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Characteristics of Ettawa Crossbred Dairy Goat Rumen Fluid and Digestibility of Palm Oil Industry By-Products

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Abstract: The *in-vitro* characteristics of the rumen fluid of ettawa crossbred dairy goats was analyzed to determine the digestibility of range of feeds based on palm oil industry by-products. The research used completely randomized design (CRD) with 5 different ratios of Palm Kernel Cake (PKC) and Palm Oil Sludge (POS) as follows: A; (10% PKC+50% POS), B; (20% PKC+40% POS); C (30% PKC+30% POS; D (40% PKC+20% POS), E; (50% PKC+10% POS). The characteristics of rumen fluid that were measured were pH, Volatile Fatty Acid (VFA) and NH3-N and digestibility of Dry Materials (DDM) and Organic Materials (DOM) *in-vitro*. The *in-vitro* study was performed according to the method of Tilley and Terry (1983). The results showed that the measured characteristics of the rumen fluid were within normal limits with pH 6.87-6.94, VFA 102.40-133.62 mM and NH3-N 9:00-9.91 mM. The digestibility of Dry Matter (DDM) ranged from 40.13 to 45.52% and the digestibility of Organic Materials (DOM) ranged from 38.94 to 44.56%. Most of the parameters depended significantly on the ratio of PKC and POS.

Key words: Rumen *in-vitro*, digestibility, Etawa, by-products of palm oil industry

INTRODUCTION

One of the factors affecting the level of livestock productivity is feed. Adequate availability and quality of food with assured continuity is required to sustain production levels. Also the largest cost in the process of farm production is the cost of feed. Some studies show that feed costs may reach 60-70% of the cost of production. Obtaining feed is becoming increasingly difficult because many ingredients such as corn, soybean meal and fish meal are imported. In the long term, alternative feed ingredients with adequate availability and quality need to be found to reduce dependence on the expensive imported feed materials and meet projected increasing demand. One possible local feed alternative is the by-products of the palm oil industry.

Indonesia is the largest palm oil producer in the world with Crude Palm Oil (CPO) production of 27 million tonnes/year (Wihardandi, 2012). The total area of oil palm plantations is 11.5 million hectares (Direktorat Jendral Perkebunan, 2012). Each hectare of oil palm plantation produces around 16 tonnes of fresh fruit bunches (FFB) from which 4 tonnes of CPO is extracted (Liwang, 2003). The by-product from each tonne of FFB include 294 kg of sludge and 35 kg palm kernel cake. Palm kernel cake (PKC) and palm oil sludge (POS) which has potential as animal feed alternatives (Carvalo *et al*., 2005; Mathius, 2004).

Unfortunately these by-products of palm oil industry have low nutritional values especially with regard to protein content and digestibility and some components are unpalatable and potentially polluting (Hanafi, 2004). The cell wall of FFB is covered with complex crystalline silica, has a high degree of lignification and contains cellulose structures that are difficult to digest (Devendra, 1990), hence the utilization still not optimal (Ningrat *et al*., 2013). One way to improve the digestibility of fibrous feed is to use probiotics. The use of probiotics improves dry matter intake, digestibility of dry matter and organic matter resulting in better productivity of livestock (Winugroho *et al*., 2000).

The vegetation that naturally grows alongside oil palm in plantation also has potential as a source of forage for livestock (Mathews, 2008). Chen *et al*. (1991) states that this vegetation can produce 2.6-2.8 tonne of dry matter/ha/year. Assuming that 60% of the total area of Indonesian plantation are at a productive stage the by-products from the palm oil industry along with this vegetation would be sufficient to feed the current number of cattle in Indonesia (Mathius, 2008).

Another form of livestock other than dairy cattle that has potential for milk production in Indonesia is the Crossbreed Etawa (CE) Goat. The CE goat can adapt to most environments in Indonesia, is dual-purpose (meat and milk), has good reproductive properties and produces milk with better nutritional properties as the fat globules are smaller resulting in easier absorption. CE goat's milk has a higher content of fluorine (10-100 times) than cow milk's which provides a natural antiseptic that can suppress the growth of pathogenic

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bacteria in the body (Damayanti, 2002). Goats milk is also reported to cure various diseases such as asthma and tuberculosis (Mulyanto and Wiryanta, 2002).

The use of by-products of the palm oil industry combined with the naturally growing plantation vegetation as feed is the focus of this study.

The potential to use oil palm plantations as a source for the dairy goat industry is high. Goat are raised in area close to the plantation and integrating these two industries could play a significant role in achieving the national 2020 goal of self sufficiency in food production, particularly milk.

Research was conducted to determine the quality and digestibility of PKC and POS as dairy goat feed using *in-vitro* testing.

MATERIALS AND METHODS

PKC and POS were combined in a concentrate with the addition of corn, rice bran and coconut cake which was then fed to dairy goats and followed by *in vitro* testing. The research objective was to optimize the formulation of this PKC/POS based feed based on measures of rumen fluid characteristics and digestibility.

Research used completely randomized design (CRD) with 5 concentrate feed ratios:

1: Treatment A: 10% PKC+50% POS
2: Treatment B: 20% PKC+40% POS
3: Treatment C: 30% PKC+30% POS
4: Treatment D: 40% PKC+20% POS
5: Treatment E: 50% PKC+10% POS

Formulation, feed composition, nutritional content and ingredients can be seen in Table 1.

Data were analyzed using analysis of Variance (ANOVA) according to Steel and Torrie (1991), while the differences between treatments were tested by Duncan's Multiple Range Test (DMRT).

Parameters measured were (1). Characteristics of rumen fluid (pH, VFA and NH3) measured by gas chromatography and (2). *In-vitro* digestibility of nutrients (dry matter digestibility (DMD) and Organic Matter Digestibility (DOM) using the method developed by Tilley and Terry (1969).

RESULTS

The results of research on the characteristics of *in-vitro* rumen can be seen in Table 2.

The results of statistical analysis showed that the POS/PKS ratio of the feed did not affect the pH or the NH3-N concentration or content of the rumen fluid. Volatile fatty acid (VFA) content increased with the percentage of palm kernel cake in the feed.

The results of statistical analysis showed a significant difference ($p<0.05$) in digestibility between different POS/PKS ratios. With a higher proportion of palm kernel cake, both the dry matter and the organic matter were more digestible.

DISCUSSION

Characteristics of rumen *in-vitro*: Statistical analysis showed that varying the POS/PKS ratio of the feed had no significant difference ($p>0.05$) on the pH of rumen fluid with pH ranging between 6.87-6.94 for all trials. A range of pH values between 6-7 is normal and is good for rumen microbial activity (France and Siddon, 1993) while the pH ideal for fiber digestion is 6.4-6.8. Values obtained in this study are only slightly higher than this optimal range. Near optimal pH can help bacteria colonize the plant cell wall and can encourage bacterial cellulase activity. Digestion will only be disrupted if the rumen fluid has a pH is below 6 and at pH 5 to 6, the activity of rumen microbes to digest the feed will be hampered or even stopped (Chanjula *et al*., 2004). A pH of less than 6.2 will inhibit rumen microbial growth significantly (Orskov and Ryle, 1992). With the observed pH in the normal range activity of rumen microbes in the digestion process was not compromised.

The average concentration of VFA observed ranged from 102.40 to 133.62 mM which is within the range suggested by previous research (Mc Donald *et al*., (2002), Preston and Leng (1989). According to Mc Donald *et al*. (2002), optimal concentration of VFA in rumen fluid for microbial growth is 80-160 mM, according to Preston and Leng (1989) the minimal amount of VFA in rumen fluid for microbial survival is 50 mM.

Silalahi (2003) stated that an increase in the number of rumen microbial cells increases the production of VFA so that rumen microbes can thrive resulting in a further increase in availability of VFA which in turn provides further energy for microbial growth. Hartati (1998) pointed out that the VFA production in rumen fluid can also be used as a measure of feed ferment ability as the higher level of ferment ability of a feed material, the greater the VFA produced. The results obtained in this study indicate that the availability of NH3-N in rumen fluid was sufficient for microbes to thrive resulting in good levels of VFA which provides an abundant source of energy for further growth and development of microbes. Sutardi (1987) suggested the optimal concentration of NH3-N in rumen fluid was between 4-12 mM and McDonald *et al*. (1995) suggesed 6-21 mM. Availability of NH3-N in the rumen fluid in goats fed each of the 5 different POS/PKS ratio feeds in this study ranged between 8.67 and 9.91 mM. This is well within both these estimates of the normal range required to support optimum growth and activity of bacteria. Adequate NH3-N in rumen fluid leads to easier degradation of protein feed in the rumen and provide a good balance of energy and nitrogen required by rumen microbes for growth. According to Erwanto *et al*. (1993) the concentration of NH3-N in rumen fluid also determines the efficiency of microbial protein synthesis which ultimately will affect the fermentation of organic material in the form of volatile

Table 1: Formulation and nutrient content of feed

	Feed (%)				
Feed ingredient	A	B	C	D	E
Palm kernel cake	10	20	30	40	50
Palm oil sludge	50	40	30	20	10
Corn	15	15	15	15	15
Rice bran	20	20	20	20	20
Coconut meal	4	4	4	4	4
Mineral	1	1	1	1	1
Percentage (%)	100	100	100	100	100
Nutrient content (%)					
Crude protein	11.58	12.59	12.93	14.28	14.46
Crude fiber	8.45	10.76	9.17	8.99	8.79
Cellulose	11.12	12.04	14.4	14.85	17.92
Lignin	18.36	15.94	13.82	10.73	10.65
Silica	5.35	4.30	3.89	3.06	1.71

Source: Results of Laboratory Analysis of Ruminant Nutrition, Andalas University (2015)

Table 2: Rumen *in-vitro* characteristics in goats fed on rations based on Palm oil by-products

Rumen *in-vitro*	Feed ratio				
Characteristics	A	B	C	D	E
pH	6.87	6.89	6.9	6.78	6.94
VFA (mM)	102.40[a]	113.64[b]	114.89[b]	117.39[b]	133.62[c]
NH3-N (mM)	9.33	9	8.67	9.5	9.91

Different superscripts on the same line indicate significantly differences in values (p<0.05)

Table 3: DMD and DOM palm oil industry by product

Digestibility	Treatment ratio				
Dry matter (%)	38.94[a]	39.61[a]	40.22[a]	40.49[a]	44.55[b]
Organic matter (%)	40.29[a]	40.13[a]	40.82[a]	41.09[a]	45.52[b]

Different superscripts on the same line indicate significant differences in value p<0.05

fatty acid (VFA) as the main energy source in ruminants. Winugroho and Maryati (1999) showed that at concentrations of NH3 exceeding 12 mM, the conversion process of NH3 to N is disturbed and if NH3 is less than 4 mM (conditions of low dietary protein) the process of degradation may also be disrupted.

Digestibility of dry matter (DDM) and digestibility of organic matter (DOM): The data of Table 3 shows that the DDM of the feed ranged between 38.94-44.55% and the DOM was 40.29-45.52%. The POS/PKS ratio E was the most completely digested (significantly different compared to the other treatments at p<0.05), with 45.52% of DOM and 44.55% of DDM digested. The higher DDM of ratio E was almost certainly due to the higher protein content of the material which resulted in greater availability of NH3 stimulating higher rumen microbe activity. Bamualim (1988) explained that the availability of adequate protein will lead to the increasing activities and growth of microorganisms resulting in more complete digestion. Oktarina *et al*. (2004) demonstrated that increased protein content of feed increased the rate of growth of microbes and higher rumen microbial population results in a better digestion of food. Higher protein content therefore raises the total digestible nutrient value of the feed. Digestibility of dry matter was closely linked to Total Digestible Nutrient (TDN). The higher protein content of ratio E positively impacts the TDN and the availability of energy that can be utilized by rumen microbes because TDN is the amount of organic matter that can be used as energy by both the rumen microbes and the livestock in the form of ATP (Tillman *et al*., 1998). The superior DDM and DOM of ratio E could be do to the lower content of relatively indigestible lignin and silica in the E ratio compare to the other ratios. than the other treatments. Silica is too hard to be fermented by rumen microbes.

Iluyemi *et al*. (2006) concluded that even though the nutrient content of the palm oil industry by-products was high, its value as animal feed was low due to the high crude fiber and lignin, particularly in the oil sludge, resulting in low palatability and digestibility. DOM depends on the balance of nutrients. Van Soest *et al*. (1994) stated that the ability to digest the feed material was determined by several factors such as the type of livestock, the chemical composition of feed ingredients and feed preparation. The digestibility of a feed was dependent on the nutrients.

DDM and DOM values obtained from this study compare with those found by Astuti (2012) who observed values of 42.76 and 43.55%, respectively but were lower than those obtained by Zain *et al*. (2009). According to Mukhtaruddin and Liman (2006) DDM and DOM should both be = 60% of feed.

Data from Table 3 also showed an increase in dry matter digestibility along with an increase of organic matter (significant difference was p<0.05). It is to be expected that the value of DDM is dependent on the DOM because the largest component of dry matter is organic matter so that when the DDM increased, DOM is also increased. Results of this research was supported by Sutardi (1987) who stated that an increase in the digestibility of dry matter was positively correlated with the increase of organic matter in feed because most of the components of the dry matter were organic matter, therefore factors that affected the level of DDM would also affect the level of DOM in the feed. The relationship between the value of dry matter and organic matter was very close (r = 0.98) as the organic matter was a major part of dry matter.

Dry matter contains indigestible ash while the organic matter does not (Fathul and Wajizah, 2009) hence DOM is always higher than DDM. The feed containing higher levels of ash was relatively harder to digest because ash would inhibit the digestion of dry matter. This data demonstrated this DOM is higher than DDM for each PKC/POS ratio trilled.

Feed digestibility and NH3-N content: Higher DDM and DOM indicated an increase of nutrient availability, especially volatile fatty acid (VFA) and NH3 for the growth of microbes that will be used for microbial protein synthesis. Suryahadi *et al.* (1993) stated that DDM and DOM measure how efficiently rumen microbes can utilize the feed and was positively correlated with the animal's ability to utilize the nutrients in the feed. Kurniawati (2007) added that feed with low digestibility values had low degradation so is not able to provide balanced environment for fermentation in the rumen. Rumen microbial growth is low affecting the microbial fermentation in the rumen.

Oktarina *et al*. (2004) obtained similar results to this study. They also concluded that increased VFA and NH3-N would increase the digestibility of dry matter (DDM) and organic matter (DOM) of feed.

Conclusion: The data demonstrates that ratio E (50% PKC+10% POS) was the best feed tested as indicated by the characteristics of *in-vitro* rumen and digestibility of nutrients with the results of pH, VFA and NH3, respectively 6.94, 133.62 and 9.91 mM. While dry matter and organic matter digestibility were 44.55 and 45.52%, respectively.

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