



Digestibility and Performance of Beef Cattle Fed Ammoniated Palm Leaves and Fronds Supplemented with Minerals, Cassava Leaf Meal and Their Combinations

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Abstract | This study aims to determine the effects of supplementation minerals [phosphorus (P) and sulfur (S)] and cassava leaf meal to ammoniated palm leaves and frond rations on the feed digestibility and performance of beef cattle. This study used a randomized block design which divided 20 male Simmental cattle into 5 treatment rations and 4 groups as replications. Treatment NG, the control, was a native grass + concentrate, PLF= Palm leaves and fronds + concentrate, PLFM= PLF + 0.27% phosphorous (P) and 0.4% sulfur (S), PLFC= PLF + cassava leaf meal (5%) and PLFMC= PLFM + cassava leaf meal (5%) Compared to other cows, cows that get PLFMC consume more but are no different ($P>0.05$) from cows that consume NG. Feed digestibility from PLFM and PLFC is lower ($P<0.05$) than PLFMC and NG. Daily gain and feed efficiency of NG were not different ($P>0.05$) from PLFMC. Feed conversion ratio (FCR) from NG and PLFMC is lower ($P<0.05$) than PLFM and PLFC. It can be concluded that PLFMC can replace native grass 100% and produce the best digestibility and performance of beef cattle.

Keywords | Ammoniation, Cassava leaf meal, Digestibility, Feed efficiency, Phosphorus, Sulfur

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INTRODUCTION

Indonesia is one of the largest palm oil producers worldwide, with a production capacity 33.5 million tons from a total area of 11.672.861 ha (Directorate General of Estate Crops, 2015). One of the palm plants wastes considerable potential to be used as a source of forage is palm leaves and fronds. Palm leaves and fronds are produced from the trimming or cutting of old palm frond on the maintenance and harvesting fruit.

The chemical composition of palm leaves and fronds was as follows: dry matter (DM) 30.4%, Ash 5.9 %, Organic Matter (OM) 94.1%, crude protein (CP) 3.64%, crude fiber (CF) 49.8%, cellulose 41.3%, neutral detergent fiber (NDF) 89.9%, acid detergent fiber (ADF) 73.2% and lignin 30.6% (Jamarun et al., 2018). Pazla et al. (2018a) reported an increase in the level of leaves and palm fronds

from 20% to 80% in the ration resulting in a significantly decreased digestibility value of protein and cellulose. High lignin levels cause this. Lignin limits rumen microbial activity in degrading feed, thereby reducing digestibility (Pazla et al., 2020).

Ammoniation technique is one of the physical treatments to loosen lignin bonds with cellulose in high-fiber feed, so enzymes from rumen microbes can penetrate, thereby increasing feed digestibility (Suyitman et al., 2013a). Optimization of the digestibility of high-fiber feed such as leaves and palm fronds can be sought through improved bioprocesses in the rumen and increasing the number of rumen microbial populations (Warly et al., 2015). Amino acids and minerals are precursors of microbial protein synthesis to increase rumen microbial populations (Pazla et al., 2018a).

One of the rumen microbes that play a crucial role

in degrading high-fiber feed is cellulolytic bacteria. Supplementation of Branched Chain Amino Acids (BCAA) in the ration can to increase growth in cellulolytic bacteria that are reflected by increasing DM digestibility and ADF digestibility (Zain et al., 2002). The use of BCAA is an obstacle because the price is quite high. For this reason, it is necessary to look for cheap and BCAA resources natural to get. Cassava leaves contain high BCAA, namely: Isoleucine 4.4%; Valine 8.43%; and Leucine 8.75% (Suyitman et al., 2017a) and potential to be used to improve fiber feed digestibility (Zain, 2007). Supplementation cassava leaves on ammoniated palm leaves can increase the growth of rumen microbes and increase the digestibility of DM, NDF and ADF (Nurhaita and Ningrat, 2011).

The addition of P and S minerals to high-fiber feed can improve animal performance and digestibility (Pazla et al., 2018b). Suyitman et al. (2013b) reported ammoniated palm leaves supplemented with minerals P and S were able to increase digestibility, volatile fatty acid (VFA) and NH₃ concentrations of rumen fluid.

The present study aimed to investigate the effects of ammoniated palm leaves and fronds supplemented mineral (P and S), cassava leaf meal and a combination of both on the feed digestibility and performance of beef cattle.

MATERIALS AND METHODS

The research was conducted in the addressable Cerdas Group Farmers: Block A Sitiung II, Jorong Koto Hilalang II, Nagari Sungai Langkok, District Tiumang, Dharmasraya, West Sumatera, Indonesia. Analysis of processed palm leaves and fronds, feed, and feces held at the Ruminant Nutrition Laboratory, Animal Science Faculty, Andalas University, Padang. The research material used 20 Simmental cows aged around 1-2 years with a bodyweight of about 350-400 kg. Guideline for ethics study of experimental animals based on the law of the Republic of Indonesia number 18 of 2009 about Animal livestock and animal husbandry. The equipment used was a cage, cages equipment, digital scales capacity of 1.500 kg, laboratory equipment, and others.

Experiment a randomized block design with five rations treatments and four Simmental cattle groups as replicates. Grouping Simmental cattle based on the bodyweight beginning of the study, each replication has consisted of 1 head of Simmental cattle. The treatments containing 5 different ration were composed of: Treatment NG, the control, was a native grass + concentrate, PLF= Palm leaves and fronds + concentrate, PLFM= PLF + 0.27% P and 0.4% sulfur S, PLFC= PLF + cassava leaf meal (5%) and PLFMC= PLFM + cassava leaf meal (5%). Each treatment

had a fiber source: concentrate ratio of 60:40. The chemical composition of feed ingredients on the experiment is shown in Table 1 and the ingredient composition and nutrition of the experimental diet are shown in Table 2.

Table 1: Chemical composition of feed ingredients on the experiment.

Chemical composition (%)	Feed ingredients				
	Native grass	Ammoniated Palm leaves and fronds	Rice bran	Tofu dregs	Palm oil sludge
Dry Matter	23.29	26.70	86.9	13.10	65.00
Crude protein	12.27	11.23	13.18	21.00	17.13
Extract ether	4.88	5.84	10.08	10.49	14.03
Crude fiber	25.44	34.69	13.50	23.58	24.62
Ash	8.57	7.86	13.10	2.96	18.55
NDF	67.20	62.37	53.32	51.93	66.78
ADF	45.76	44.98	38.26	25.63	57.92
Lignin	4.20	28.87	9.40	-	19.38
TDN	84.08	77.49	55.52	76.00	74.00

Table 2: Ingredient composition and nutrition of the experimental diet (% DM).

Items	Diet (% DM)				
	NG	PLF	PLFM	PLFC	PLFMC
Native grass	60	-	-	-	-
Ammoniated palm leaves and fronds	-	60	60	60	60
Rice bran	29	21.5	21.5	21.5	21.5
Tofu dregs	2	5	5	5	5
Palm oil sludge	8	12.5	12.5	12.5	12.5
Premix	1	1	1	1	1
Nutrition (%)					
Dry matter	44.64	43.48	43.48	43.48	43.48
Crude protein	12.97	12.76	12.76	12.76	12.76
Extract ether	7.18	7.95	7.95	7.95	7.95
Crude fiber	21.62	27.97	27.97	27.97	27.97
Ash	7.18	10.00	10.00	10.00	10.00
TDN	73.99	71.48	71.48	71.48	71.48

NG: native grass + concentrate (used as the control); PLF: Palm leaves and fronds + concentrate; PLFM: PLF + 0.27% phosphorous (P) and 0.4% sulfur (S); PLFC: PLF + cassava leaf meal (5%) and PLFMC: PLFM + cassava leaf meal (5%).

The following parameters analysed were: feed digestibility (%), feed intake (kg/head/day), average daily gain (ADG) (kg/head/day), feed conversion ratio (FCR) and feed efficiency (%). The results obtained in this study were analyzed based on a randomized block design by ANOVA. Duncan's multiple range test was subsequently conducted when there was a significant difference among dietary

groups (Steel and Torrie, 1991).

MEASUREMENT OF PARAMETERS

Digestibility trials were conducted using for animals for each treatment and animals were separated in individual pens. Cows were fed ad libitum during the adaptation period (30 days). After the last 10 days of each preliminary period, weight gain was observed for 30 days. During the collection period (6 days), animals were equipped with fecal shelter for the total collection and accurate records were kept for each individual intake. Feed consumption is calculated by reducing the amount of feed given by the amount of feed remaining. The total fecal excretion was collected once daily and 10% representative samples were dried at 60 °C overnight and kept in sealed bags until the analysis. The feed and fecal were ground to pass through a 1 mm screen and formed into a composite sample. DM, OM, CP and CF were analyzed by standard methods, according to AOAC (2000). Cellulose, NDF and ADF were analyzed by conventional methods according to Van Soest et al. (1991). Calculation formula:

$$\text{Feed Digestibility} = \frac{\text{Feed Intake} - \text{Fecal}}{\text{Feed Intake}} \times 100\%$$

$$\text{Feed Intake} = \text{Feed Given} - \text{Remaining Feed}$$

$$\text{Average Daily Gain} = \frac{\text{Final Weight} - \text{Initial Weight}}{\text{Research Time}}$$

$$\text{Feed Efficiency} = \frac{\text{Average Daily Gain}}{\text{Feed Intake}} \times 100\%$$

$$\text{Feed Conversion Ratio} = \frac{\text{Feed Intake}}{\text{Average Daily Gain}}$$

RESULTS

FEED DIGESTIBILITY

The result of the study of feed digestibility fed experimental diets is shown in Table 3.

PERFORMANCES OF BEEF CATTLE

The result of the study of average daily gain, feed intake, feed conversion ratio and feed efficiency of Simmental cattle fed experimental diets are shown in Table 4.

DISCUSSION

FEED DIGESTIBILITY

Feed digestibility data is presented in Table 3. The highest digestibility value was in the PLFMC treatment and significantly different (P<0.05) from the PLFM and PLFC treatment, but it was not different (P>0.05) from the NG.

Ruminant feed digestibility very dominantly influenced by the activity and number of microbial populations in the rumen. The quality is determined by the ration digestibility of nutrients from the ration, which illustrates what percentage substance ingested and what percentage

were discharged through feces. In Table 3, it appears that the value of the digestibility of nutrients PLF (no supplementation) was significantly lower than other treatments. Low digestibility in the treatment; this is due to the growth of bacteria not useful as a result of the unavailability of nutrients that stimulate the growth of rumen microbes so that the fermentation process in the rumen also runs less than optimal. Growth cellulolytic bacteria are less optimal in this treatment, seen by the low digestibility of cellulose and ADF. Zain (2007) reported the low digestibility of cellulose and ADF in palm fiber without nutritional supplementation.

Table 3: Feed digestibility of Simmental cattle fed experimental diets (%).

Parameters	Treatment groups					SEM	P
	NG	PLF	PLFM	PLFC	PLFMC		
Dry matter	61.6 ^a	51.5 ^c	55.9 ^{bc}	59.0 ^a	60.9 ^a	1.45	0.04
Organic matter	64.6 ^a	54.7 ^c	58.6 ^b	59.6 ^{ab}	61.9 ^a	1.39	0.04
Crude protein	71.6 ^a	49.4 ^c	56.6 ^b	58.9 ^b	70.9 ^a	0.12	0.02
Crude fiber	55.3 ^a	48.6 ^b	51.2 ^{ab}	53.5 ^a	54.8 ^a	0.24	0.03
NDF	53.1 ^a	42.6 ^d	45.2 ^c	48.5 ^b	51.8 ^a	0.24	0.03
ADF	39.6 ^a	22.4 ^d	27.8 ^c	34.1 ^b	38.7 ^a	0.13	0.02
Cellulose	52.3 ^a	43.3 ^c	46.7 ^{bc}	48.7 ^b	52.0 ^a	0.09	<0.01
Hemicellulose	78.5	75.2	75.5	76.4	77.1	0.16	0.19

^{abc}The different superscripts in the same row indicate differences at P<0.05; NG: native grass + concentrate (used as the control); PLF; Palm leaves and fronds + concentrate; PLFM: PLF + 0.27% phosphorous (P) and 0.4% sulfur (S); PLFC: PLF + cassava leaf meal (5%) and PLFMC: PLFM + cassava leaf meal (5%).

Table 4: Average daily gain, Feed intake, Feed conversion ratio and feed efficiency of Simmental cattle fed experimental diets.

Parameters	Treatment groups					SEM	p
	NG	PLF	PLFM	PLFC	PLFMC		
ADG (kg/head/day)	0.79 ^a	0.63 ^b	0.65 ^b	0.69 ^b	0.88 ^a	0.06	0.02
Feed intake (DM) (kg/head/day)	10.5	10.6	10.8	10.8	11.2	1.05	0.19
FCR	13.3 ^b	16.9 ^a	16.6	15.6 ^a	12.8 ^b	2.87	0.03
Feed efficiency (%)	7.49 ^a	5.95 ^b	6.02 ^b	6.38 ^b	7.82 ^a	1.54	0.03

^{abc}The different superscripts in the same row indicate differences at P<0.05; NG: native grass + concentrate (used as the control); PLF; Palm leaves and fronds + concentrate; PLFM: PLF + 0.27% phosphorous (P) and 0.4% sulfur (S); PLFC: PLF + cassava leaf meal (5%) and PLFMC: PLFM + cassava leaf meal (5%).

Cassava leaf meal and mineral (P and S) increased the digestibility of nutrients, but the increase is only slight

and could not match the NG. This is due to the P and S supplementation that has led to the improvement of the condition of the rumen, thus improving the rumen microbes activity. Mineral P and S is an essential component for the synthesis the amino acids for microbial protein synthesis (Febrina et al., 2016). Phonotheop et al. (2016) reported cassava leaves to contain high protein (24.1%) with the digestibility of DM and CP 72.6% and 82.4% so that it helps the growth and development of rumen microbes.

The digestibility of OM, CP, NDF and ADF on PLFM significantly increased by 7.13%, 14.57%, 6.10% and 24.11% compared to PLF but did not significantly increase the digestibility of DM, CF, cellulose and hemicellulose. P and S supplementation can improve the digestibility of high-fiber feed such as leaves and palm fronds, especially ADF digestibility. This is following the opinion Komisarczuk and Durand (1991) that it's vital for fiber digestion in the rumen, which is sufficient to optimize the supply S digestibility of cellulose by cellulolytic bacteria-specific stimulation, ciliated protozoa activity and anaerobic rumen fungi. Phosphorous is needed by rumen bacteria for cellulose digestibility, but it is not easy to prove that P can stimulate the VFA production (Jamarun et al., 2017). Phosphorous is specifically required for cell wall digestibility of major elements, especially for P cellulolysis requiring higher compared to hemiselulolysis and amilolysis. In most in vivo studies showed P deficiency could negatively affect the digestibility of the fiber fraction (NDF, ADF, cellulose and hemicellulose) and OM digestibility (Komisarczuk and Durand, 1991).

Cassava leaf meal supplements in PFLC produce higher digestibility than PFL. Cassava leaf meal contains branched-chain amino acids that can stimulate the growth of cellulolytic bacteria. Suyitman et al. (2017a) get an increased digestibility value in the treatment of supplementation cassava leaf meal to ammoniated palm leaves.

Digestibility of DM in this study ranged from 51.51% to 61.6% and ADF digestibility ranged from 22.4% to 39.6%. This figure is slightly lower than the dry matter digestibility and ADF obtained by Akbar (2007), who use fermented palm empty fruit bunches, which is 60.1% -70.9% for DM digestibility and 36.4% -56.5% for ADF digestibility. This is due to differences in the quality of the ration given. The digestibility rate of DM in this study is almost identical to that obtained by Ningrat et al. (2018), which received 59.9% -62.0% DM digestibility in Simmental cattle given ammoniation palm fronds, supplemented with gambier leaf waste.

PERFORMANCES OF BEEF CATTLE

Performance data (daily gain, feed intake, feed conversion ratio and feed efficiency) from the treatments are presented

in Table 4. Feed consumption does not show differences ($P>0.05$) between all treatments, but the highest ADG and feed efficiency in PLFMC treatments. In contrast, feed conversion ratio (FCR) between NG and PLFMC is not significantly different ($P>0.05$), but PLFMC still gets the lowest FCR value.

The consumption of ration is closely related to palatability. The results in this research indicate that the five types of ration treatment are palatable enough for cattle. This is evidenced by the data in Table 4 showing unreal differences. However, the rate of beef body weight increased significantly in PLFMC treatment, not different ($P>0.05$) from NG. This is due to the combination of Mineral P, S, and cassava flour, which can improve feed digestibility (Table 3) so that more nutrients are utilized for muscle and meat tissue growth.

FCR from PLFMC has the lowest conversion value compared to NG, PLFM, and PLFC. This is intended for the effect of a combination of minerals P, S, and cassava leaf meal, which reduces the value of feed conversion. The FCR value of the study results follows the opinion of Siregar (2008), which states that the conversion of feed for good cows is 8.56-13.29. Feed conversion is influenced by the availability of nutrients in the ration and animal health. Feed conversion is greatly influenced by the condition of livestock, digestibility of animals, sex, nation, quality, and quantity of feed, as well as environmental factors. According to Sutardi (1990), feed conversion is affected by feed quality. Feed conversion produced in this study is good because, according to Suyitman et al. (2017b) and Pazla et al. (2018b), the mineral P and S and cassava leaf meal proved to be effective in increasing feed intake and bodyweight gain. Increasing the digestibility value and efficiency of nutrient utilization in the metabolic process in livestock body tissue is influenced by the better quality of feed intake by livestock, this is followed by a high bodyweight gain, the lower the conversion value and the more efficient the feed used (Pond et al., 1995). The results of this study are almost the same as those of Suryani et al. (2017), they gained daily body weight gain of 0.7 kg Bali cattle on the use of palm frond ammoniation supplemented with *Saccharomyces cerevisiae* and virgin coconut oil and lower than Ningrat et al. (2018) of 0.92 kg in Simmental cattle fed with palm frond ammoniation supplemented with gambier leaf waste. This difference is due to the ingredients used as supplementation.

The lowest value of feed efficiency was found in the treatment of PLFM and PLFC rations, as seen from the smallest body weightgain. The quality of feed given to this treatment is still not right and does not meet the needs of livestock. As stated by Tilman et al. (1989) that feed quality is one of the factors that influence the efficient

use of feed. The lower the nutritional value in feed, the lower the efficiency of feed use. Febrina (2016) added that other factors that influence the efficiency of feed use are digestibility of feed ingredients and the ability of digestive devices to absorb feed substances contained in the ration. The NG and PLFMC treatments have better feed efficiency values because the rations in this treatment already meet the physiological needs of livestock because of their high protein and energy content. This statement is following the opinion of Efendi (1993), which states that the protein content and energy in the ration is closely related to the efficient use of the ration. The higher the protein content and energy in the ration, the higher the efficiency of its use. Cattle will consume ration efficiently if the energy and protein content in the ration is high.

CONCLUSION

Supplementation of mineral P, S and Cassava Flour on the leaves and palm fronds of ammoniation (PLFMC) provides the best digestibility and performance of cattle to replace 100% native grass.

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AUTHORS CONTRIBUTION

The authors were hereby given a declaration that this work was done by all of them named in this paper and all liabilities pertaining to claims relating to the content of this article will be borne by them. Suyitman, Lili Warly, Arif Rahmat and Roni Pazla conceived the idea, participates in data collection and run the test. All authors participated in conceptualization of the idea, study design, review, and editing of paper. All authors have read and agreed with submission of final paper to the journal.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

REFERENCES

• Akbar SA (2007). Pemanfaatan tandan kosong sawit fermentasi yang dikombinasikan dengan defaunasi dan protein by pass rumen terhadap performan ternak domba. J. Pengembangan

Peternakan Tropis XXXII: 80–85.

- AOAC (2000). Official methods of analysis. Association of analytical chemists, Arlington, Virginia, USA.
- Directorate General of Estate Crops (2015). Tree crop estate statistics of Indonesia 2014–2016. Ministry of Agriculture, Jakarta, Indonesia.
- Efendi S (1993). Pengaruh pemberian tepung kertas koran terhadap penambahan bobot badan domba lokal jantan. Jurusan Peternakan, Fakultas Pertanian, Darussalam. Banda Aceh.
- Febrina D (2016). Utilization of palm fronds from biodelignification for ruminants feed. Ph. D. thesis, Andalas University, Padang.
- Febrina D, N Jamarun, M Zain and Khasrad (2016). The effects of P, S, and Mg supplementation of oil palm fronds fermented by *Phanerochaete chrysosporium* on rumen fluid characteristics and microbial protein synthesis. Pak. J. Nutr., 15: 299–304. <https://scialert.net/abstract/?doi=pjn.2016.299.304> <https://doi.org/10.3923/pjn.2016.352.358>
- Jamarun N, Zain M, Arief, Pazla R (2017). Effects of calcium (Ca), phosphorus (P), and manganese (Mn) supplementation during oil palm frond fermentation by *Phanerochaete chrysosporium* on rumen fluid characteristics and microbial protein synthesis. Pak. J. Nutr., 16: 393–399. <https://doi.org/10.3923/pjn.2017.393.399>
- Jamarun N, Zein M, Arief, Pazla R (2018). Populations of rumen microbes and the *in vitro* digestibility of fermented oil palm fronds in combination with Tithonia (*Tithonia diversifolia*) and elephant grass (*Pennisetum purpureum*). Pak. J. Nutr., 17: 39–45. <https://doi.org/10.3923/pjn.2018.39.45>
- Komizarczuk S, Durand M (1991). Effect of mineral on microbial metabolism. In: Rumen microbial metabolism and ruminant digestion, Jouany, J.P. (Eds.). INRA Publication, Versailles, France.
- Ningrat RWS, Zain M, Erpomen, Suryani H (2018). Effects of supplementation of different sources of tannins on nutrient digestibility, methane production and daily weight gain of beef cattle fed an ammoniated oil palm frond based diet. Int. J. Zool. Res., 14: 8–13. <https://doi.org/10.3923/ijzr.2018.8.13>
- Nurhaita, Ningrat RWS (2011). Efek suplementasi daun ubi kayu terhadap pencernaan daun sawit amoniasi *in vitro*. Jurnal Peternakan Indonesia, Vol 13, No 1. <https://doi.org/10.25077/jpi.13.1.43-47.2011>
- Pazla R, Jamarun N, Zain M, Arief (2018a). Microbial protein synthesis and *in vitro* fermentability of fermented oil palm fronds by *Phanerochaete chrysosporium* in combination with tithonia (*Tithonia diversifolia*) and elephant grass (*Pennisetum purpureum*). Pak. J. Nutr., 17: 462–470. <https://doi.org/10.3923/pjn.2018.462.470>
- Pazla R, Zain M, Ryanto HI, Dona A (2018b). Supplementation of minerals (phosphorus and sulfur) and *Saccharomyces cerevisiae* in a sheep diet based on a cocoa by-product. Pak. J. Nutr., 17: 329–335. <https://doi.org/10.3923/pjn.2018.329.335>
- Pazla R, Jamarun N, Agustin F, Zain M, Arief, Oktiahyani N (2020). Effects of supplementation with phosphorus, calcium, and manganese during oil palm frond fermentation by *Phanerochaete chrysosporium* on ligninase enzyme activity. Biodiversitas, 21: 1833–1838. <https://doi.org/10.13057/biodiv/d210509>
- Phonetep P, Preston TR and Leng RA (2016). Effect on feed intake, digestibility, N retention, and methane emissions

- in goats of supplementing foliages of cassava (*Manihot esculenta* Crantz) and *Titbonia diversifolia* with water spinach (*Ipomoea aquatica*). *Livest. Res. Rural Dev. Volume 28, Article #72*. Retrieved April 21, 2020, from <http://www.lrrd.org/lrrd28/5/phon28072.html>
- Pond WG, Church DC, Pond KR (1995). *Basic Animal Nutrition and Feeding*. Fourth edition. John Wiley and Sons, New York.
 - Siregar SB (2008). *Penggemukan Sapi*. Penebar Swadaya, Jakarta.
 - Steel RGD, Torrie JH (1991). *Principles and procedures of statistics, A Biometric Approach*. 2nd edition B. Interpreting Sumantri. PT. Gramedia Press. Jakarta.
 - Suryani H, Zain M, Ningrat RWS, Jamarun N (2017). Effect of dietary supplementation based on an ammoniated palm frond with direct fed microbials and virgin coconut oil on the growth performance and methane production of Bali cattle. *Pak. J. Nutr.*, 16: 599-604. <https://doi.org/10.3923/pjn.2017.599.604>
 - Sutardi T (1990). *Landasan ilmu nutrisi departemen ilmu makanan ternak*. IPB, Bogor.
 - Suyitman, Warly L, Evitayani (2013a). Palm leaf processing as ruminant feeds. *Pak. J. Nutr.*, 12: 213-218. <https://doi.org/10.3923/pjn.2013.213.218>
 - Suyitman, Warly L, Evitayani (2013b). S and P mineral supplementation of ammoniated palm leaves as ruminant feeds. *Pak. J. Nutr.*, 12: 903-906. <https://doi.org/10.3923/pjn.2013.903.906>
 - Suyitman, Warly L, Rachmat A (2017a). Effect of cassava leaf meal supplementation on *in vitro* digestibility of ammoniated palm leaf enriched with sulfur and phosphorus minerals. *Pak. J. Nutr.*, 16: 249-252. <https://doi.org/10.3923/pjn.2017.249.252>
 - Suyitman, Warly L, Rachmat A, Ramadhan DR (2017b). Optimizing the production of beef cattle utilizing palm oil leaf sheet ammoniation supplemented by sulfur minerals, phosphorus, and cassava leaf flour. *Pak. J. Nutr.*, 16: 870-875. <https://doi.org/10.3923/pjn.2017.870.875>
 - Tillman AD, Hartadi H, Reksahadiprodjo S, Prawirokusumo dan S, Lebdosukojo S (1989). *Ilmu makanan ternak dasar*. Gajah Mada University Press. Fakultas Peternakan, Universitas Gajah Mada. Yogyakarta.
 - Van Soest PJ, Robertson JB, Lewis BA (1991). Methods for Dietary Fiber, Neutral Detergent Fiber and Non-Starch Polysaccharides in Relation to Animal Nutrition. *J. Dairy Sci.* 74: 3583-3597. [https://doi.org/10.3168/jds.S0022-0302\(91\)78551-2](https://doi.org/10.3168/jds.S0022-0302(91)78551-2)
 - Warly L, Suyitman, Evitayani, Fariyani A (2015). Supplementation of solid ex-decanter on the performance of cattle fed palm fruit by-products. *Pak. J. Nutr.*, 14: 818-821. <https://doi.org/10.3923/pjn.2015.818.821>
 - Zain M, Sutardi, T, Sastradipradja D, Nur, MA, Ramli SN (2002). Efek suplementasi asam amino bercabang terhadap fermentabilitas dan pencernaan *in vitro* ransum berpakan serat sabut sawit. *Media Peternakan*. 23(2): 32-61.
 - Zain M (2007). The supplementation of cassava leaves to optimize the use of palm press fiber as ruminant feed. *J. Indon. Trop. Anim. Agric.* 32 (2) June 2007.