Research Article

The Effect of Using *Gliricidia sepium* Leaves as a Source of Protein in the Complete Feed on the Performance of Fattened Male Bali Cattle in West Timor, Indonesia

Paulus Klau Tahuk*, Oktovianus R. Nahak T.B., Gerson F. Bira, Adrianus Manek, Donatus Manek, Tobias Y. Purnama, Emanuel Bubun, Bergias Subay

Departement of Animal Science, Faculty of Agriculture, Universitas Timor, Kefamenanu, North Central Timor, East Nusa Tenggara, Indonesia-85613.

Abstract | This research aimed to know the effect of using different levels of *Gliricidia sepium* leaves in the Complete Feed on the Performance of Fattened Male Bali Cattle. The cattle employed in this research were 12 male Bali cattle aged between 2-2.5 years old, with the average initial body weight was 181.50±16.51 kg. The animals were divided into three groups according to the ration treatment used. The rations include T1 ration which contained standard crude protein and high energy (11% CP and 72% TDN), T2 ration which contained medium protein and high energy (13% CP and 72% TDN); and T3 ration which contained high protein and high energy (15% CP and 72% TDN). The level of *Gliricidia sepium* leaves in each treatment ration was also different, where T1 contained 10% of, T2 contained 20% of *Gliricidia sepium* leaves, and T3 contained 31% of *Gliricidia sepium* leaves. Results of the study indicated that the dry matter and organic matter intake were relatively the same among treatments. However, the intake of CP and CF in T2 and T3 was higher (P<0.05) than T1. On the other hand, the TDN intake of T2 was higher (P<0.05) than T1. However, T3 has relatively the same consumption with T2 and T1. Furthermore, the nutrient digestibility was relatively the same among the treatments, while the daily body weight gain (ADG) of T2 was higher (P<0.05) than T1 and T3. Additionally, the conversion and efficiency on T2 were higher than T3, but relatively the same as T1. It is concluded that the application of complete feed with protein source from *Gliricidia sepium* with crude protein and TDN of 13 and 72% respectively could improve the fattened Bali cattle performance.

Keywords | Fattened bali cattle, Complete feed, Feed intake, Digestibility, Growth performance

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***Correspondence** | Paulus Klau Tahuk, Departement of Animal Science, Faculty of Agriculture, Universitas Timor, Kefamenanu, North Central Timor, East Nusa Tenggara, Indonesia-85613; **Email:** paulklau@yahoo.co.id
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INTRODUCTION

The sufficient availability of feed in terms of both quality and quantity plays an important role in supporting livestock productivity, especially the fattened Bali cattle. Even though feed is the main component that needs to be considered by farmers, in fact, the sufficient feed availability is still a serious problem faced by farmers/breeders who fatten their livestock.

According to various reports of research, due to insufficient feed availability, the productivity of fattened Bali cattle in West Timor has not been optimal. In the rainy season, the availability of feed is abundant, so there is a positive growth of livestock indicated by increased body weight. Conversely, in the dry season, the availability of feed is

lacking with inadequate nutritional quality which results in negative growth of livestock, even frequently causes death (Tahuk and Dethan, 2010). The average daily weight gain of fattened Bali cattle in the dry season is quite low which is at 0.30 kg/day. Meanwhile, in the rainy season, the daily weight gain of fattened Bali cattle on smallholder farms reaches 0.51 kg/day (Tahuk *et al*., 2018b). The above conditions illustrate that the rainy and dry seasons have a significant influence on the appearance of Bali cattle production which is fattened on the smallholder farms.

Considering the reality above, one of the efforts to solve that needs is developing feed processing technologies such as producing complete feed. The development of complete feed can solve the problem of feed shortages because it has complete nutrients to meet the needs of livestock. In addition, complete feed can guarantee the availability of feed throughout the year, especially in the dry season (Tahuk and Bira, 2020).

Complete feed production in West Timor is quite promising because it is supported by the abundant availability of feed, especially the rainy season. The extent of pasture livestock can provide abundant natural grass forage to be used as raw material for making complete feed. In addition, forage legumes such as *Gliricidia sepium* are also abundant, but have not been maximally utilized as animal feed by farmers/breeders. When both of these forage ingredients combined with digestible carbohydrate sources, it can produce high-quality complete feed that can meet the needs of livestock.

The use of *Gliricidia sepium* leaves as a source of protein in making complete feed can increase livestock access to these feed ingredients. This is because *Gliricidia sepium* is a feed forage with the less palatable when given fresh to Bali cattle. According to Tahuk *et al*. (2017), if the provision of fresh *Gliricidia sepium* leaves reaches 46% as a source of protein, it can reduce palatability and improve the selection characteristics of Bali cattle to consume them. As a result, the protein obtained by livestock is not optimal so it causes non-optimal performance of livestock.

In its application, the production of complete feed by utilizing *Gliricidia sepium* leaves as a source of protein needs to be adequately formulated in the ration by combining it with digestible carbohydrates feed source. Thus, rations that have sufficient protein and energy can be obtained to meet livestock needs. According to Pedreira *et al*. (2013), the use of concentrates with the proportion of 30% and 60% in the ration can increase the consumption and digestibility of dry matter and organic matter in beef cattle.

In general, the application of complete feed is believed to improve the performance of fattened Bali cattle because it has adequate nutritional quality. When fresh *Gliricidia sepium* leaves are given to the fattened male Bali cattle on smallholder farms as a source of protein, it can increase the daily body weight gain ranging from 0.47 ± 0.47 to 0.70 ± 0.16 kg/head/day (Tahuk *et al*., 2017) due to the complete nutritional content. However, information regarding the effect of using the different levels of *Gliricidia sepium* Leaves on Complete Feed on the Performance of Fattened Male Bali Cattle has not been widely reported. It requires a thorough review on the information regarding the provision of complete feed with different CP content (by increasing the proportion of *Gliricidia sepium*) and affect the performance of fattened Bali cattle.

MATERIALS AND METHODS

This study did not use treatments that interfere with animal welfare. Therefore, approval from the ethnic committee for the use of livestock in research is not required.

Time, location, cattle and feed

The research was done in experimental cage of the Faculty of Agriculture of Universitas Timor in April to October 2019 consisting of stages of preparation, data collection, analysis, and report. Feed sample and feces were analyzed in the Chemistry Laboratory of Feed, Faculty of Animal Husbandry, Universitas Nusa Cendana Kupang.

The cattle employed was 12 male Bali cattle aged between 2-2.5 years old based on the teeth estimation. The general average initial body weight of the cattle during the research was 181.50±16.51 kg, with the average initial body weight detail of T1 treatment was 175.25±9.18; T2 was 184.75 ±13.94; and T3 was 184.50±25.36. The addition of daily body weight gain (ADG) expected was 0.75 kg/cattle/day.

The complete feed contained *Gliricidia sepium*, field grass, ground corn, bran pollard, and rice bran, which have been compiled into three types of ration of T1, T2 and T3. The T1 ration contained standard crude protein and high energy (crude protein by 11% and total digestible nutrient (TDN) by 72%) (According to recommendations of Kearl, 1982). Furthermore, T_2 contained medium protein and high energy (Crude Protein by 13% and TDN by 72%). Meanwhile, T_3 ration contained high protein and high energy (crude protein by 15% and TDN by 72%). In addition, mineral premix was also added to meet the cattle needs.

Before the application of complete feed, the ration feed ingredients in the form of *Gliricidia sepium* and natural grass were dried for approximately 2-3 days. Furthermore, it was grinded using grinding machine with sieve size of 10 mm. The corn grain as digestible carbohydrate source was also grinded using grinding machine on sieve size of 5

mm. The corn that has been grinded was then mixed with other feed ingredients of rice bran and bran pollard evenly until it became homogeny. The complete feed that has been prepared was then provided to the cattle.

Research design

This research was carried out using complete randomized design (CRD) of unidirectional pattern. Twelve male Bali cattle were divided into three groups consisting of two groups obtained ration treatment while the other one acted as the control. The number of cattle in each group was 4 cattle for T1, T2 and T3 ration. Cattle was placed in individual cage with the size of 150 x 200 cm, equipped by a place for eating and drinking. The cattle adaption towards the complete feed took 21 days (3 weeks), while the data collection stage spent 11 weeks. The provision of ration during the data collection was performed twice a day which were in the morning at 08.00 central Indonesian time and afternoon at 16.00 central Indonesian time. The drinking water was provided *ad libitum*.

Variable measurement

The variable measured in this research included: (1) consumption and digestibility of nutrient and (2) growth performance.

The feed consumption is the difference of the amount of feed given from the remaining feed for the 24 hours. The calculation used was dry matter (DM) (g): {the amount of feed provision (g) x (%DM)} – (remaining feed (g) x % DM)}. The nutrient consumption (organic matter (OM), crude protein (CP), crude fiber (CF)), and Nitrogen-Free Extract (NFE), %) were calculated with equation of {the amount of feed provision (g) x %DM x (%nutrient)} – {remaining feed (g) x %DM) x (%nutrient)}.

Feed nutrient digestibility was measured employing total collection method including digestibility of DM, OM, CF, CP and TDN. The equation to measure the dry ingredient digestibility (%) is: A - B/A x 100%. Where A: average dry ingredient consumed (g); B: the average dry feces excreted (g) (Cullison, 1979). Feed nutrient digestibility was calculated using the equation of A x a (%) – B x b (%)/Axa (%) x 100 %; where a = nutrient level in feed A; b = nutrient level in feces B. Nutrient digested (%) = DN x feed ingredients nutrient (%). TDN (%) was calculated using the equation of CP digested + CP digested +NFE digested + (EE digested x 2.25) (Cullison, 1979).

The addition of daily body weight gain (ADG) was obtained by calculating the difference of the final cattle weight (kg) with the initial cattle weight (kg) divided by the length of breeding (day). Feed conversion ratio/FCR was obtained by comparing the dry ingredient consumption (kg) per day with the daily body weight gain of the cattle (kg).

Data collection

Data collection was done for 3 (three) months according to the length of research conducted. The feed provided was weighted and recorded along with the remaining feed in order to know the amount of feed consumption. Feed nutrient composition was known by taking 500 g of feed sample which was then sun-dried until it reached constant weight and 220 g concentrate which was grinded using willey mill with sieve hole of 1 mm to analyze the nutrient content in the laboratory.

The cattle weighting to obtain body weight was done on each cattle in the preliminary research. Further weighting was done each week (7 days) to adjust the amount of feed to be given in addition to know the daily body weight gain and cattle growth pattern.

The collection of feces and urine from each cattle was done through total collection in the last week of the end of the research for 10 days in order to know the feed digestibility (Cullison, 1979). Feces collected was then sun-dried until it reached constant weight. In order to know the feces chemical composition, feces sample was taken by 20%, grinded using willey mill of 1 mm diameter, and was analyzed in the laboratory proximately.

Data analysis

Data were analyzed using variance according to the procedure of Complete Randomized Design. In order to obtain and fasten the analysis, SPSS 20 software was employed (Quinn and Keough, 2002).

RESULTS AND DISCUSSION

Feed intake and digestibility

The intake of dry matter (DM)), organic matter (OM), and nitrogen free extract (NFE) (kg/day) was relatively the same among the treatments. However, the intake of DM, OM, and NFE (g/kgBB$^{0.75}$) of T2 dan T3 treatment was not different and was higher than T1 treatment. The percentage DM of body weight of T3 group was higher ($P<0.05$) than T2; and T2 group was higher ($P<0.05$) than T1. The intake of crude protein (CP), crude fiber (CF), and TDN (kg/day, g/kgBB$^{0.75}$) from T2 and T3 cattle group was relatively the same, but higher ($P<0.05$) than T1 treatment (Table 4).

The digestibility of DM, OM, CP, CF, and NFE (%) from the three cattle group was relatively the same among the treatment. It indicates that the complete feed quality used in fattening was sufficient and not far different among the three treatment groups (Table 4).

Table 1: Nutrient content of feed ingredients composition and ration of complete feed which uses *Gliricidia sepium* leaves as a source protein for Bali cattle fattening.

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

Note: DM: dry matter; OM: organic matter; CP: crude protein; EE: extract eter; CF: crude fiber; CHO: carbohydrate; NFE: Nitrogen Free Extract. Calculated through the equation: NFE = [100 – (ash content + CF level + EE content + CP content)] %; GE: gross energy; ME: energy metabolism; T1: complete feed ration containing 11% CP, 72% TDN, T2: complete feed ration containing 13% CP, 72% TDN; T3: complete feed ration containing 15% CP, 72% TDN.

The intake of crude protein (CP), crude fiber (CF), and TDN (kg/day) from T2 and T3 cattle group was relatively the same, but higher ($P<0.05$) than T1 treatment. If the intake of CP and CF was calculated from metabolic body weight, then T3 treatment was higher than T2 and T1 treatment (Table 4).

Average daily gain, feed conversion, and efficiency

The body weight gain (BWG) and daily body weight gain (ADG) of T2 treatment cattle was higher than T1 and T3 treatments. However, the difference between the cattle in T1 and T3 groups was not significant. The feed conversion of T2 group relatively the same with T1 treatment, but was higher (the conversion value was lower) ($P<0.05$) than T3. Conversely, the T1 treatment was relatively the same as T3 treatment. The feed efficiency also has pattern which is not far different, in which the cattle of T2 treatment has higher feed efficiency value than T3 treatment, but relatively the same as T1 group. In addition, feed efficiency produced by T3 treatment was not far different from T1 (Table 5).

Feed intake and digestibility

Dry and organic matter intake

The dry matter (DM) and organic matter (OM) intake of T3 and T2 treatments were relatively the same but higher than T1 treatment (Table 1) due to differences in the initial body weight of the cattle involved. The initial body weight of cattle in each treatment was 175.2500 kg ($BW^{\wedge 0.75}$: 48.16) for T1 treatment, 184.7500 kg ($BW^{\wedge 0.75}$: 50.09) for T2 treatment, and 184.5000 kg ($BW^{\wedge 0.75}$: 50.00) for T3 treatment. Moreover, it shows that complete feed used had a quality that was not far different, thus it gave relatively the same cattle response in consuming it.

Cattle positive response in consuming complete feed was due to the ration feed ingredients, which contains sufficient palatable and sufficient nutrient content, especially the energy and protein. When protein and energy are sufficiently obtained by cattle, then the rumen microbes to digest the feed is higher, leading to faster emptying rate. The percentage of DM intake (%BW) in average reaching 2% of DM is high enough to fulfill the maintenance need and production need aiming to improve the cattle performance.

Furthermore, even though the complete ration feed ingredients in this research had different ratio of forage and concentrate among the treatment, however, in general the concentrate proportion consisting cornmeal, rice bran and bran pollard was higher (Table 2). It further gave the same effect on the cattle which consumed it to meet the nutrient need for their maintenance and growth.

Table 2: Comparison of feed ingredients composition and ration of complete feed which uses *Gliricidia sepium* leaves as a source protein for Bali cattle fattening.

Feed type	T1	T2	T3
Field Grass	27	27	27
Gliricidia sepium	10	20	31
Ground corn	34	28	20
Bran pollard	15	15	15
Rice Bran	14	10	7
Total	100	100	100

According to the recommendation given by Kearl (1982), DM needs for young male cattle weighted 250 kg with expected ADG of 0.75 kg reaches 6.6 kg or 2.64% of the body weight. When it is compared to this research, then the three cattle treatment has relatively low DM intake than the standard above. This describes that the complete feed given has enough protein and energy, so that it limits the cattle to continuously increase its intake. Cattle consume feed aiming to meet their energy needs, where the energy comes from non-fiber carbohydrates (NFC) to improve digestibility and reduce enteric methane intensity in beef cattle (Kongphitee *et al*., 2018).

Sufficient feed consumption (nutrient) is proven by the growth performance, especially ADG which was quite high on T1 to T3 cattle (Table 5). This research proved that complete feed with protein source from *Gliricidia sepium* forage was actually effective in improving the cattle growth. Tahuk *et al*. (2017) report indicates that the use of fresh *Gliricidia sepium* as protein source actually has negative effect on feed intake. This is related to the low palatability due to anti-nutrition substance (*Coumarin*) contained. On the other hand, on the complete feed, the *Gliricidia sepium* has been dried and grinded and mixed with concentrate. Therefore, the cattle selection nature is limited; in addition to the *Gliricidia sepium* characteristic smell which has been omitted leading to cattle fattening productivity improvement. In general, ruminant cattle ability in consuming feed ranges between 40-90g/kg.$BB^{0.75}$/day or 1-2.8% from the body weight (Aregheore and Yahaya, 2001).

The intake of crude protein, crude fiber and TDN

The increased intake of crude protein (CP), crude fiber (CF), and total digestible nutrients (TDN) on T2 and T3 treatments compared to T1 treatment is directly proportional with DM intake from the two treatments which were higher as well. Furthermore, the different intake of CP, CF, and TDN is the feed quality description related to the palatability. The feed of T2 and T3 cattle group has high palatability so that it contributed to the DM intake improvement. It causes the improvement of nutrient consumption including CP, CF, and TDN.

The CP intake of T2 and T3 treatments was very high in which T2 was 0.894±0.036 kg/head/day; while T3 reached 0.942±0.127 kg/head/day. Crude protein need for young male cattle weighted 250 kg with daily body weight gain of 0.75 kg/day is 0.693 kg/day Kearl (1982). Referring to that recommendation, then CP intake of T1 cattle reached 0.727±0.057 has exceeded the standard above since it is nearly the same as CP intake on the cattle which has ADG target of 1 kg/cattle/day. On the other hand, T2 and T3 cattle has CP intake of 0.894±0.036 and 0.942±0127 respectively which has exceeded the recommendation since it has been much higher than the need of male cattle with ADG target of 1.10 kg/cattle/day.

This research report indicates that *Gliricidia sepium* proportion improvement on complete feed of T2 by 20% and T3 by 31% contributes positively in improving CP obtained by the cattle. On the other hand, CP intake on T1 treatment was lower since the *Gliricidia sepium* proportion used only 10% of the total ration DM. Furthermore, this CP intake improvement is the illustration of high complete feed palatability so that it triggers the cattle to consume the feed. Feed with high protein content will not indicate positive protein consumption rate if it has low palatability rate. According to Van Soest (1994), CP intake is affected by many factors, such as DM intake and its digestion, fermentation activity in rumen, the effect of digestive enzyme, metabolism by microbe and feed quality.

Based on CF intake, the proportion of feed ingredient used in the three treatments is expected to also affect the rate of CF content. Natural grass which is the fiber source is expected of having low influence due to having the same proportion in ration which is 27% of the total dry ingredient. On the other hand, *Gliricidia sepium* and rice bran contribute to the CF increase. The proportion of *Gliricidia sepium* employed in T2 and T3 increases, leading to the increase of CF. In contract, the effect of rice bran was not significant since the proportion is increasing in T2 and T3.

This research result illustrated that complete feed applied on cattle fattening positively contribute to increased nutrient digested by the cattle. Complete feed used in this research has higher digestible carbohydrate source proportion so that it leads to the high TDN obtained by the cattle.

The high intake of TDN of T2 and T3 cattle group in this research increased the cattle productivity, especially to the daily body weight gain. The TDN for the maintenance need of young male cattle weighted 250 (ADG 0 kg/day) is 1.0 kg/day, while in increasing body weight with ADG target of 1.10 kg/day, the cattle need DM by 6.60 kg and TDN by 4.6 kg Kearl (1982). The TDN intake of the three cattle treatment groups was lower than the recommendation above. However, the TDN consumption for Bali cattle is already sufficient for the growth. This was proven by the high ADG of the cattle during the research (Table 5). According to Fiems *et al*. (2015), improving the efficiency of energy utilization is important because it can reduce feed costs for livestock production thus increase the breeders' income. Furthermore, higher efficiency of energy also means that nutrients are better utilized by the animal, resulting in a lower excretion into the environment and

lower costs for manure management.

Nutrient digestibility

The digestibility of dry matter, organic matter, crude protein, and crude fiber of the three treatments was relatively the same. This indicated that the complete feed in T1, T2, and T3 treatments, although containing different CP and TDN, had optimally met the needs of rumen microbes to digest feed optimally. The digestibility of DM and OM on male Bali cattle is quite high so that it leads to the sufficient nutrient needed by cattle, both for maintenance and production needs. However, DM digestion which ranges between 53–56 %, and OM which ranges between 56–59% has not been optimal yet; this is because the plant cell wall content (NDF, ADF, lignin, and hemicellulose) on complete feed used is quite high. Therefore, it limits the rumen microbe to digest the feed consumed (Table 3). The livestock was given feed ingredient which contains high lignin, thus it will decrease the fiber degradation done by microbe if there is no sufficient energy source. Kanani *et al.* (2014) reported that the higher lignin content in rations could reduce the dry matter intake and digestibility in cattle. Other than that, according to other research reports, increasing CP levels in concentrate had no significant effect on DM and OM digestibility, whereas increasing the proportion of concentrate resulted in increased DM and OM digestibility (Dung *et al.*, 2014).

According to various reports, feed digestibility in the rumen is determined and depending on the chemical and physical composition of the feed consumed by the cattle. If the feed consumed by the cattle is fibrous, then the digestibility rate owned is low since the degradation done by the rumen microbe is low (Prayitno *et al.*, 2017; Baran *et al.*, 2008).

This research reported higher DM digestibility than what reported by Koddang (2008) which was as much as 51.92% on male Bali cattle without concentrate which obtains *Pennisetum purpuphoides* grass by 100% *ad libitum;* but lower than male Bali cattle which obtained concentrate of 1.5-2.0% with *Pennisetum purpuphoides* of 100% *ad libitum* with DM digestion by 59.63–64.11 %. Likewise, this research report is lower than report by Tahuk *et al.* (2017) which obtained DM digestion of 62–76% on male Bali cattle with different CP level and the breeding was done in local community breeding.

Crude protein digestion (%) of male Bali cattle obtained really high complete feed, in which T1 was 80.023±2.670; T2 was 82.358±1.978, and T3 was 83.168±1.635 (Table 4). The CP digestion which was quite high and relatively the same indicates that the quality of complete feed used in fattening is sufficient and not much different between the three treatment groups. It leads to the increase of rumen microbe ability in digesting feed since it is supported by sufficient nutrient, especially protein and energy. This illustrates that the digestion value is not the same in every feed or cattle. However, it is also affected by other factors such as chemical composition, food processing, amount of feed given, and types of animal (Prayitno *et al.*, 2017; Baran *et al.*, 2008; McDonald *et al.*, 2002).

Table 3: Formulation of complete ration which uses *Gliricidia sepium* leaves as a source protein for Bali cattle fattening.

T1 Ration				
Feed ingredients	**Amount (kg)**	**DM content (%)**	**CP content (%)**	**TDN content (%)**
Gliricidia sepium	10.00	86.00	2.60	7.80
Ground corn	34.00	89.00	3.70	30.60
Rice bran	14.00	90.00	1.00	7.10
Bran pollard	15.00	85.00	2.40	11.10
Total	100.00		11.60	72.20
T2 Ration				
Field Grass	27.00	86.00	1.90	15.70
Gliricidia sepium	20.00	86.00	5.20	15.60
Ground corn	28.00	89.00	3.10	25.20
Rice Bran	10.00	90542	0.70	5.10
Bran pollard	15.00	85.00	2.40	11.10
Total	100.00		13.30	72.60
T3 Ration				
Field Grass	27.00	86.00	1.90	15.70
Gliricidia sepium	31.00	86.00	8.10	24.20
Ground corn	20.00	90.00	2.20	18.00
Rice bran	7.00	90.00	0.50	3.50
Bran pollard	15.00	85.00	2.40	11.10
Total	100.00		15.00	72.500

The result of this research illustrated that CP digestion is sufficient in meeting maintenance need so that the excessive protein consumed can be utilized to improve the body weight gain and beef production. Cattle in T1 treatment digested CP by 576.621 g, T_2 by 730.931 g, and T_3 by 785.538 g. According to the recommendation by Kearl (1982), protein needs for male cattle weighted 250 kg for body weight gain of 0.75 kg per day reached 693 g or 438 g/day of CP digested. Crude protein digested obtained by the cattle in this research was higher and exceeded the recommendation.

Digestion of CP value in this research was higher that report given by Tahuk *et al.* (2017) which obtained CP digestion ranged between 64–74% on fattened male Bali cattle in smallholder farms. In this research, the CP

digestion was also higher than report given by Koddang (2008) which obtained 58.58% CP digestion on male Bali cattle obtaining 100% *Pennisetum purpuphoides* grass *ad libitum* and 72.48–74.66% on male Bali cattle obtaining concentrate of 1.5–2.-0 % of the body weight qith *Pennisetum purpuphoides ad libitum*. In addition, CP digestion in this research was also exceed the report given by Da Cruz de Carvalho *et al*. (2010) which obtained CP digestion as much as 51.74% and 50.02%, respectively on PO and SimPo male cattle which obtained concentrate on feedlot breeding. Factors affecting the different CP digestion between the research result above are genetic factor, cattle physiological status, and different feed ingredient composition.

CF digestion in this research is relatively low, but relatively the same between the treatments. The digestibility of CF was quite low which only ranged from 22.42 - 24.66% due to the complete ration used composed of feed ingredients that had a fairly high CF content such as field grass of 28.221%, *Gliricidia sepium* of 11.137%, and rice bran of 15.103%. In addition, the T1 - T3 rations used in addition to having high CF, were also thought to contain high levels of NDF, ADF, lignin, and hemicellulose. As a result, it was difficult for rumen microbes to digest. Cell wall content, which is quite high, becomes the limited factor for rumen microbe to digest CF consumed by the cattle. In addition, feed ingredients, which composed the ration especially grass forage, have reached the flowering phase, even part of it has passed that phase which then leads to the increase of plant cell wall.

Table 4: Feed Consumption of male Bali cattle fattening using of *Gliricidia sepium* leaves as a source of protein on complete feed[1].

Variable	T1[2]	T2[2]	T3[2]
Feed intske			
Dry matter (DM)			
Intake (kg/ day)[ns]	4.89±0.381	5.736±0.231	5.650±0.760
Intake /$BW^{0,75}$ (g/kg)	82.3033±1.342[a]	89.538±1.284[b]	92.750±3.084[b]
Intake /BW (%)	2.120±0.062[a]	2.242±0.046[b]	2.360±0.336[c]
Organic matter (OM)			
Intake (kg/day)[ns]	3.935±0.306	4.569±0.184	4.497±0.605
Intake /$BW^{0,75}$ (g/kg)	66.226±1.080[a]	71.328±1.612[b]	73.812±2.455[b]
Intake /DM (%)	80.466±0.000[c]	79.663±0.000[b]	79.582±0.000[a]
Crude protein (CP)			
Intake (kg/ day)	0.727±0.057[a]	0.894±0.036[b]	0.942±0.127[b]
Intake /$BW^{0,75}$ (g/kg)	12.235±0.199[a]	13.958±0.251[b]	15.462±0.514[c]
Intake /DM (%)	14.866±0.000[a]	15.589±0.000[b]	16.671±0.000c
Crude fiber (CF)			
Intake (kg/ day)	0.679±0.054a	0.813±0.033[b]	0.840±0.113b
Intake /$BW^{0,75}$ (g/kg)	11.580±0.187[a]	12.685±0.223[b]	13.786±1.14c
Intake /DM (%)	14.070±0.000[a]	14.167±0.000[b]	14.863±0.000[c]
Nitrogen free extract (NFE)			
Intake (kg/ day)[ns]	2.249±0.175	2.571±0.104	2.253±0.339
Intake /$BW^{0,75}$ (g/kg)	37.850±0.617a	40.131±0.722b	41.414±1.377[b]
Intake /DM (%)	45.988±0.000[c]	44.820±0.000[b]	44.651±0.000[a]
Feed digestion (%)			
Dry matter[ns]	53.645±2.607	56.528±2.275	53.518±2.455
Organic matter[ns]	57.540±3.083	59.605±2.232	56.050±2.329
Crude protein[ns]	80.023±2.670	82.358±1.978	83.168±1.635
Crude fiber[ns]	24.335±6.954	24.665±5.793	22.420±6.031
NFE[ns]	56.270±2.846	60.150±1.953	56.900±2.360[b]
Total digestible nutrients (TDN)			
Intake (kg/day)	2.830±0.139[a]	3.400±0.207[b]	3.100±0.490[ba]
Intake/$BW^{0,75}$ (g/kg)	47.994±1.774[a]	53.479±2.364b	50.605±3.518[ba]
Intake/DM (%)	58.250±2.500[b]	60.000±0.000[b]	54.500±2.380[a]

[1]Data is presented on the average±SD; [2]T1: Complete Ration with CP 11%, TDN 72%; T2: complete ration with 13% CP and TDN 72%; T_3: complete ration with 15% CP and TDN 72%; [3]$BW^{0,75}$: metabolism body weight; [a, b, c] superscript which is different in the same line indicates difference (P<0.05).

Table 5: Growth performance and of male Bali Cattle fattening using using of *Gliricidia sepium* leaves as a source of protein on complete feed[1]

Variable	T_1[2]	T_2[2]	T_3[2]
Growth performance			
Initial weight (kg)[ns]	175.250±9.179	184.750±13.937	184.500±25.357
Final weight (kg)[ns]	229.500±11.690	253.750±13.326	240.750±31.889
BWG[3] (kg)	54.250±4.717[a]	69.000±4.761[b]	56.250±11.870[a]
ADG[3] (kg)	0.775±0.066[a]	0.985±0.071[b]	0.805±0.169[a]
FCR[3]	6.325±0.523[ab]	5.835±0.369[a]	7.193±1.210[b]
Feed efficiency (%)	15.880±1.246b[ab]	17.193±1.110[b]	14.178±2.201[a]

[1]Data is presented on the average±SD; [2]T1: Complete Ration with CP 11%, TDN 72%; T2: complete ration with 13% CP and TDN 72%; T_3= complete ration with 15% CP and TDN 72%; [3]BWG: body weight gain; ADG = average daily gain; FCR = feed conversion ratio. [a, b, c] superscript which is different in the same line indicates difference (P<0.05).

The low DM digestion of complete feed in the three treatments is also related to the unbalance nutrient, especially the protein and energy. Crude protein intake and digestion in the three cattle treatment has exceeded the cattle need (Table 1 and 4); on the other hand, TDN consumed by the cattle was lower (Table 1). It causes the protein and energy supply for microbe activity in degrading the fiber cannot be maximal. Tahuk *et al.* (2017) reported that if Bali cattle has CP intake exceeding the optimal cattle need, it will be inefficient and cannot be utilized by the cattle to improve its performance if it is not counterbalanced by sufficient energy from digestible carbohydrate.

The percentage of digestibility and intake rate is not only affected by feed cell wall proportion, but also the physical form of the cell wall. Feed fiber fraction very much determines the digestion in terms of both the amount and the fiber chemical (Prayitno *et al.*, 2017). Cellulose and hemicellulose are included in structural carbohydrate fraction (fiber fraction) which the main component of cell wall of plant and often related to lignin, so that it becomes difficult to be digested by rumen microbe (Minson, 1993).

Digestion of CF value of complete feed on male Bali cattle fattening in this research was lower than CF digestion of male Bali cattle as reported by Da Cruz de Carvalho *et al.* (2010) on male PO and SimPO which was given different concentrate in feedlot breeding with the respective CF digestion was as much as 58.82% and 57.06%.

Growth performance

Body weight gain and average daily gain

Body weight gain (BWG) and average daily body weight gain (ADG) on cattle in T2 treatment obtaining complete feed composed by 13% CP level and 72% TDN level effectively improved the cattle performance. The T2 cattle has higher ADG by 21.320% than T1; and higher by 18.274% than T3 treatment. The T2 cattle performance which was quite high indicates that the use of complete ration with protein level of 13% and TDN of 72% has been sufficient for protein and energy needs so that it contributes positively on the cattle performance improvement. When the protein and energy needs are fulfilled, the synthesis of body tissue runs maximally, which eventually improves body weight gain. Although it was not measured in this research, it is expected that the propionate acid production as glucose precursor increase so that it triggers the synthesis of cattle body tissue.

According to Fluharty (2009) report, the provision of feed containing high digestible carbohydrate can increase the propionate proportion produced thorough rumen fermentation with acetate proportion of 50-60%, propionate of 35-45%, and butyrate of 5–10%. VFA movement to propionate is really important in beef cattle fattening (Fluharty, 2009). The three cattle treatments (T1 – T3), although in ration composition has the same TDN content (average of 72%) and the same energy source, affect the cattle fattening performance obtaining the ration since the proportion use of the feed is different. In the three treatments, the rill feed consumption was different from the initial ration formulation. The T1 ration initially has CP of 11% and TDN of 72%, but after the calculation, it obtained CP of 14% and TDN of 58%. T3 treatment cattle initially has CP and TDN ration of 15% and 72% respectively, changed into CP of 16% ad TDN of 54% after the calculation.

Cattle on T3 treatment used sufficiently high *Gliricidia sepium* which reaching 31% of the total DM which leads to sufficiently high feed of CP. However, the energy source especially from the grass forage is not sufficient due to the high CF content (Tahuk *et al.*, 2016). Likewise, the use of rice bran in complete feed ration which also contributes to the low TDN. According to Tahuk *et al.* (2016), the rice bran digestion rate in North Central Timor is quite low where DM digestion is 42.10% and OM digestion is 44.58%. This contributes to the low digestible carbohydrate obtained by the cattle.

This research result illustrated that the proportion and quality of feed ingredients in making complete feed determines the high and low of CP and TDN of complete ration used. The low intake of TDN on T1 and T3 affects to the unbalance energy and protein obtained by the cattle. It causes the rumen microbe activities to degrade the feed to be not maximal. Such condition causes the synthesis of body tissue to be not maximal, indicated by relatively lower body weight gain in the two treatments than T2 treatment. The results of the studies on T1 and T3 treatments were similar to reports of Boonsaen *et al*. (2017) which states that the use of CP levels of 12% and 14% in TDN ranges from 70.17 to 73.15% resulting in daily weight gain that is relatively the same as young cattle.

Cattle growth on T2 treatment exceeds the T1 and T3 treatments due to the protein consumed which was 15% of DM which was sufficiently synchrony with TDN intake which reached 60%. Such CP and TDN consumption was little bit different from the initial ration formulation which has CP of 13% and TDN of 72%. The nutrient change (CP and TDN) was caused by the change of ration nutrient composition based on the laboratory analysis result and feed quality, especially the energy source of feed nutrient content. This research report is in line with report given by Gleghorn *et al*. (2004), which stated that the use of CP by 13% in ration has been optimal in beef cattle fattening since at such CP range, the DM intake, ADG and gain feed is higher. On the other hand, the use of CP less than 13% (11.5%) and more than 13% (14.5%) decreases the beef cattle fattening performance seen from the observation parameter above.

This research result indicates that in general, the protein source feed is sufficiently available to fulfill the cattle needs. However, the availability of energy sources feed is not sufficient to fulfill the needs of cattle, especially those in the form of fibrous forage. This research was conducted in the dry season which affects the low quality of the feed used, where the protein content of feed is getting lower. On the other hand, the crude fiber content of the feed used was higher (Tahuk and Dethan, 2010).

According to Bach *et al*. (2005), the high protein intake must be balanced enough by the availability of digestible carbohydrates as an adequate source of energy. The role of digestible carbohydrates, besides providing energy for rumen microbes for degradation activities, also acts as a source of carbon framework for the synthesis of microbial proteins along with N-NH3. If the energy intake in cattle is low, it will affect the rumen microbial activity which is not optimal, and the low utilization of rumen NH3 for microbial protein synthesis (Bach *et al*., 2005).

The potential of cattle growth will be maximal when sufficiently high-quality feed is obtained (Forbes, 2007). According to Bennet *et al*. (1995), male cattle given forage alone will show lower growth. Conversely, cattle that are given concentrate will show higher growth. In ruminant animals, cattle that are fed with high coarse fibrous, bulky feed with low digestibility most often experience the problem of undereating feed consumption. Such feed nature limits the amount of feed consumed. As a result, the amount of nutrients obtained by the cattle, especially energy is also low (Forbes, 2007).

Feed conversion ratio (FCR) and feed efficiency

The optimal DM intake and the high daily body weight gain (ADG) for T2 treatment cattle have a better (lower) conversion ratio and feed efficiency than T1 and T3 treatments. This condition proves that cattle in the T2 treatment require less feed than T3 to raise one unit of body weight. Meanwhile, in order to increase one unit of weight in T1 and T3 groups, it needed more feed. This also indicates that cattle at T2 treatments is very efficient in using feed to improve their growth performance compared to T1 and T3 treatments.

Conversely, high feed conversion rates in T1 and T3 treatments indicate that high DM intake has not been followed by a high body weight gain. When DM consumption is high, but ADG produced by the cattle is low, the conversion rate of feed becomes high because of the low utilization efficiency of feed. In cattle fattening efforts, the lower the value of feed conversion, the better. The best feed conversion value is 4.5 - 7.5 (Shike, 2013). Cattle that will convert at a high rate (lower FCR) are highly desirable for cattle owners and for feedlots that charge on again basis (Lamb and Maddock, 2009).

The conversion value of feed which is still high at T1 and T3 is probably due to the nutrients consumed by cattle which are still concentrated to meet maintenance needs and other vital needs for normal bodily activities. According to Shike (2013), about 70% of the food consumed by cattle is used for body maintenance. The remaining 30% gives a hint that the complete feed used has a different quality. Where complete T2 rations are generally of higher quality than T1 and T3 treatments. In addition, this condition is also affected by the quality of cattle, including the ability to adapt to feed, as well as the feeding method used (Tahuk *et al*., 2018a).

The amount of feed conversion in ruminant animals is affected by feed quality, body weight gain and digestibility value. In addition, the micro-rumen and its activities play an important role in determining the feed conversion and maximum growth performance of livestock (Lima *et al*., 2019). According to McGee (2014), factors affecting feed

efficiency were live weight and live weight gain, duration of finishing period/slaughter weight, breed type/genetics, gender, and compensatory growth potential. Improvements in feed efficiency can be achieved in various approaches such as through selection, nutrition, the use of growth promotants and management practices. Nutrition-related practices include changes in diet composition (Boaitey, 2017). When cattle are given high quality feed, the growth achieved is higher. Thus, the conversion of the resulting feed will get better as well.

Male Bali cattle that received complete feed in this study had smaller feed conversion values compared to Tahuk and Dethan Reports (2010) whose cattle received feed conversion of 7.55 by forage. Meanwhile, the research conducted Oematan (2000) obtained 6.01-7.56 in male Bali cattle fattening which received concentrated rations with different protein and energy ratios. In addition, Boonsaen *et al*. (2017) obtained 8.80-10.75 in Kamphaeng Saen steers fed different protein level and energy source.

This research feed conversion is smaller than the report of Tahuk *et al*. (2017) which obtained feed conversion of 11.50 - 16.57 in male Bali cattle fattening with different CP levels from sources protein of *Gliricidia sepium*. More optimal feed conversion in this study proves that the use of *Gliricidia sepium* a source of protein will effectively improve the performance of Bali cattle which are fattened when formulated and processed in the form of complete feed. In addition, the results of this research also explain that changes in the physical form of feed, especially in forage, contribute positively to improve the performance of cattle. When the forage is milled and mixed with concentrate, the opportunity for cattle to make a selection is reduced so that it has an impact on meeting the nutritional needs.

CONCLUSIONS AND RECOMMENDATIONS

The application of complete feed with protein sources from forage of *Gliricidia sepium* with CP and TDN content of 13% and 72%, respectively, can improve the performance of fattened male Bali cattle. This can be seen from the growth production which was higher than the use of CP of 11% and 15% with TDN 72%. It is proven that the use of *Gliricidia sepium* as the source of protein in the complete feed contributes positively to the performance of fattened male Bali cattle.

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NOVELTY STATEMENT

Research contributes to the improvement of science and technology, especially the use of protein sources from Gliricidia sepium leaves in complete feed to improve the performance of male Bali cattle fattened in the tropics.

AUTHOR'S CONTRIBUTION

PKT, designed research and drafted the manuscript, ORN and GRB research process, statistical analysis and drafted the manuscript. AM, DM, TYP, EB, and BS assisted in the research process and data collection. The authors have the maximum contribution to the research; and have read and approved this published article.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Aregheore EM, Yahaya SS (2001). Nutritive values of some browses as supplements for goats. Malays. J. Anim. Sci., 7(1): 29 – 36.

Bach A, Calsamiglia S, Stern MD (2005). Nitrogen metabolism in the rumen. J. Dairy Sci., 88(E. Suppl.): E9–E21. https://doi.org/10.3168/jds.S0022-0302(05)73133-7

Baran MS, Demirel R, Yokus B, Kocabagli N (2008). The effects of sorghum grain on live weight gain, feed conversion ratios and digestibility of nutrients in beef cattle. J. Anim. Vet. Adv., 7(9): 1123-1127.

Bennett LL, Hammond AC, Williams MJ, Kunkle WE, Johnson DD, Preston RL, Miller MF (1995). Performance, carcass yield, and carcass quality characteristics of steers finished on rhizome peanut (*Arachis glabrata*) - tropical grass pasture or concentrate. J. Anim. Sci., 73: 1881. https://doi.org/10.2527/1995.7371881x

Boaitey A, Goddard E, Mohapatra S, Crowley J (2017). Feed efficiency estimates in cattle: the economic and environmental impacts of reranking. Sustain. Agric. Res., 6(2): 35-47. https://doi.org/10.5539/sar.v6n2p35

Boonsaen P, Reungprim T, Soe NW, Sawanon S, Maitreejet W, Majarune S (2017). Effects of protein levels and energy sources in total mixed ration on feedlot performance and carcass quality of Kamphaeng Saen steers. Agric. Natl. Resour., 51: 57-61. https://doi.org/10.1016/j.anres.2017.02.003

Cullison AE (1979). Feed and feeding. 2nd Edn., Reston Publishing Company, Reston, Virginia, pp. 12-27.

Da Cruz de Carvalho M, Soeparno dan N, Ngadiyono (2010). Pertumbuhan dan produksi karkas sapi peranakan ongole

dan simental peranakan ongole yang dipelihara secara feedlot. Bull. Peternakan, 34(1): 38–48. https://doi.org/10.21059/buletinpeternak.v34i1.105

Dung DV, Shang W, Yao W (2014). Effect of Crude protein levels in concentrate and concentrate levels in diet on *in vitro* fermentation. Asian Australas. J. Anim. Sci., 27(6): 797-805. https://doi.org/10.5713/ajas.2013.13560

Fluharty FL (2009). Interactions of management and diet on final meat characteristics of beef animals. Beef Information, The Ohio State University Extension. http://beef.osu.edu/library/mgtdiet.html. Akses, 9 Fesember 2015.

Fiems LO, De Boever JL, Vanacker JM, De Campeneere S (2015). Maintenance energy requirements of double-muscled Belgian blue beef cows. Animals, 5: 89-100. www.mdpi.com/journal/animals Article. https://doi.org/10.3390/ani5010089

Forbes JM (2007). Voluntary food intake and diet selection in farm animals. Second Edition. ISBN-13: 978 1845932794. CABI Publishing, USA. https://doi.org/10.1079/9781845932794.0000

Gleghorn JF, Elam NA, Galyean ML, Duff GC, Cole NA, Rivera JD (2004). Effects of crude protein concentration and degradability on performance, carcass characteristics, and serum urea nitrogen concentrations in finishing beef steers. J. Anim. Sci., 82: 2705 – 2717. https://doi.org/10.2527/2004.8292705x

Kanani J, Philipp D, Coffey KP, Kegley EB, West CP, Gadberry S, Jennings J, Young AN, Rhein RT (2014). Comparison of acid-detergent lignin, alkaline-peroxide lignin, and acid-detergent insoluble ash as internal markers for predicting fecal output and digestibility by cattle offered bermudagrass hays of varying nutrient composition. J. Anim. Sci. Biotechnol., 5(7): 1-8. https://doi.org/10.1186/2049-1891-5-7

Kearl LC (1982). Nutrient requiments of ruminants in developing countries. International Feedstuff Institute Utah Agricultural Experiment Station, Utah State University, Logan, Utah, U.S.A.

Koddang MYA (2008). Pengaruh tingkat pemberian konsentrat terhadap daya cerna bahan kering dan protein kasar ransum pada sapi bali jantan yang mendapatkan rumput raja (*Pennisetum purpurephoides*) Ad-libitum (The Effect of Feeding Level of Concentrate on Dry Matter and Crude Protein Digestibility of Male Bali male Which Get King Grass (*Pennisetum purpurephoides*) Ad-libitum. J. Agroland, 15(4): 343–348.

Kongphitee K, Sommart K, Phonbumrung T, Gunha T, Suzuki T (2018). Feed intake, digestibility and energy partitioning in beef cattle fed diets with cassava pulp instead of rice straw. Asian-Australas. J. Anim. Sci., 31(9): 1431-1441. https://doi.org/10.5713/ajas.17.0759

Lamb GC, Maddock T (2009). Feed Efficiency in cows. https://animal.ifas.ufl.edu/beef_extension/bcsc/2009/pdf/lamb.pdf. Akses 22 April 2020.

Lima J, Auffret MD, Stewart RD, Dewhurst RJ, Anne Duthie C, Snelling TJ, Walker AW, Freeman TC, Watson M, Roehe R (2019). Identification of rumen microbial genes involved in pathways linked to appetite, growth, and feed conversion efficiency in cattle. Front. Genet., 10, Article 701: 1-18. https://doi.org/10.3389/fgene.2019.00701

McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA (2002). Animal nutrition. 5th Edition. Pearson Prentice Hall, Harlow, England.

McGee M (2014). Feed efficiency in beef finishing systems. Teagasc-IGFA Nutrition Conference-June2014. https://www.teagasc.ie/media/website/publications/ 2014/ Mark_McGEE_PAPER.pdf. Akses 22 April 2020.

Minson DJ (1993). Forage in ruminant nutrition. San Diego, California: Academic Press Inc. pp. 150–161.

Oematan JS (2000). Pertumbuhan kompensasi sapi Bali jantan pada beberapa imbangan energi-protein ransum dan efeknya terhadap sifat-sifat karkas. Graduate Thesis, Bogor Agricultural University, Indonesia.

Pedreira M, dos Santos SG, de Oliveira, Primavesi O, de Lima MA, Frighetto RTS, Berchielli TT (2013). Methane emissions and estimates of ruminal fermentation parameters in beef cattle fed different dietary concentrate levels. R. Bras. Zootec., 42(8): 592-598. https://doi.org/10.1590/S1516-35982013000800009

Prayitno CH, Mukminah NL, Jayanegara A (2017). Research article effects of different feeding methods on feeding behavior, feed intake and digestibility of lactating dairy cows. Int. J. Dairy Sci., 12: 73-80. https://doi.org/10.3923/ijds.2017.73.80

Quinn GP, Keough MJ (2002). Experimental design and data analysis for biologists. Cambridge University Press, New York. pp. 174-207. https://doi.org/10.1017/CBO9780511806384

Shike DW (2013). Beef cattle feed efficiency. Driftless region beef conference. University of Illinois at Urbana-Champaign.

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

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

Tahuk PK, Baliarti E, Budhi SPS, Panjono (2018b). The effect of season on the feed quantity and quality and growth performance of male Bali cattle fattened in smallholder farms. Bull. Peternakan, 42(3): 203-209. https://doi.org/10.21059/buletinpeternak.v42i3.33058

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

Tahuk PK, Budhi SPS, Panjono, Ngadiyono N, Utomo R, Noviandi CT, Baliarti E (2017). Growth performance of male Bali cattle fattening fed ration with different protein levels in smallholder farms, West Timor, Indonesia. Asian J. Anim. Sci., 11(2): 65–73. https://doi.org/10.3923/ajas.2017.65.73

Tahuk PK, Budhi SPS, Panjono, Baliarti E (2018a). Carcass and meat characteristics of male bali cattle in Indonesian smallholder farms fed ration with different protein levels. Trop. Anim. Sci. J., 41(3): 215-223. https://doi.org/10.5398/tasj.2018.41.3.215

Van Soest PJ (1994). Nutritional ecology of the ruminant. 2nd Ed. Cornell University Press, Ithaca and London. https://doi.org/10.7591/9781501732355