. Cooking loss combines liquid and soluble matter lost from the meat during cooking. Besides, cooking loss is a critical factor in the meat industry as it determines the technological yield of the cooking process. From a nutritional perspective, cooking loss brings about the loss of soluble proteins, vitamins, and different supplements (Pathare and Roskilly 2016).

The findings showed that the cooking loss (%) of Bali cattle that were fed a complete diet with fishmeal as a protein source was low and pretty much the same across treatments (P>0.05) (Table 4). The low cooking loss illustrates that the nutrients in the beef still survive (and are protected) well during the cooking process. The WHC, which remained relatively high in this study, and the meat's ultimate pH content, which remained within the normal range, also contributed to the low cooking loss of the meat. The cooking loss value of T3 animals was lower than that of T1 by 1.71% and T2 by 1.61%, respectively.

The use of 4, 8, and 12% fishmeal levels in complete rations with CP levels of 11, 13, and 15% and TDN of 72% positively impacted the cooking loss of Bali cattle. The high energy content of feed in this study increased the synthesis of intramuscular fat (marbling) in meat, which impacted the protection of fluids during the cooking process. Increased intermuscular fat content in meat will reduce the amount of heat-resistant connective tissue, improving the juiciness, tenderness, and aroma characteristics of meat (Kutay et al. 2024). In addition, temperature and cooking time determine the cooking shrinkage value of meat (Ježek et al. 2019). The low cooking loss value is closely related to the type of feed consumed by the animals. Feeding with a high energy content can incrae intramuscular fat synthesis (marbling), which protects fluids during cooking (Tahuk et al. 2018).

The amount of cellular membrane damage influences the amount of cooking loss in meat, the amount of water that escapes from the meat, the shelf life of the meat, protein degradation, and the ability of the meat to bind water, as well as genetic factors and feed given to cattle (Strydom et al. 2016). The cooking shrinkage produced in this study was lower (better) than the report of Ninu (2017), who obtained cooking losses of 33.88 and 28.49% in the meat of 2- and 3-year-old male and female Bali cattle, respectively. Nevertheless, it is better than Tahuk et al.'s (2018b) findings, which found that cooking losses in Bali cattle raised on smallholder farms with varying feed protein levels ranged from 37.60±0.88 to 40.50±1.11%. Thus, it can be said that using fishmeal as a protein source in fattening Bali cattle can improve the quality of the meat produced.

Water holding capacity (WHC)

Water holding capacity is one of the indicators of meat quality, as seen from the ability of meat to bind water. Water holding capacity is the amount of water that meat can hold during cutting, heating, grinding, and pressing, as well as during transport, storage, and cooking. Therefore, water-holding capacity is an essential criterion in quality assessment in meat processing (Warner 2014).

The results showed that the water-holding capacity (%) of Bali cattle meat fed with complete feed containing fishmeal as a protein source was relatively similar among treatments (Table 4); this illustrates that the use of fishmeal at levels of 4, 8, and 12 percent in complete feeds containing CP 11, 13, and 15% with TDN 72% in fattened Bali Bulls did not hurt the water-holding capacity of meat. The rations used in T1, T2, or T3 were optimized for meat protein deposits, thus contributing positively to the WHC of the meat. The nutritional effect of feed significantly influences the value of meat's water-binding capability (Watanabe et al., 2018). Furthermore, there is a stronger correlation between the pH level of meat and water binding ability than between intramuscular fat content. Therefore, the normal WHC in this study is thought to be influenced by the pH of the meat, which is still within the normal range. Jankowiak et al. (2021) reported that the pH value strongly correlated with water-holding capacity, water loss, meat tenderness, and water and protein content(Jankowiak et al. 2021). The value of water binding capacity obtained in this study is higher than the report of (Tahuk et al. 2020) who obtained water binding capacity ranging from 29.54±5.69% to 32.34±26.26% in Bali bulls fattened with complete feed containing *Gliricidia sepium* leaves as a protein source; as well as the report of (Tahuk et al. 2018b) who obtained WHC ranging from 14.93±1.60 to 15.79±2.48% in Bali cattle fattened in smallholder farms.

Tenderness

Meat tenderness value can describe the quality of meat, which can be known from the Warner Blatzler (WB) breaking power value. The study showed the tenderness (kg/cm2) of T1 at 8.60±0.81, treatment T2 at 8.26±0.61, and T3 at 8.13±0.49. We did some statistical testing and found that when different amounts of fishmeal were added to the complete diet, the average meat tenderness from Bali bulls was about the same across treatments (Table 4). The relatively similar meat tenderness values of the three groups of treated animals are related to influencing factors such as higher water binding capacity and lower cooking shrinkage and are not much different. Connective tissue content, sarcomere length, and myofibrillar damage are the primary sources of variation in meat tenderness (Strydom et al. 2016). The significant determinants of meat tenderness are connective tissue and cross-links, myofibrillar integrity, sarcomere length, protein denaturation, and intramuscular fat (Warner et al. 2022).

Meat tenderness was not affected by bulls' growth on pasture with energy supplementation or in pens with a 50:50 forage concentrate ratio. However, the amount of collagen in meat is closely correlated with high and low meat tenderness scores. When the collagen level is high, the meat will be less tender (Patino et al. 2015). In this study, the variation in collagen content was not much different, which resulted in relatively the same meat tenderness value.

Thus, the difference in the tenderness value of the fattened Bali bulls in this study is also expected to be caused by the difference in the presence of collagen cross-linking in the meat, which is not much different. Collagen solubility negatively correlates with meat tenderness, especially in aged cattle. An increase in collagen with low solubility can reduce meat tenderness (Li et al. 2018). It is also reported that the effects of species, age, and muscle type contribute to variations in meat tenderness due to the influence of collagen. Tenderness in meat is one of the variables whose value is largely determined by cooking. In addition, the tenderness of the meat is largely determined by the anatomical-histological structure of the muscle, especially the connective tissue sheath in the muscle, the activity of meat tenderization, as well as meat preparation, temperature, and cooking time (Ježek et al. 2019).

The meat tenderness of the three groups of cattle in this study was lower than the report of Ninu (2017), who obtained meat breakage values of 4.10 kg/cm2 and 4.09 kg/cm2 (more tender), respectively, for male and female Bali cattle aged 2–3 years. Similarly, this tenderness value is lower and almost the same as the report of Tahuk et al. (2018b), who obtained the tenderness of Bali beef in smallholder farms ranging from 5.58±0.79 to 8.80±0.86 kg/cm2 and lower than the report of Tahuk et al. (2020), who obtained tenderness of 4.42±0.82 to 6.32±1.42 kg/cm2 in Bali bulls fattened with complete feed containing *Gliricidia sepium* leaves as a protein source. The difference in tenderness value is caused by differences in feed quality, cattle growth pattern, muscle type, pH, intramuscular fat (IMF), and total and soluble collagen content (León-Ecay et al. 2022).

CONCLUSION

Using fishmeal as a protein source in complete feed generally positively affected fattened Bali bulls. The body weight gain was exceptionally high, especially when the cattle received a proportion of fishmeal at a ratio of 12%. The improved growth performance led to an increase in carcass and meat production. Therefore, it is recommended that farmers and animal husbandry practitioners consider using fishmeal as a potential protein source to enhance the performance of fattened Bali bulls.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this published article, neither the funding nor the content.

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