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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Palm Leaf Processing as Ruminant Feeds

Suyitman, Lili Warly and Evitayani
Faculty of Animal Husbandry, Andalas University, Campus Limau Manis, Padang, Indonesia

Abstract: This study aims to determine the best processing methods of palm leaves that can improve nutrient and digestibility as ruminant feed. An *in vitro* study was conducted from June, 15th 2012 until September, 20nd 2012. Palm leaf samples were analyzed using Proximate and Van Soest method in Laboratory of Ruminant Nutrition of the Faculty of Animal Husbandry, University Andalas, Padang. This study is an experimental study that uses a completely randomized design with 5 (five) treatment and 4 (four) replications. Treatment consists of: A = control (no treatment), B = physical processing (steam), C = chemical processing (ammoniation), D = biological treatment (ensilage) and E = combination of physical-chemical properties (steam-ammoniation). Data were analyzed using analysis of variance (ANOVA). Differences between treatments were tested by Duncan's Multiple Range Test (DMRT). The results showed that treatment of C = chemical processing palm leaf (ammoniation) provides nutrients and better digestibility than some other palm leaf processing methods with its nutritional value was as follow: dry matter (41.51%), organic matter (86.56%), crude protein (14.65%), NDF (53.22%), ADF (40.76%), cellulose (19.67%), hemicellulose (12.46%), lignin (9, 91%). *In vitro* digestibility were as follow: dry matter (36.57%), organic matter (43.88%), crude protein (47.24%), NDF (32.65%), ADF (23.70%), cellulose (30.30%), hemicellulose (51.94%). Rumen fluid characteristics: pH (7.10), VFA (135.55 mM) and NH_3-N (58.72 mg/100 ml).

Key words: Palm leaf processing, ammoniation, steam, ensilage, *in-vitro*

INTRODUCTION

One of plantation wastes considerable potential to be used as a source of green feed is palm leaves (*Elaeis guineensis* Jacq.). Palm leaves were obtained from pruning or cutting old palm midrib on maintenance and harvesting fruit. Production of palm midrib is 10.40 tones dry matter/ha/year (Sa'id, 1996). In 2010 extensive palm plantations in West Sumatra cover 301, 127 ha (Central Bureau of Statistics (BS), 2011) and is estimated that the production of palm midrib could be as much as 3, 131, 720.8 tons of dry matter/year.

Although palm leaf is available in large amounts and has great potential to be used as green feed but its utilization as feed is still very limited. This is partly due to the low biological quality palm leaf. The results of the analysis showed palm leaf nutrient content: The dry matter: 54.12%; organic matter: 89.86%, crude protein: 8.51%, crude fiber: 28.48%, NDF: 59.11%; ADF: 42, 87%; cellulose: 24.69%; hemicellulose: 16.24% and lignin: 14.21%. The high content of lignin causes low digestibility and palatability (Widjaja and Utomo, 2001). Efforts to optimize feed utilization of waste had focused on processing techniques, physical, chemical, biological, or combinations thereof. Processing only showed a small response to increased digestibility. Therefore, efforts to increase the digestibility of fibrous feeds should be combined with efforts to optimize bioprocess in the rumen through the rumen microbial population increase (Warly *et al*., 1998).

This study aims to determine the best processing methods of palm leaves that can improve nutrient content and digestibility as ruminant feed. The benefit of this research is to increase the diversity of feed materials by utilizing oil palm waste potentially huge as ruminant animal feed as well be an alternative solution in overcome green forage shortage and environmental improvement as well. In addition, the results of this study may also improve the welfare of society and the expansion of the labor force. It is expected that the results of this study could be of beneficial to the development of science in general and animal science in particular.

MATERIALS AND METHODS

Research materials: At this stage of palm leaves were exposed to several processing methods tested, whether physical, chemical, biological, or combinations there of. Processed sampels were subjected *in vitro* for its nutritional content and digestibility. The goal is to determine the best treatment method that can improve the digestibility and nutritional value of palm leaves.

The material used in this study is an old palm leaves, urea for ammoniation, rice bran for making silage, rumen fluid microbes as donor and Mc Dougall's solution as a buffer. Tools used are: Chopper, analytical scales, autoclave, plastic bags and oven for drying materials, milling machines for prepare samples prior to analysis, *in vitro* equipments, digital pH meter to

Corresponding Author: Suyitman, Faculty of Animal Husbandry, Andalas University, Campus Limau Manis, Padang, Indonesia

measure the pH of rumen fluid and a set of laboratory equipment for Proximate, Van Soest, VFA and NH_3-N analysis.

Research methods: The method used in the study of palm leaf processing is an experimental method using completely randomized design with 5 treatments and 4 replications. Treatment consists of: A = control (no treatment), B = physical processing (steam), C = chemical processing (ammoniation), D = biological treatment (silage), E = combination of physical-chemical properties (steam- ammoniation) . Design model used by Steel and Torrie (1991) is as follows:

$$Y_{ij} = \mu+P_i+K_j+E_{ij}$$

Differences between treatments were tested by Duncan's Multiple Range Test (DMRT).

Research procedures

Processing of palm leaves: Palm leaves was separated from petioles and cut into+5 cm. Treatment A (control = no treatment). Treatment B (steam): Palm leaves that have been cut into pieces and weighed as much as 1 kg of steam in the autoclave at a pressure of 0.5 kg/cm^3, temperature of 121°C for 30 minutes. Treatment C = ammoniation with 4% N-urea (Komar, 1984): 1 kg of palm leaves that have been cut into pieces put in a two layer plastic bag that has a capacity of 5 kg. 47 grams of urea dissolved in 80 ml water and then pour evenly into a plastic bag which contains a palm leaf. Furthermore palm leaves in bags and tied tightly and incubated for 21 days. After 21 days, the plastic bag can be opened and ammoniated leaves were aired dried. Treatment D = (ensilage) 1 kg of palm leaves that have been cut into pieces supplemented with 10% fine bran and mixed evenly, then the palm leaf is placed in a two layer plastic bag that has a capacity of 5 kg. Furthermore palm leaves in bags and tied tightly and incubated for 21 days. Treatment E = (steam-ammoniated) is a combination of steam treatment and ammoniation. All products are processed palm leaves dried and ground for subsequent analysis for digestibility and nutritional content tested *in vitro*.

***In-vitro* digestibility trial of processed palm leaves:** Into the tube which was filled erlemeyer 5 g of processed palm leaf samples included 200 ml McDougall's buffer solution (temperature 39°C, pH 6.92 to 7.02) and added 50 ml of rumen fluid as a source of microbes. CO_2 gas flowed for 30 seconds in order to keep an aerobic condition in sealed tube. Samples were incubated for 48 hours. After fermentation end, Erlenmeyer tube containing the sample is inserted into the ice water to stop the fermentation. Furthermore, all samples centrifuged with a speed of 1200 rpm for 15 min, the supernatant was taken for further measured pH, NH_3-N and VFA, while the sediment was collected and dried for analysis Dried Matter (DM), Organic Matter (OM), Crude Protein (CP), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), cellulose and hemicellulose.

Parameters observed:

- Processed palm leaf nutrient content were subjected to Proximate analysis for dry matter, organic matter, crude protein and analysis of Van Soes't for fibre fraction; Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), cellulose and hemicellulose
- Digestibility of dry matter, organic matter, crude protein and fiber fractions: Neutral detergent fiber, acid detergent fiber, cellulose and hemicellulose *in vitro* by the method of Tilley and Terry (1963)
- Characteristics of rumen fluid (rumen fluid pH was measured using a digital pH meter, levels of VFA rumen fluid by gas chromatography and distillation of steam and NH_3-N levels were measured by the method of distillation Sthill Markhan (general procedures Laboratories)

RESULTS AND DISCUSSION

Nutrient content of processed palm leaf: Nutritional content of processed palm leaf with some method of treatments can be seen in Table 1 below.

In Table 1 above shows that the content of nutrients palm leaves significantly ($P<0.05$) affected by treatment. Dry matter of processed Palm leaf in this study ranged from 41.51-61.89%. DMRT test results showed that steamed and steam-ammoniated palm leaves

Table 1: Nutritional content of processed palm leaves (% DM)

	Treatment					
Parameters	A Control	B Steam	C Ammoniation	D Ensilage	E Steam-Ammoniation	SE
Dry matter	54,97^b	61,45^c	41,51^a	41,95^a	61,89^c	0,2189
Organic material	89,20^b	85,69^a	86,56^a	86,62^a	86,95^a	0,2460
Crude protein	8,60^a	12,43^c	14,65^d	11,90^b	14,94^d	0,1258
NDF	63,07^e	58,60^c	53,22^b	52,47^a	61,83^d	0,2486
ADF	44,61^d	43,44^c	40,76^a	41,06^b	43,72^c	0,1354
Cellulose	24,31^e	20,31^b	19,67^a	20,65^c	22,04^d	0,0973
Hemicellulose	18,46^d	15,16^c	12,46^b	11,41^a	15,11^c	0,1664
Lignin	14,35^c	10,28^b	9,91^a	9,78^a	10,53^b	0,1067

Description: Values with different superscripts in the same row indicate significantly different ($P<0.05$)

significantly increased dry matter content compared to controls, whereas ammoniated treatment and ensilaged significantly lower dry matter content to controls but the dry matter content between different ammoniation treatments and ensilage non significant, nor between treatments steam and steam-ammoniated.

The increase in dry matter content of steamed and steamed-ammoniated processing output caused by the loss of most of the water content of materials through evaporation. During the process of steam will be stretching the cell wall structure by steam pressure, so that the cell walls become more loose, at that amount of water that fills the cavity between the cell wall out, so that the water content of the material reduced and result in increased dry matter content. In this study, an increase in the dry palm leaves at 6.48-6.92% compared to controls.

Ammoniated treatment and ensilaged leaves significantly lower dry matter content. A decrease in dry matter content in the leaves of palm leaf (ammoniated and ensilaged) due partly dissolved the soluble fraction as a result of chemical reactions in the ammoniation process and the effluent lose the ensilase process.

Organic matter content in processed palm leaves significantly decreased compared to controls. But not significantly different between the treatments of processed palm leaves. Decline in organic matter content in the study were of 2.25-3.51% of the controls. This is due to the loss of most of the organic material in the processing.

Crude protein content of processed palm leaves significantly ($P<0.05$) increased 3.30-6.34% compared to controls. In the steamed treatment increased crude protein content of 6.34% increased compared to controls due to increased dry matter content, whereas the protein content of silage increased by 3.30% the contribution of lactic acid bacteria during ensilage. Increased protein content is highest in the ammoniation processing and steam-ammoniated that is 6.05-6.34%, this is due to the addition of urea which is a source of N, in accordance with the opinion of Leng (1991) that ammoniation with urea on feed fiber besides able to loosen the bonds of lignocellulose so more easily digested by rumen bacteria are also able to supply nitrogen for the growth of bacteria.

Processes of Steam treatment, ammoniation and ensilage were significantly ($P<0.05$) lower the content of fiber fractions, NDF, ADF, cellulose and hemicellulose. This is in accordance with the recommendation of Preston and Leng (1987) who said there should be initial treatment for fibrous materials to enhance the potential digestibility of crude fiber. Sa'id (1996) added a useful initial treatment to increase the rate of hydrolysis of lignocellulosic materials. Decrease in fiber fractions were highest for ammoniated treatment and ensilage at 15% compared to non-processed palm leaves.

The content of fiber fractions in the treatment of steamed-ammoniation (E) is almost the same as the control (A) in other words, not a decline in the fiber fraction. This indicates that the steam treatment followed by ammoniation not effectively lower fiber fraction, because the processing method of steam partially soluble substances have evaporated, so that the living are substances that are poorly soluble and ammoniation can not reduce the content of fiber fractions.

Treatment significantly ($P<0.05$) lower lignin content of leaf of 3.82-4.57% compared to control. The decrease was due to the influence of lignin content of the heat generated during processing. Lignin can be mobilized by the heat. The heat generated during processing can lead to expansion of the cell wall structure, at that time most of the lignin and silica deposits are found in the cell walls will fall, so that the material becomes more exposed to digestion by rumen bacteria. This is in accordance with the opinion Sutardi (1997) and Sundstol (1988). Lignin can not be digested by rumen microbes and is a limiting factor for fiber feed utilization, particularly agricultural waste. Lignin in the cell wall structure binds to cellulose and hemicellulose to form complex lignocellulose and lignohemiselulosa, so cellulose and hemicellulose that are the source of energy becomes less useful (Komar, 1984 and Sutardi, 1979). Feed processing from agricultural waste principally an effort to lower lignin content. The decrease lignin content will affect to the increased digestibility of feed ingredients.

Nutrient digestibility palm leaves: Increased nutrient content as seen in Table 2, followed by an increase in nutrient digestibility. From the experimental data obtained nutrient digestibility of nutrients, as seen in Table 2 below.

Results of statistical analysis showed that the treatment of palm leaves significantly ($P<0.05$) influence the digestibility of nutrients. DMRT test result is known that steam treatment significantly ($P<0.05$) increase the digestibility of dry matter, organic matter, crude protein and fiber fractions of palm leaves compared with no treatment (control). Increased digestibility of nutrients due to the occurrence of cell wall surface structure alienation due to pressure of hot steam, therefore it can be easily digested by rumen microbes. This is in accordance with the opinion of Doyle *et al*. (1986) that the pressure of steam on the substrate would expand fiber or complex bonding of feed materials, that make them easily digested by microorganisms. Due to the breaking of lignocellulosic or glycosidic bonds, widening the substrate surface to facilitate penetration into the substrate of microbial enzymes. Treatment with steam pressure effectively improve palatability and digestibility of feed (Broderick *et al*., 1993).

Table 2: Digestibility of nutrients palm leaves in *in vitro* treated with several methods of treatment (%)

	Treatments					
Parameters	A Control	B Steam	C Ammoniation	D Ensilage	E Stream-Ammoniation	SE
Dry Matter	32,60[b]	37,97[e]	36,57[d]	32,08[a]	35,49[c]	0,1443
Organic Material	39,69[b]	42,54[d]	43,88[e]	38,40[a]	41,16[c]	0,0999
Crude Protein	20,78[a]	42,16[c]	47,24[e]	42,82[d]	35,10[b]	0,1109
NDF	31,35[a]	36,68[d]	32,65[b]	33,62[c]	37,73[e]	0,1073
ADF	18,62[a]	36,26[e]	23,20[b]	25,88[c]	27,65[d]	0,2970
Cellulose	29,18[b]	40,86[d]	30,30[c]	26,46[a]	29,32[b]	0,0630
Hemicellulose	61,02[d]	40,36[a]	51,94[b]	52,56[c]	64,54[e]	0,1536

Description: Value with different superscripts in the same row indicate significantly different (P<0.05)

Treatment C (Ammoniation) significantly (P<0.05) increase the digestibility of dry matter, organic matter, crude protein and fiber fractions than palm leaves without treatment (control = A). The increment of protein degradation is highest for ammoniation treatment compared to other treatments. This is in accordance with the opinion of Leng (1991) that urea treatment on fibrous feed will loosen up lignocellulosic and make them more easily digested by rumen bacteria besides supplying nitrogen for the growth of bacteria.

Nutrient digestibility in palm leaf silage (D) was lower than the control. The decrease is caused by the complex molecular dismantling moderated by lactic acid bacteria activity for ensilage process. Silage is preserved forages in fresh condition in anaerobic conditions. During ensiling process, the fermentation occurred by lactic acid bacteria and anaerobic *Streptococcus lactic* living at pH 4. Due to the occurrence of bacteria and pH decline, then the growth of other bacteria that cause forage decay can be prevented in the silo (Susetyo, l980).

Steamed-Ammoniated treatment (E) in this study can enhance the digestibility of nutrients. It can be seen from the degradation of dry matter and organic matter which were better with treatment A (control) and a significant increase in digestibility of crude protein and fiber fractions. This is due at the time of steam some soluble substances (soluble) also dissolved/disappeared, so that the remaining only the insoluble fraction on the nutrient content that can not be increased further by ammoniation process. In this study, treatment Steam-Ammoniation seen less increase in digestibility of NDF and ADF compared to Ammoniation but significant enough to increase the digestibility of cellulose and hemicellulose.

Characteristics of rumen fluid: Rumen fluid characteristics are essential to ensure the activity of rumen microorganisms. Characteristics of rumen fluid include pH, production of VFA and NH_3-N. Rumen fluid characteristics in this study are shown in Table 3 below. From the table above shows rumen fluid pH ranged from 6.53 to 7.10. Highest pH values obtained in treatment C (Ammoniation) is 7.10, while the lowest pH values obtained on treatment B (Steam) 6.53. The results of statistical analysis showed that the effects of different treatments highly significant (P<0.01) on the pH of the rumen fluid. DMRT test showed that the pH in the treatment of B is significantly lower (P<0.01) compared to the other treatments, while others give effect between treatments did not differ significantly (P>0.05) on the pH of the rumen fluid *in vitro*.

The low pH value at B = steam treatment due to the high concentration of VFA produced from the digestibility of feed ingredients, in accordance with the opinion of Van Soest (1982) that the pH of the rumen fluid influenced by the production of VFA and NH_3. The increase in VFA will cause a decrease in pH of rumen fluid while increased NH_3 will increase the pH of the rumen fluid. According to Arora (1989) the rumen fluid pH describes the balance of the fermentation products (VFA and NH_3).

The range of pH values in this study are within the optimal range for rumen microbial growth, according to the opinion of Sayuti (1989) that the pH of the rumen microbes required for life and the active process of fermentation is 6 to 6.8, while the optimum pH for protein synthesis is 6 to 7 and the process of protein synthesis would be disturbed at a pH lower than pH optimum. Erdman (1988) states that the optimal pH range for rumen digestion of cellulose is 6.4 to 6.8 and when the rumen pH below 6.2 cellulolytic bacterium will be disrupted so that the digestibility of the fiber will decreased.

Concentrations of NH_3-N were highest rumen fluid obtained in treatment C (ammoniation) ie 58.72 mg/l00 ml rumen fluid, followed by treatment E (steam-ammoniation) ie 25.95 m1 mg/l00 rumen fluid. This value is highly significant (P<0.01) compared to treatment A and B. This occurs due to the addition of urea in the treatment C and D resulting in increased levels of protein and digestibility of palm leaves so that the concentration of N-NH_3 produced was high.

Concentration of NH_3 obtained in this study ranged from 8.90 to 58.72 mg/100 ml rumen fluid, this value was sufficient enough for growth and rumen microbial activity, according to the statement of Satter and Slyter (1974) that the concentration of NH_3 in the rumen varies between 0-l30 mg/100 ml rumen fluid, whereas minimal levels of rumen microbial protein synthesis optimal is 5

Table 3: Rumen fluid characteristics

Rumen fluid Characteristics	Treatments A Control	B Steam	C Ammoniation	D Ensilage	E Stream-Ammoniation	SE
pH	6,85[c]	6,53[a]	7,10[d]	6,85[c]	6,78[b]	0,0318
VFA (mM)	87,62[a]	134,46[d]	135,55[d]	119,74[b]	122,75[c]	0,7652
NH_3-N (mg/100 ml)	8,90[a]	9,39[a]	58,72[d]	14,43[b]	25,95[c]	0,2153

Description: Values with different superscripts in the same row indicate significantly different (P<0.05)

mg/100 ml of rumen fluid. However, Mehrez *et al*. (1977) and Perdok *et al*. (1988) reported that maximum concentrations of NH_3 are required for consumption, digestibility and microbial protein synthesis is in the range between 10-23 mg/100 ml of rumen fluid.

Pathak and Ranjhan (1979) stated that factors affecting levels of N-NH_3 rumen fluid are sources of nitrogen such, solubility and digestibility levels of protein, level of nitrogen in ration, the rate of emptying the contents of the rumen, absorption of ammonia or urea recycling and bacterial nitrogen.

Production of total VFA in this study ranged from 87.62 to 135.55, mM. The results of the statistical analysis showed a highly significant effect (P<0.01) than the treatment of the total production of VFA. From the DMR test found that treatment C (ammoniation) produced the highest concentration of total VFA l35, 55 mM. VFA value of this research is an indicator of energy demand has been met to support rumen microbial growth and activity according to the statement of Sutardi (1979) the VFA required for rumen microbial activity and growth is 80-160 mM.

Davies (1982) mentioned that the increased levels of VFA reflect increased solubility of soluble carbohydrate. VFA, especially acetic, propionic and butyric acid were the major results of the digestion of carbohydrates in ruminants and is the main energy source for ruminants. VFA is able to provide 55-60% of energy required by ruminants (Ranjhan, 1980).

VFA in ruminants have a dual role as a source of energy for livestock and carbon source for microbial protein synthesis (Sutardi *et al*., 1983). Rumen microbes utilizes rumen VFA in the form of ATP as an energy source and ammonia from digestibility of protein and non protein nitrogen as a source of N. VFA will be used to form protein in microbes. The balance between the production of ammonia and VFA in the rumen will increase microbial protein synthesis that can be used as a source of quality protein for ruminant livestock (Winugroho and Maryati, 1999).

Conclusion: The results showed that treatment of C = chemical processing palm leaf (ammoniation) provides nutrients and better digestibility than some other palm leaf processing methods. The nutritional values are as follow: dry matter (41.51%), organic matter (86.56%), crude protein (14.65%), NDF (53.22%), ADF (40.76%), cellulose (19.67%), hemicellulose (12.46%), lignin (9, 91%). Digestibility *in vitro* are as follow: dry matter (36.57%), organic matter (43.88%), crude protein (47.24%), NDF (32.65%), ADF (23.70%), cellulose (30.30%), hemicellulose (51.94%). Rumen fluid characteristics are as follow: pH (7.10), VFA (135.55 mM) and NH_3-N (58.72 mg/100 ml).

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