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Potential Use of Lemongrass (*Cymbopogon winterianus*) Residue as Dairy Cow Feed

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Abstract: *Cymbopogon winterianus* (lemongrass) is a plant native to Indonesia that is able to produce essential oil as its secondary metabolite. Nevertheless, the residue of *Cymbopogon* after distillation to extract the essential oil is currently not being valorized. Hence, this study was conducted to evaluate the potential use of *Cymbopogon* residue as dairy cow feed. Results from the proximate test confirm that *Cymbopogon* residue nutritional content meets the requirement of Indonesian National Standard for cattle feed. *In vitro* test also shows good results for gas production (32.33 mL/200 mg), VFA (187 mM), NH_3 production (28.65 mM), DMD (64.75%) and OMD (73.57%) content. It is also demonstrated that the use of *Cymbopogon* residue as feed for cows increased 23% of the milk production. Hence, this study suggests that the *Cymbopogon* residue has the potential to replace the conventional feed source (rice straw only) in ruminant diets.

Key words: *Cymbopogon winterianus*, plant residue, dairy cow feed, milk production

INTRODUCTION

Cymbopogon winterianus, or generally known as 'Lemongrass', is a plant native to Indonesia that is able to produce essential oil as its secondary metabolite. The essential oil from *Cymbopogon winterianus*, which is internationally known as 'Java citronella oil', is extracted from the leaves. This oil can be used as a raw material in the pharmaceutical, cosmetics, perfume, deodorant soap, disinfectant, pesticide plant, polish material, fuel octane enhancer and a variety of technical preparation (Sukamto *et al*., 2011).

Citronella oil has a high global demand. In 2007, the world consumption of citronella oil reached 2000 tons/year (Rizal *et al*., 2009). Indonesia is the third world's largest producer of citronella oil's (more than 200 tons/year) after China and Vietnam. In 2007, the total area *Cymbopogon* plantation in Indonesia is 19592 ha. To meet the high market demand of citronella oil, the amount of citronella oil production in Indonesia is expected to increase continuously.

Currently the increasing production of citronella oil is not accompanied by the technology to manage the citronella residue itself. For every 1000 kg of distilled citronella leaves, 8 kg of essential oil will be produced, while the remaining biomass residue (992 kg) from the citronella leaves, are discarded as a waste. In Indonesia, the citronella residue is still not being used optimally although the citronella residue still contains fiber, protein and fat that can be used for other needs such as cattle feed.

Therefore, this work tries to demonstrate the potential use of *Cymbopogon* residue as cattle feed. It is hoped that this study may provide a sustainable production of citronella oil by valorizing the waste to create value added products.

MATERIALS AND METHODS

The *Cymbopogon* fresh leaves and residue, rice straw and Holstein-Friesian cows used in this study were provided by Kebun Percobaan Manoko, Lembang, Indonesia.

Analytical methods: Experiments were performed using Completely Randomized Design consisting of five treatments viz. R0 (100% rice straw), R1 (75% rice straw: 25% *Cymbopogon* residue), R2 (50% rice straw: 50% *Cymbopogon* residue), R3 (25% rice straw: 75% *Cymbopogon* residue) and R4 (100% *Cymbopogon* residue). Each test has three replications. Data were subjected to a t-test: two samples assuming equal variances using Microsoft Excel software. Significant differences between individual means were identified using at least significance difference (LSD) multiple range test.

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A proximate test was performed to analyze the component of *Cymbopogon* fresh leaves and residue. The test was conducted at Ruminant Nutrition Laboratory, Faculty of Animal Husbandry, University of Padjajaran, Indonesia.

In vitro test was conducted at Ruminant Nutrition Laboratory, BATAN to confirm the feasibility of *Cymbopogon* residue as cattle feed by using rumen fluid. The measured variables were NH_3 production by using Conway Micro-diffusion (Sutardi, 1994), volatile fatty acid (VFA) by using steam distillation method (Sutardi, 1994), dry matter digestibility (DMD) and organic matter digestibility (DMO) by Hohenheim gas test (Menke *et al.*, 1979; Krishnamoorthy, 2001).

Effect of *cymbopogon* residue as cattle feed on the volume of milk produced by holstein-friesian cows: A preliminary study was carried out to investigate the potential of *Cymbopogon* residue as cattle feed. The test was carried out at Kebun Percobaan Manoko, Lembang, Indonesia. Nine Holstein-Friesian cows available at the Kebun Percobaan Manoko were fed with the *Cymbopogon* residue and the volume of milk produced by the cows were investigated. The weight of the cows involved in this test vary in the range of 500-600 kg whereas the age of the cows vary from 2-5 years. Initially, the cows were fed with 30 kg of rice straw twice per day for 10 days and later fed with 30 kg of *Cymbopogon* residue twice per day for the following ten days. The milk was collected from every cow twice per day at 0500 and 1600 h, using a Sezer SEZ PLS 2/1 cow milking machine. The volume of milk collected for every cow fed with rice straw was compared with the corresponding volume obtained fed with the *Cymbopogon* residue.

RESULTS AND DISCUSSION

Nutritional content of *Cymbopogon* residue: A proximate test was carried out to analyze the nutritional content *Cymbopogon* residue such as water, ash, protein, fiber, fat and non-nitrogen free extract (Cherney, 2000). The result of the proximate test for *Cymbopogon* residue and the nutritional content of rice straw (typical cattle feed at KP Manoko) is presented in Table 1. The nutritional content of both feeds are compared with the Indonesian National Standard SNI 3148.1:2009 for concentrated feeds of dairy cows.

Oven-drying is commonly used for water content determination. At a drying temperature of 100°C, mechanically trapped water will be evaporated, leaving chemically bounded water. The water content of both rice straw and *Cymbopogon* residue are much higher than that of SNI characteristic. However, this water content can be reduced by drying the materials until the water content become less than 14%, as required by the SNI standard.

After dried, the feed was burnt at temperature of 500°C to separate the ashes and the organic content. The ash content indicates the mineral (inorganic) content of the feed (Cherney, 2000). The organic content includes the protein, fat, fiber and non-nitrogen free extract (Cherney, 2000).

Protein content is important for dairy cow feed to support the synthesis of microbial protein in cow's rumen. Microbial protein synthesis depends on the availability of a continuous supply of precursors, principally ammonia and amino acid (Beever and Mould, 2000). The protein content in *Cymbopogon* residue is higher than in rice straw. However, the protein content in *Cymbopogon* residue is still not adequate to meet the standard of SNI concentrated feed. We can add feed supplement so that the protein content can reach at least 15%, which is a minimum standard of SNI feed for dairy cows.

Cymbopogon's ether extract content is higher than rice straw's. The ether extract refers to the fat content in feed. Fat plays an important role in the synthesis of fatty acids for deposition as triglycerides in adipose tissue or secretion in milk (Beever and Mould, 2000). Fiber content includes cellulose, hemicellulose and lignin which are indigestible. The fiber content of both feed meet the requirement of SNI standard, less than 35%. The higher the fiber content, the harder it is for the cows to digest the feed (Beever and Mould, 2000). Because the *Cymbopogon* residue contains less fiber, it can be digested better than rice straw.

Nitrogen free extract (NFE) includes the monosaccharide, disaccharides and polysaccharides that are digestible, like sugar, starch, organic acids, etc. (Cherney, 2000). The NFE is very important to provide energy for cows. NFE in *Cymbopogon* residue is higher than in rice straw, therefore it can provide more energy for cows.

Hence, it is concluded that the *Cymbopogon* residues meets the standard characteristics of Indonesian Standard for Dairy Cows Feed; better than rice straw does (usual feed in Manoko).

Effect of feed composition on gas production: *In vitro* gas production technique was carried out to stimulate the rumen fermentation process and the results are shown in Table 2-5.

Table 2 shows the total gas production obtained from the rumen *in vitro* test in. The results indicate that R3 and R4 treatment produce the highest amount of gas. Incubation of rice straw and *Cymbopogon* residue with buffered rumen fluid *in vitro* results in the fermentation of carbohydrates to short chain fatty acid (SCFA) (acetate, propionate and butyrate) and gases, mainly CO_2 and CH_4 (Sallam, 2005). Therefore the total gas production can be used as an indicator for digestibility of the substrates. Fermentation of protein and fats does not contribute much to the gas production.

Table 1: Nutritional content of rice straw and *Cymbopogon* residue

Component	Rice straw (typical feed at Manoko)	*Cymbopogon* residue (this study)	Concentrated feeds for dairy cows (SNI 3148.1:2009)
Water	69.12%	56.49%	<14%
Ash	20.35%	9.7%	<10%
Crude protein	6.25%	9.72%	>15%
Crude fibre	32.41%	22.40%	<35%
Ether extract	1.19%	4.07%	<7%
Nitrogen free extract (NFE)	39.09%	54.11%	n.a.

Table 2: Total gas and volatile fatty acid (VFA) production using variability of *Cymbopogon* residue and rice straw mixture as feed

Treatment	Total gas (mL/200 mg)	VFA (mM)
R0	20.67±1.53[a]	59.23±0.00[a]
R1	28.17±1.61[b]	64.17±4.28[a]
R2	22.17±4.19[ab]	118.46±7.44[b]
R3	33.67±1.16[c]	185.1±7.44[c]
R4	32.33±2.08[bc]	187.57±4.28[c]

a, b, c: Not significantly different; ab, bc: Significantly different

Table 3: CH_4 content and NH_3 production using variability of *Cymbopogon* residue and rice straw mixture as feed to rumen *in vitro*

Treatment	CH_4 (%)	NH_3 (mM)
R0	14.15	34.62±0.385[a]
R1	15.46	33.85±0.838[a]
R2	18.52	39.62±0.838[b]
R3	22.37	29.81±1.346[c]
R4	25.22	28.65±1.261[c]

a, b, c: Not significantly different

Table 4: Dry matter digestibility (DMD) and organic matter digestibility (OMD) test using variability of *Cymbopogon* and rice straw mixture as feed to rumen *in vitro*

Treatment	DMD (%)	OMD (%)
R0	78.15±2.429[a]	86.42±2.541[a]
R1	73.47±1.003[a]	80.34±3.014[ab]
R2	70.93±2.054[ab]	76.96±0.721[b]
R3	68.06±1.886[bc]	74.09±1.689[b]
R4	64.79±0.470[c]	73.57±1.432[b]

a, b, c: Not significantly different; ab, bc: Significantly different

The significantly lesser ($p<0.05$) gas production in treatment R0, R1 and R2 (Table 2) are explained by the higher content of crude fiber and lower content of nitrogen free extract (NFE). In contrast, the significantly higher ($p<0.05$) gas production in treatment R3 and R4 are correlated to the lower fiber content and higher nitrogen free extract (NFE) content of them. R3 and R4 treatments contain more *Cymbopogon* residue than rice straw in the mixture.

The VFA production of treatment R3 and R4 are significantly higher than treatments R0, R1 and R3 ($p<0.05$).The result of total gas production is positively correlated to the volatile fatty acid (VFA) production (Table 2), which mainly comes from carbohydrate fermentation.

Methane-producing bacteria that naturally lives in rumen microbial system uses hydrogen and formate to produce CH_4. Formate and hydrogen are products of fermentation by other microorganisms in the rumen (Baker, 1999). Therefore, the CH_4 content indicates the energy losses that relates to energy efficiency of the feed. However the production of CH_4 increases linearly with the total gas production (Table 2 and 3).

The optimal concentration of ammonia for microbial growth *in vitro* has been reported to range between 20-50 mM (Sommart *et al*., 2000). Therefore, it can be assumed that in the current study, sufficient ammonia were available for microbial growth for all variety of feed mixture (Table 3).

The content of crude protein linearly affects the ammonia production (McDonald *et al*., 2002). Nevertheless, the results obtained in this study show a different tendency; the higher the protein content (R4), the lesser the ammonia production. The reduction of ammonia concentration may be attributed to anti-nutritional factors like condensed tannins which form a complex compound with protein which adversely affect N digestion (Sallam, 2005).

Dry Matter Digestibility (DMD) is the proportion of the dry matter in a feed that can be digested by an animal, while Organic Matter Digestibility (OMD) is the proportion of the organic matter in a feed that can be digested by an animal. The dry matter digestibility (DMD)% was significantly higher ($p<0.05$) in treatment R0, R1 and R2 than in treatment R3 and R4, while the organic matter digestibility (OMD)% was significantly higher ($p<0.05$) in treatment R0 and R1, than in treatment R2, R3 and R4 (Table 4).

The digestibility content of a feed is linearly related to the fiber content of it (van Soest, 1994). However, the results of this current experiment show that the digestibility, both of treatment R3 and R4 are lower than the others (Table 4) even though the fiber content of them are higher (Table 1). This is probably because the lignin content of *Cymbopogon* residue cell wall is higher than that of rice straw cell wall. Lignin in the cell wall of plants reduces the digestibility of cellulose and hemicellulose by rumen microbes (Jung, 1986). Nevertheless, the digestibility content of all treatments can be accepted because they meet the requirement of minimum digestibility content of feed in SNI 3148.1:2009, which is 65%.

Table 5: Volume of milk produced (L/d) by nine holstein-friesian cows fed with 60 kg rice straw per day for the first 10 days and later fed with 60 kg *Cymbopogon* residue for another 10 days

	Volume of milk produced per day (L/d)								
Day	Cow 1	Cow 2	Cow 3	Cow 4	Cow 5	Cow 6	Cow 7	Cow 8	Cow 9
1	13	11	10	15	9.5	8.5	8.5	8.5	8.5
2	11	11	10	13	8.5	8.5	9.5	9.5	8.5
3	8	8	6	11	8	8	9	9	8
4	13	11	10	15	8	8	8	8	8
5	13	11	10	15	9	8	8	9	8
6	13	11	10	13	9	8	8	9	8
7	13	11	10	15	8	7	7	7	7
8	9.5	10	6.5	14	8	7	7	7	7
9	9	10	7	13	9	9	9	8	8
10	13	11	9	16	9	8	8	8	8
11	15	12	12	18	14	10	10	10	10
12	15	11	11	18	14	10	10	10	10
13	15	11	11	18	8	6	6	6	6
14	17	15	15	20	14	10	10	10	10
15	17	14	14	20	14	10	10	10	10
16	17	17	13	21	14	10	10	10	10
17	15	11	11	18	14	10	10	10	10
18	17	11	11	22	9	6	6	6	6.5
19	17	11	11	20	10	9	8	7	7
20	15	11	11	19	11	9	9	9	9

Effect of *Cymbopogon* residue as cattle feed on the volume of milk produced by holstein-friesian cows: Nine Holstein-Friesian cows available at the Kebun Percobaan Manoko were fed with the *Cymbopogon* residue and the volume of milk produced by the cows were investigated. Initially, the cows were fed with 30 kg of rice straw twice per day for 10 days and later fed with 30 kg of *Cymbopogon* residue twice per day for the following ten days. The milk was collected from every cow twice per day and the total volume of collected milk per day for all the nine cows is given in Table 5.

From Table 5, it can be observed that the milk produced by the cows vary from one cow to another. As such indicates that the amount of milk produced by the cows are heavily influenced by the biological conditions of the cows which is beyond the scope of this study. Nevertheless the average milk produced by all the nine cows shows a similar increasing pattern when fed with *Cymbopogon* residue as shown in Fig. 1. When fed with 60 kg of rice straw daily for a period of 10 days, the average milk produced by the cows is in the range of 8 to 14 L/d. After 10 days, the cows were fed with 60 kg *Cymbopogon* residue daily for a period of 10 days and the average milk produced by the cows is in the range of 9 to 19 L/d.

A relatively high increase of milk production was observed for cow 1 to cow 5 with an average increase of 1.8 to 5.1 L/d. As for cow 6 to cow 9, the average milk produced only slightly increased in the range of 0.4 to 0.9 L/d. This low average is contributed by the fact that the amount of milk produced by the cows suddenly decreased on day 18 from 10 L/d to 6-6.5 L/d as shown in Table 5. A clear explanation of what caused this decreased is still not well understood. But in general it can be said that the milk produced by the cows increased from an average of 9.5 L/d when fed with rice straw to 11.8 L/d when fed with the *Cymbopogon* residue.

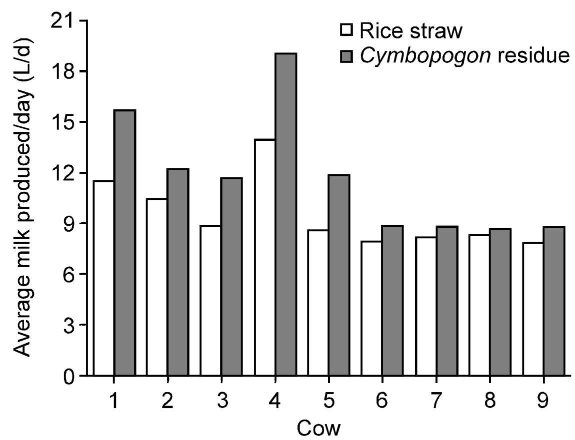

Fig. 1: Average milk produced per day (L/day) by holstein-friesian cows fed with rice straw and *Cymbopogon* residue for 20 days

Higher milk production by the cows fed with *Cymbopogon* residue is probably contributed by the higher non-fibrous carbohydrates content of *Cymbopogon* residue. Non-fibrous carbohydrates content is depicted by nitrogen free extract (NFE) content in Table 1, which includes monosaccharide, disaccharides and polysaccharides that are digestible, like sugar, starch, organic acids, etc., (Cherney, 2000). As seen in Table 1, the NFE content of *Cymbopogon* residue is 54.11%, which is higher than its corresponding value in rice straw, 39.09%.

These types of non-fibrous carbohydrates promote the production of propionic acid (Wattiaux, 1999), which will be converted to glucose by the liver. This conversion is important because normally cows cannot absorb glucose from digestive tract so that all the sugar found in milk must be produced by the liver. In addition, the liver can use amino acids for glucose synthesis.

During lactation, the mammary gland has a great need for glucose which is used primarily for the formation of lactose (milk sugar). The amount of lactose synthesized in the udder is closely associated with the amount of milk produced per day. Lactose contributes most to osmotic pressure in milk (about 50%) and the rest is contributed by citrate, ions, proteins, etc., (Dzidic, 1999). Rook *et al*. (1965) concluded that a reduction in lactose secretion causes a reduction in water secretion and therefore the milk yield is reduced.

Lactose secretion into the alveolar cavity will cause the alveolar cavity osmotic pressure increased when compared to the osmotic pressure in the secretory cells. This osmotic pressure gradient will result to the water movement into the alveolar cavity to reach the isotonic condition, which causes the milk volume increase. In this way, lactose production acts as a “valve” that regulates the amount of water drawn into the alveoli and therefore the volume of milk produced.

Conclusion: In brief, the proximate test confirms that *Cymbopogon* residue nutritional content meets the requirement of SNI for cattle feed. The *in vitro* test also shows good results for gas production (32.33 mL/200 mg), VFA (187 mM), NH_3 production (28.65 mM), DMD (64.75%) and OMD (73.57%) content. It is also demonstrated that the use of *Cymbopogon* residue as cow’s feed could increase 25% of the milk production. Hence, this study suggest that the *Cymbopogon* residue has the potential to replace conventional feed source (rice straw only) in ruminant diets.

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