J I T A A
Journal of the Indonesian Tropical Animal Agriculture
Accredited by Ditjen Penguatan Risbang No. 60/E/KPT/2016

J. Indonesian Trop. Anim. Agric.
pISSN 2087-8273 eISSN 2460-6278
http://ejournal.undip.ac.id/index.php/jitaa
45(1):28-36, March 2020
DOI: 10.14710/jitaa.45.1.28-36

The ammoniation of total mixed fiber with mineral organic supplementation in ration to increase beef cattle production

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Received April 12, 2019; Accepted December 04, 2019

ABSTRAK

Tujuan dari penelitian ini adalah untuk mengevaluasi tingkat mineral organik dalam ransum amoniasi Total Mixed Fiber (ATMF) sebagai pakan basal terhadap performa sapi potong. Penelitian ini dilakukan secara In Vivo dengan metode eksperimen menggunakan uji-t, membandingkan hasil suplementasi terbaik pada penelitian in vitro dan control. Sapi yang digunakan adalah Sapi Bali dengan Berat Badan + 120kg sebanyak 12 ekor. Perlakuan yang diuji adalah P1: 60% amoniasi TMF tanpa suplementasi mineral organik P2: 60% Amoniasi TMF + 1,5 x Organik makromineral (Ca, P, dan S) NRC (2000). Masing2 perlakuan ditambah dengan 40% konsentrat. Setiap perlakuan mendapatkan 6 kali ulangan. Parameter yang diukur dalam teknik in-vivo adalah kecernaan nutrisi yang terdiri dari bahan kering dan organik, protein kasar, serat kasar, NDF, dan ADF. Performa ternak: konsumsi ransum, konsumsi bahan kering, pertambahan bobot badan dan efisiensi ransum. Hasil penelitian menunjukkan bahwa suplementasi mineral organic Ca, P dan S dalam ransum dengan ATMF sebagai pakan basal memberikan pengaruh yangb berbeda nyata (P<0,05) terhadap kecernaan nutrisi (bahan kering, bahan organik, serat kasar, NDF, dan ADF) dan performa ternak. Kesimpulan dari penelitian ini adalah suplementasi macrominerals organik (Ca, P, dan S) 1,5 x NRC (2000) dalam ransum dengan 60% ammoniasi TMF sebagai pakan basal dapat meningkatkan performa sapi Bali.

Kata kunci : total mixed fiber, suplementasi, mineral organik , sapi potong, performa, amoniasi

ABSTRACT

The objective of this study was to evaluate the level of organic minerals and total mixed fiber ammoniation (TMFA) as basal feed on the performance of beef cattle. This study used the In Vivo technique and the experimental method using t-test. The t-test compares the best supplementation result on in vitro research and control treatment, each treatment got 6 replications. The treatments tested were P1: 60% TMF ammoniation + 15% swamp legume without supplementation of organic minerals P2: 60% TMF ammoniation + 1.5 x Organic macrominerals (Ca, P, and S) NRC (2000) + 15% Swamp Legumes. The parameters measured in the in-vivo technique were nutrient digestibility consisting of dry and organic matters, crude protein, crude fiber, NDF, and ADF. The animal performance: ration and dry matter consumption, body weight gain and ration efficiency. The results showed that supplementation of minerals in rations with TMFA as basal feed had a significant effect (P<0.05) on nutrient digestibility

(dry matter, organic matter, crude fiber, NDF, and ADF) and animal performance. The conclusion of this study was supplementation of organic macrominerals 1.5 x (Ca, P, and S) NRC (2000) in a ration with TMF ammoniation as basal feed can improve the beef cattle performance.

Keywords: total mixed fiber, supplementation, organic minerals, beef cattle, performance, ammoniation

INTRODUCTION

The quality and productivity level of local cattle in Indonesia is very low, this is due to one of them due to the lack of available forage, lack of processing technology applications such as amoniation or fermentation and feeding management. The lack of availability of forages can be a solution to the development of forages originating from agricultural and plantation waste (Herlambang, T, 2014). Mixing several sources of fiber from both forage and agricultural waste is known as total mixed fiber (TMF) (Maneerat *et al*., 2013). The preparation of TMF comes from fiber sources with different fiber content and depends on the availability. Based on previous research,the use of TMF from agricultural waste in the form of oil palm frond, rice straw and swamp grass (Indonesian: *kumpai tembaga*) with composition of 20% oil palm fronds , 20% rice straw, and 20% swamp grass give the best results but the level of digestibility. This TMF produces the digestibility of dry matter and organic matter 36.32% and 35.96% respectively, NDF digestibility 17.86%, N-NH3 rumen concentration 10.84mM, and SCFA concentrations, i.e., acetic acid, propionic acid, and butyric acid 12.39mM 4.39mM and 4.36mM respectively. Also, methane gas produced is 6.91mM, it is lower than the other experiment (Imsya *et al*., 2016). Low fiber quality will affect livestock performance. The livestock that get low nutrition will produce lower performance than their genetic ability. Body weight gain only reached 10%, rarely exceeding 30% of the actual potential of livestock, so that new cattle reaching 3-5 years of age can be slaugthtered and can produce calves in 4-5 years of age with 2-year intervals (Leng, 1993).

The method to increase the nutrition of livestock rations based on agricultural waste is feed processing technologies such as ammoniation as well as increasing the optimization of rumen bioprocesses by supplementing proteins and minerals. Increasing the utilization of feed with a low nutrient content so that it can be optimally utilized can be done by applying technology to feed ingredients such as ammoniation or feementation, besides that it can also be carried out by supplying minerals and proteins in rations. Suplementation minerals and protein used for increasing of rumen microbe activity (Ponds *et al*, 2005). This method is conducted to maximize the level of productivity of livestock and improve the metabolism of ruminant animals.

The use of organic minerals can increase the content of minerals to protect organic matter that is bound to minerals from degradation in the rumen. The use of organic minerals can increase the content of minerals to protect organic matter that is bound to minerals from degradation in the rumen. Micro and macromineral metabolism interact with each other. This interaction can be both negative and positive in the digestive tract system of livestock, especially in the rumen. The other factors that can affect the role of minerals in the rumen such as phytic acid, crude fiber, and other items.These factors can reduce the minerals in the rumen (Muhtarudin, 2003; Muhtarudin *et al*., 2003). Minerals in the form of chelates can be more easily absorbed in the digestive process. Chelating agents can be carbohydrates, lipids, amino acids, phosphates, and vitamins. In the digestive process, chelates in the ration facilitate penetrating the intestinal cell wall. Theoretically, it increases the absorption of minerals. Amino acid lysine and polyunsaturated fatty acids (PUFA) are the chelating agents used in this study for made organic macromineral. Supplementation in rations is required for cattle that intensively maintenance (Dwiyanto, 2003). Based on previous research, TMF ammoniation in the ration with organic mineral supplementation of Ca, P and S in the ration can improve the fermentative condition in rumen and population of cellulolytic bacteria, but not affect the total population of bacteria and protozoa and can decrease methane gas production in vitro. The organic mineral supplementation level of Ca, P and S 1.5 times from NRC recommendation with 60% of TMF ammoniation gives the best result to the rumen fermentative condition and rumen microbe by in vitro (Imsya, *et al*., 2018). However, the study of supplementation organic mineral (Ca, S and P) with TMFA has not done with beef cattle by in vivo. Therefore, this study was conducted to

investigate the effect of organic mineral supplementation level with TMFA as basal feed to digestibility and performance of Beef cattle

MATERIALS AND METHODS

Animal and Feed

This study utilized an experimental method using the t-test whose each treatment was repeated for six times. The treatment consists of: P0: 60 % ammoniation of TMF without supplementation. P1: 60 % ammoniation of TMF + 1.5 x Organic macrominerals (Ca, P, and S) NRC (2000) (best results of digestibility and characteristics of rumen condition under in vitro). The study was conducted under in vivo using Bali cattle with a body weight of ±150 kg 12 Bali cattle. The treatment ration was added with a concentrate (meal corn, rice bran, tofu waste, salt, and urea) to obtain 100% of the ration (Table 1). A ratio of forage and concentrate = 60: 40 (Table 2 and Table 3)

The parameters measured in the in-vivo technique were performance (Feed intake, body weight gain and feed efficiency), and nutrient digestibility consisting of dry matter, organic matter and NDF, ADF and crude fiber.

Preparation of TMFA

Total mixed fiber ammoniation (TMFA)was composed of swamp grass, agricultural and plantation wastes. TMF formulation consisted of 20% Kumpai Tembaga grass + 20% palm oil frond + 20% rice straw (Imsya *et al*., 2016). The ammoniation was carried out using 4% urea/kg of dry matter TMF. The TMF material was cut 3−5 cm by using a chopper, each forage was mixed according to TMF composition. Urea diluted by water in a ratio of 1: 1 w/l. The urea solution was sprayed in TMF, put into the plastic and incubated for 21 days.

Making Organic Macrominerals (Ca, P and S) according to Muhtarudin and Liman (2006).

The process of making organic macromineral supplements consists of the steps: NaOH 10M 400g diluted in distilled water until 1 litre, added palm 912g (Initial solution). Furthermore, for organic Ca minerals, $CaCO_3$ 5M 680.33g dissolved in distilled water to 1 liter. This solution was mixed with the initial solution and composted until homogeneous. Organic P minerals: Initial solution added KH_2PO_4 solution 601.84g and then was diluted in distilled water to 1 liter. Organic S minerals are carried out by dissolving the initial solution into 601.84 g $(NH_4)_2SO_4$ 5M solution dissolved in distilled water to 1 litre.

In Vivo Period

In vivo research was begun by the preliminary period, i.e. by weighing the initial weight of the livestock and calculating the number of feed requirements (feed intake) prepared from TMF and concentrates. Water was given with ad libitum. During this period, the adaptation for livestock to the given ration is made, by fasting the cattle in the morning and giving the ration treatment for the day. The adaptation period is carried out for one month.

Table 1. Nutrient Content of Feedstuff (%)

Feed Materials	Ccrude Protein	Crude Fiber	Total Digestible Nutrient
Rice Bran	11.2	18.85	65
Milled Corn	10.82	2.61	83
Tofu Waste	11.6	7.79	70
Salt	0	0	0
Urea	2.61	0	0
TMFA	6.65	27.91	66.99

Laboratory of Agricultural Products Technology of Sriwijaya University (2016)
TMFA: Total Mixed Fiber Ammoniation

Table 2. Ingredient and Concentrate Component Intake*

Feed Materials	Usage	CP	CF	TDN
		%		
Rice Bran	60.5	6.77	11.19	39.32
Milled Corn	12	1.29	0.31	9.96
Tofu Waste	26	3.01	2.02	18.2
Salt	0.5	0	0	0
Urea		2.61	0	0
Total	100	13.68	13.52	67.48

*Calculated based on Table 1 with the use of feed ingredients in concentrates

Table 3. Nutrient of Ration*

Ration	Nutritional Contents			
	Usage	CP	CF	TDN
		%		
TMFA	60	3.99	16.75	40.19
Concentrate	40	5.47	5.40	26.99
Total	100	9.46	22.15	67.18

*Calculated bases on Table 1 and Table 2. TMFA: Total Mixed Fiber Ammoniation

The treatment period is carried out for three months while the interval or the adaptation period with the next treatment period is three days

Collecting Period

Collecting is carried out during the last three days per period, feces collected and was weighed every day. Feces dried for 24 hours and calculated as dry weight. Feces was composited and homogenized to analyzed at laboratory to calculate the level of feed digestibility

Determination of Parameter

Feed digestibility was determined by the following calculations:

Dry Matter Digestitility (%) = [(Dry Matter Intake - Dry Matter Feces)/Dry Matter Intake] x 100

The same method is used to calculate Organic Matter, NDF, ADF and crude fiber Digestibility

Animal Performance Determination

Ration Intake Determination

Feed intake was measured by weighing the difference between the amount of feed given and the remaining feed. Weighing was done every evening and morning before the next feed was given

Determination of Body Weight Gain (BWG)

BWG was measured using cattle scales weighed every 15 days. BWG was obtained by calculating the difference between the final body weight and the initial weight during the study.

Feed Efficiency (FE)

Feed efficiency is calculated by comparing intake and weight gain multiplied by 100%

Data analysis

All data were statistically analysed according to independent t-test of SAS (SAS, 2000). The

formula of independent t test was:

$$t = \frac{\text{xa} - \text{xb}}{\text{Sp}\sqrt{(\frac{1}{na}) + (\frac{1}{nb})}}$$

$$Sp = \frac{(na-1)Sa - (nb-1)sb}{na + nb - 2}$$

Note:
Xa= mean of sample a
Xb= mean of sample b
Sp= total of standar deviation
Sa= Standar deviation sample a
Sb= standar deviation sample b
Na= Total of sample a
Nb= Total of sample b

RESULTS AND DISCUSSIONS

The level of digestibility of feed in the rumen was one indicator to see the quality and fermentation process in the rumen. The high of feed digestibility indicate a good quality of ration and digestive process. The level of feed digestibility in this study shown in Table 4. Based on the t-test analysis, it showed that organic mineral supplementation of 1.5 x from NRC recommendation (2000) in ration with TMFA as basal feed affected significantly (P<0.05) on the digestibility of feed nutrient (dry matter, Organic Matter, crude protein, crude fiber, NDF, and ADF) (Table 4). There was an increase in digestibility with the supplementation of Ca, P and S organic minerals in a basal ration of TMFA. Dry matter digestibility increases 25%, digestibility of organic matter 24.45%, crude protein digestibility 36.84%, digestibility of crude fiber 68.76%, NDF digestibility 34.61% and ADF digestibility 35.00%

The performance of Bali cattle received organic mineral Ca, P and S supplementation with TMFA as basal feed in the ration is shown in Table 5. The performance consists of feed intake, dry matter intake, and crude protein intake, body weight gain and feed efficiency. Based on the t-test, supplement did not affect significantly (P> 0.05) feed intake, dry matter intake and crude protein intake, but increased body weight gain and feed efficiency. there was an increase in body weight gain 66.66% and an increase in ration efficiency of 62.89 with supplementation of organic minerals (Ca, S and P) and TMFA as basal feed .

There was an increase in digestibility with the supplementation of Ca, P and S organic minerals in a basal ration of TMFA. Dry matter digestibility increases 25%, digestibility of organic matter 24.45%, crude protein digestibility 36.84%, digestibility of crude fiber 68.76%, NDF digestibility 34.61% and ADF digestibility 35.00% (Table 4) . This significant increase in digestibility reflects the influence of Ca, P and S organic mineral supplementation in improving rumen conditions. According to Muhtaruddin and Liman (2006), supplementation of organic minerals provided a better digestibility rate than those without supplementation due to the activity of rumen microbes requiring several minerals such as Ca and Mg. It was also following Hogan (1996) stated that for optimal growth and breeding, rumen microbes require macro and

Table 4. Nutrition Digestibility TMFA with and without supplementation

Digestibility (%)	TMFA without Supplementation	TMF Ammoniation + 1.5 x Mineral Macro Organic (Ca, P, and S) *
Dry Matter	57.16[a]	76.22[b]
Organic Matter	55.03[a]	68.49[b]
Crude Protein	40.06[a]	54.82[b]
Crude Fiber	32.05[a]	54.09[b]
NDF	38.83[a]	52.27[b]
ADF	37.71[a]	50.91[b]

* NRC (2000)

NDF : Neutrat Detergent Fiber; ADF : Acid Detergent Fiber

Table 5. Average of feed Intake (kg/head/day), Weight gain (kg/head/day) and feed Efficiency (%) of Bali Cattle with TMFA as basal Feed and Organic Minerals of Ca, P and S Supplementation

Treatment	Ration Intake	DMI	CPI	BWG	FE
TMFA without Supplementation	10.35	9.58	0.55	0.45[a]	4.69[a]
TMFA with Ca, P and S Organic Supplementation	10.60	9.81	0.62	0.75[a]	7.64[a]

Different superscripts in the same column indicate significantly different (P<0.05)
DMI : Dry Matter Intake, CPI : Crude Protein Intake, BWG : Body Weigh Gain, FE : Feed Efficiency

micro mineral. The increase in crude protein, NDF, and ADF digestibility also had an impact on increasing the digestibility of dry matter and organic matter. Supplementation of organic minerals Ca, P and S in the basal feed of TMFA influenced positively on the improvement of rumen conditions, especially for rumen microbial activity and growth. This activity will also affect the increase in feed digestibility. Bravo *et al*. (2003) stated that the minerals Ca, and Mg in ration stimulating rumen microbial growth also contribute to the activity of metabolic enzymes related to energy so that the impact provides an increase in digestibility. Mineral P is needed by all microbes especially to maintain membrane and cell wall integrity, nucleic acid components and parts of high-energy molecules ATP, ADP and others.

Increased digestibility of fiber (crude fiber, NDF, and ADF) occurred with the use of organic mineral supplementation (Ca, P and S) in rations. The results of this study were in accordance with the results of Nurhaita *et al*. (2010) stating that there was an increase in fiber digestibility in rations sheep with a basal feed of palm leave ammoniated and supplemented with Sulfur minerals 0.4% and phosphorus 0.27%. This was due to the role of sulfur minerals in helping the formation of amino acids and the synthesis of microbial proteins to optimize cellulose digestion through specific stimulation of cellulolytic bacteria. Based on the results of in vitro studies there was an increase in microbial population with the presence of organic mineral supplementation of 1.16 Log cell/Mn of rumen liquid of cellulolytic bacteria, 0.13 log cell/Mn of total rumen bacteria and 0.44 log cell/Mn of rumen fluid and 0.44 log cell/protozoa/Mumen of rumen fluid as presented in Table 6 (Imsya *et al*, 2018). Mineral Sulfur is needed by rumen microbes to synthesize methionine and cysteine used to form microbial proteins. By adding sulfur to the ration, microbial protein synthesis was increasing (Adelina, 2006).

There was no increase in feed intake, dry matter intake, and intake of crude protein, but there was an increase in daily body weight gain and feed efficiency (Table 5). There was no difference in the intake level due to the same ration palatability, i.e., the color and smell between rations. The reason for this was because the supplementation of organic minerals does not affect palatability ration. Palatability is an essential factor in determining the level of feed intake. The taste, smell and color of the forage feed determine ration palatability (Prawirokusumo, 1994; McDonald *et al*., 2002). Physical and chemical properties of the ration also strongly influence and can change as a result of physiological and psychological differences of the individual livestock (Grovum, 1988).

Dry matter intake which received organic mineral supplementation 1.5 times from NRC (2000) recommendation also revealed no significant effect with no supplementation in the ration. Dry matter intake range of 9.58-9.81 kg/head/day or 6.54% of body weight. The dry matter intake obtained in this study is sufficient for the dry matter needs of a cattle with a body weight of 150-250kg. According to Tillman *et al*. (1991), the ability to consume feed per cattle per day is 3% dry matter ration of its body weight. Based on measurements of cattle body weight during the study, BWG was obtained at 0.45-0.75 kg/head/day. Cattle body weight gained in this study with TMFA as basal feed was sufficient enough. The BWG of this research is relatively high compared to the BWG of Bali cattle fed local rations with a range of BWG between 0.3-0.5 kg/head/day (Hafid and Rugayah, 2010).

Table 6. The Rumen Microbial Population of Beef Cattle Received the 60% Ammonia TMF Basal Feed with Ca, P and S Organic Mineral Supplementation in Ration

Treatment	Cellulolityc Bacteria	Total Bacteria (Log Cell/ mn Rumen Liquid)	Protozoa
Non Supplementation	7.46[a]	9.09	5.78
0.75 x organic macro minerals*(Ca, P and S)	7.16[a]	9.25	5.45
1 x organic macrominerals (Ca, P and S)*	8.55[b]	9.40	5.63
1.5 x organic macrominerals (Ca, P and S) *	8.62[b]	9.22	5.34

Data obtained from Imsya et al. (2018), *NRC (2000)

Meanwhile, for the average BWG female PO cattle fed agricultural waste and bran is 0.65 kg/head/day (Hasbullah, 2003). There was an increase in daily body weight gain of a cattle by 0.3 kg/head/day with the presence of organic mineral supplementation 1.5 times the NRC recommendation (2000) with a basal ration of TMFA compared to rations without supplementation. This shows that supplementation of Ca, S and P organic minerals with a level 1.5 times that of NRC recommendations (2000) affects the improvement of digestibility in the rumen. As a result, the amount of dry matter intake is not significantly different between TMFA as basal ration supplemented by organic minerals Ca, S, and P and without supplementation. It can increase digestibility and cattle body weight. In this study, an increase in dry matter digestibility is 33.34% and organic digestibility of 24.45%, crude protein digestibility of 36.84%, digestibility of crude fiber 68.76%, NDF digestibility 34.61% and ADF digestibility 35.00% of rations without organic mineral supplementation with organic mineral supplementation 1.5 times from NRC recommendations (2000) (Table 2). This increase in digestibility will have an impact on increasing the daily weight of livestock. Livestock with good/high ration intake with normal digestion of feed substances will also produce high body weight (Hafid and Rugayah, 2010). According to Parakkasi (1995), cattle that obtain less nutrient show less optimal productivity. To increase the body weight of a cattle, some needs must be met such as dry matter, crude protein, and additional energy sources.

The efficiency of feed usage is a comparison between daily body weight and intake of dry matter. The use efficiency of feed in this study was obtained for ration with TMFA as a basal feed which did not get supplementation of organic minerals Ca, S and P (4.69%). Also, the ration with organic mineral supplementation was 1.5 times that of NRC recommendation (2000) (7.64%). There was an increase in ration efficiency with TMFA as basal feed with supplementation of Ca, S and P minerals. The higher feed use value efficiency, the fewer rations feed consumed to produce body weight gain. According to Siregar (2001), the efficiency of the use of feed for cattle ranges from 7.52% -11.29%. Some factors that influence feed efficiency include age feed quality and body weight. The better the quality of feed, the better the efficiency of energy formation and production (Pond *et al*., 2005).

Based on the results of the study, it could be concluded that supplementation of Ca, S and P organic minerals with a dose of 1.5 times of NRC recommendations (2000) in rations with basal feeds of Total Mixed Fiber (TMF) ammoniation could improve the performance of cattle. Cattle with basal feed ammoniation TMF and supplementation of Ca, S and P organic minerals with a dose of 1.5 times NRC recommendations (2000) resulted in feed intake of 10.60 kg/head/day, intake of dry matter 9.81 kg/head/day, weight gain 0.75 kg/head/day and feed efficiency 7.64%

CONCLUSION

The level supplementation of Ca, S and P organic minerals 1.5 times of NRC recommendations (2000) in rations with TMFA as basal feed could improve the performance of

cattle. Cattle with basal feed ammoniation TMF and supplementation of Ca, S and P organic minerals with level 1.5 times NRC recommendations (2000) resulted in feed intake of 10.60 kg/head/day, intake of dry matter 9.81 kg/head/day, weight gain 0.75 kg/head/day and feed efficiency 7.64%

ACKNOWLEDGMENTS

This research was supported by Competitive Competitive research grands from Research and services Institution Universitas Sriwijaya through PNBP Funds (No. 0007/UN9/SK.LP2M.PT/2018 dated June 6, 2018).

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