Research Article

Response of Etawa Dairy Goat to Provision of Probiotics in Ration Containing By-Product of Palm Oil Industry

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Abstract | The aim of this study was determining the effect of probiotic supplementation on the characteristics of rumen fluid and quality of milk of etawa dairy goat which was given mixed rations of palm oil industry by-product, namely Palm Kernel Cake (PKC), Palm Oil Sludge (POS) and Palm Fiber (PF). This study used Completely Randomized Design (CRD) and consisted of three phases research. Phase I was 4 concentrate treatment rations formulated from various mixture of palm oil industry by-product (PKC, POS and PF) and 5 replications. Best ration of Phase I was continued to supplementation of probiotics (Research Phase II), namely: A) 75g, B) 100g, B) 125 g, and D) 150 g. Parameters measured from Phase II were rumen's fluid characteristics (pH, VFA, NH3-N, and rumen microbes). Research Phase III was biological test of Etawa Dairy Goat (ECDG) with 5 treatment rations and 4 replications. The treatment rations of Phase III were as follows: 1) A = 100% Basal Ration (BR) + 0% Ration of Palm Oil Industry Byproduct (RPalm), 2) B = 75% (BR) + 25% (RPalm), 3) C = 50% (BR) + 50% (RPalm), 4) D = 25% (BR) + 75% (RPalm), and 5) E = 0% (BR) + 100% (RPalm). Parameter of Phase III is milk quality (protein, fat, solid non fat and lactose of milk). The results of this study showed that rumen fluid characteristics and milk quality are in normal range. Probiotics and by-product of palm oil can be used as a feedstuff of etawa crossbred dairy goats.

Keywords | Etawa goat, Milk quality, Palm oil industry by-product, Probiotics, Ration

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INTRODUCTION

Waste product of palm oil plantation, known as by-product, was one of the alternative feed ingredients for livestock that are plentily available in Indonesia as it is the world's largest palm oil producing country with 11.2 million hectares of oil palm plantation.

Carvalho et al. (2005) stated that palm oil industry waste products of palm oil industry, consisted of palm kernel cake (PKC), palm oil sludge (POS) and palm fibers (PF) have the potential as animal feedstuff because of their fairly good nutrient content. Iluyemi et al. (2006) stated that the three by-products of palm oil industry (PKC, POS and PF) have quite high content of nutrient but low benefit as animal feedstuff, while the high content of crude fiber and lignin causes the low palatability of the by-product, especially palm fiber (Arief et al., 2016). In Africa, Chanjula et al. (2011) stated that Palm Kernel Cake has been used in ration of sheep and efficiently used 20-30% of concentrates, while POS can substitute 60% of rice bran in the ration of sheep. Meanwhile, PF can substitute 25% of forage in cattle rations (Harfiah, 2007).

Processing technology needs to be applied physically, chemically, and biologically in order to increase the nutrient content of palm oil industry by-product, aiming to improve digestibility. Physical, chemical and biological treatment is an effort done outside the body of cattle in order to improve digestibility of rations. Other efforts that can be done is by giving probiotics where microbes are inserted into the body of livestock which then will help the fermentation process in the rumen, thus higher digestibility of fibrous.

Table 1: Composition and Nutrient Content of Feed Rations of In-vitro Experiment Phase I

Feedstuffs	Composition of Treatment Ration (%)			
	A	**B**	**C**	**D**
Palm Kernel Cake	10	20	30	40
Oil sludge Palm	30	20	10	5
Palm fiber	10	10	10	5
Polar	5	5	5	5
Soypulp	25	25	25	25
Molasses	6	6	6	6
Corn	13	13	13	13
Mineral	1	1	1	1
Total (%)	100.00	100.00	100.00	100.00
Nutrient Content				
Dry Matter (DM)	88.76	88.91	89.05	89.07
Crude Protein (CP)	13.11	13.26	13.40	13.79
Crude Fiber (CF)	21.39	22.03	22.66	21.91
NDF	60.66	62.74	64.81	65.31
ADF	43.53	44.28	45.02	45.02
Cellulose	29.58	31.89	34.19	35.87
Hemicellulose	22.82	24.59	26.35	27.24
Lignin	14.70	15.74	16.77	17.46
TDN	64.46	65.14	64.91	66.88

Table 2: Composition of Basal Feed (BF) and Ration By Palm Oil Industry By-product (Rpalm) Ingredients in ration (%)

Feedstuff	Percentage in Ration (%)	
	Basal Ration (BR)	**RPalm**
Palm Kernel Cake (PKC)	-	40
Palm Oil Sludge (POS)	-	5
Palm Fiber (PF)	-	5
Polar	50	5
Soypulp	25	25
Molases	5	6
Corn	19	13
Mineral	1	1
Total	100	100
Nutrient Content (%)	15.25	13.79
Crude Protein	100	100
TDN	69.97	66.88

Probiotics are feed additive that contained live microbe that are beneficial for cattle. The role of probiotics are to create balance of microbes in the digestive tract, optimum condition for feed fibrous digestion and increase efficiency of feed conversion, resulting in increased of livestock production (Winugroho, 2008). Probiotic bacterias are also able to suppress the growth of pathogenic microorganisms residing in the gastrointestinal tract through the production of its anti-microbial substances thus improving the health of livestock (Supardjo, 2008).

Etawa crossbred dairy goat (ECDG) is indigenous livestock goat of Indonesia especially for dairy goat. ECDG comes from crossing of etawa goats from India with local Indonesian goats (Arief, 2013). ECDG is one of the livestock alternative, aside from dairy cows for milk production.

With its enormous potential and supported by its high nutritional content, it is believed that the use of palm oil industry by product with supplementation of probiotics will positively affect the production and quality of goat milk of ECDG.

METHODOLOGY

The study consists of 3 phases, which are as follows:

Study Phase I

***In-vitro* Test of Phase I. Phase I *In-vitro* test is atudy about Rations from by-product of palm oil industry (RPalm):** This phase I study used completely randomized design (CRD) with 4 ration treatments, consisted of by-products mixture of palm oil of industry (PKC, POS and PF). Treatments rations are as follows: A). 10% POS + 30% POS + 10% PF, B). 20% PKC + 20% POS + 10% PF, C). 30% PKC + 10% POS + 10% PF and D). 40% PKC + 5% POS + 5% PF. Other materials used in the ration are polar, soypulp, molasses and corn. Ration formulations treatment and nutrient content of ration can be seen in Table 1.

In-vitro test phase I was referred to Theodore and Brook (1990) method by preparing solution medium to obtain the same conditions of the true ruminant rumen. Materials used in preparation of solution medium are macromineral and micromineral solution and reazurin. The medium solution may later determine the level of oxygen reduction in the medium solution. CO2 is required to create anaerobic environment for the solution medium, keeping the oxygen not entering the in vitro bottle that is in an anaerob state when materials were inserted or samples of rumen fluid were taken. The collected rumen fluid samples were inserted into the flask directly to maintain the temperature of 39^0C under anaerobic environment.

Study Phase II

Probiotics supplementation on Best Rations of Phase I (RPalm): The aim of this phase of study was to determine the effect of probiotic supplementation of ration D (RPalm) on characteristics of rumen fluid. The study phase II used completely randomized design (CRD) with 4 ration treatment and 5 replications. The treatments are doses of probiotic supplementation of ration D (RPalm), which were as follows; A) 75 g, B) 100 g, C) 125g, and D 150 g. Based on the study of Winugroho et al. (2008), Prihandono (2001) and Ngadiyono et al. (2001), probiotics were administered at the beginning of the research. Parameters measured on this phase II study were rumen fluid characteristics; pH, VFA, NH3-N, and rumen's microbe. Level of pH was measured using a pH meter, VFA levels were determined using the General Laboratory Procedure (1966), the determination of NH3-N production was carried out by the Conway Cup Method (Conway and O'Malley, 1992).

Study Phase III

Biological Test of Phase I Best Ration (RPalm) with Probiotic supplementation on ECDG: The objective of this phase of study was to determine the best percentage use of RPalm to substitute Basal Ration with supplementation of Probiotics 150 g on Etawa Crossbred Dairy Goats (ECDG). The composition of Basal Feed and RPalm can be seen in Table 2.

The study was designed using completely randomized design (CRD) with 5 treatments and 4 replications. The treatments were; A) 100% Basal Ration (BR) + 0% (RPalm), B) 75% (BR) + 25% (RPalm), C) 50% (BR) + 50% (RPalm), D) 25% (BR) + 75% (RPalm), and E) 0% (BR) + 100% (RPalm). Parameters of this phase of study were milk quality of ECDG in terms of protein, Fat, Solid Non Fat and Lactose of milk. Analysis of variance (Anova) was referred to Steel and Torrie (2002), while differences between treatments was referred to DMRT (Duncan Multiple Range Test).

RESULTS

Rumen Fluids Characteristics

The result of the study of Phase II on rumen's fluid characterisctic (pH, VFA, NH3N, and Rumen's microbe) is shown in Table 3.

Milk Quality of Etawa Crossbred Dairy Goat

The result of study on milk quality of Etawa Dairy Goat fed with treatment rations of Phase III is shown in Table 4.

DISCUSSION

pH level of Rumen's Fluid

Probiotic supplementation produces better pH of rumen (from 6.44 to 6.52 - 6.68). This pH change shows the occurrence of fermentation process by microbes on materials that exist in the medium, supported by the availability of VFA in which the content of rumen VFA is directly proportioned to pH (Sugoro et al., 2005). The condition of rumen's pH is related to cellulolytic microbial growth with the optimum pH> 6.5 for cellulolytic microbial growth. Therefore, level of pH <6.5 will reduce the rate of cell wall degradation due to decreased of microbial growth (Pelczar and Chan, 1992).

Rumen requires optimum pH conditions for bacteria to carry out fermentation activities properly, as well as to in

Table 3: Rumen's Fluid Characteristics (pH, VFA, NH3N and Rumen Microbe) of Etawa Dairy Goat Fed with RPalm (Best Ration of Phase I)

Parameters	No Probiotics	Probiotics				SEM	p
		A	B	C	D		
pH	6.44	6.52[b]	6.53[b]	6.54[b]	6.68[a]	0.09	0.05
VFA (mM)	81.68	83.45[b]	85.11[b]	85.38[b]	94.90[a]	1.14	0.05
NH3 (mM)	6.91	7.81[b]	8.90[ab]	8.97[ab]	10.11[a]	1.22	0.05
Rumen microbe (cfu/ml)	5.02 ($x10^9$)	1.4 (10^{11})[b]	1.8 (10^{11})[ab]	2.0 (10^{11})[ab]	2.3 (10^{11})[b]	1.44	0.05

Note : Different superscript of lowcase letters in the same column and uppercase letters in the same line indicate a significant difference (P<0.01)

Table 4: Milk quality of etawa dairy goat fed with treatment rations of Phase III (%)

Treatments	Milk Quality (%)			
	Protein	Fat	Solid Non Fat	Lactose
A	4.62	5.16	12.23	5.02
B	4.72	5.30	12.28	5.24
C	4.84	5.55	11.20	4.67
D	4.85	5.10	11.27	4.77
E	4.91	5.10	12.55	4.50
Average	4.78	5.24	11.91	4.84
SEM	0.12	0.19	0.63	0.29
P	0.05	0.05	0.05	0.05

crease the production of volatile fatty acids (Fathul and Wajizah, 2009). Furthermore, the acidity (pH) of rumen fluid is one of the indicator that shows bioprocess activities in the rumen. According to Hoover and Miller (1992), the pH level of rumen fluids that is good for growth of microbe, development and activity of rumen bacteria, especially cellulolytic bacteria are pH 6.6 – 6.8.

The pH data in Table 3 showed the pH of the rumen fluid was still in the normal range of pH. This normal pH range is an indicator that the biofermentation process in the etawa dairy goat's rumen is normal. The difference in the composition of palm kernel cake in the ration did not affect the acidity of the rumen pH because the nutritional content of the ration did not differ either, especially the crude fiber content of the ration. Increased pH of rumen fluid due to the addition of probiotics has actually increased the population of rumen bacteria. This shows that probiotic bacteria are able to synergize with rumen microbes, making it capables of developing. According to Oematan (1997), a good pH level for growth, breeding and activity of rumen bacteria, especially fiber digesting bacteria was 6.18 - 6.68, whereas according to Orskov and Ryle (1990) a normal pH of rumen fluid is 6.0 - 7.3. Level of pH that is too high or too low can cause the biofermentation process in the rumen working poorly.

From Table 3, we can see that probiotic supplementation can increase the number of rumen microbes from 109 to 111 cfu / ml of rumen fluid. The increasing number of rumen microbes was also followed by an increase in the concentration of NH3 derived from fermentation of protein to ammonia.The increasing concentration of NH3 also means increasing availability of microbial protein-forming components with NH3-N as the main component of amine groups in form of protein microbes.

The growth and development of rumen microbes influenced by NH3 concentration was also shown in Table 3. Lack of NH3 will cause poor synthesis of microbial protein. The low content of food rations due to the high crude fiber content of the ration will reduce the rumen microbial population, thus affecting NH3 availability in the rumen. The range of NH3 from the above data is still in the normal range, as stated by Kamra (2005) that the optimal concentration of NH3 rumen fluid to support the growth of rumen microorganisms was 7-8 mM.

Volatile Fatty Acid (Vfa), Nh3, and Rumen's Microbein Rumen's Fluid

The supplementation of probiotics can increase VFA production by 16.19% (from 81.68 mM to 94.90 mM). The high production of VFA in treatment D was also followed by a high number of microbes in the treatment (2.3 x 10^{11}cfu / ml). This also indicates that the increase in microbial protein synthesis due to the increasing number of rumen microbes will cause an increase of energy availability. The relationship between pH level, total bacterial colonies, concentration of NH3 and VFA in ration supplemented with and without probiotics can be seen in Figure 1 below.

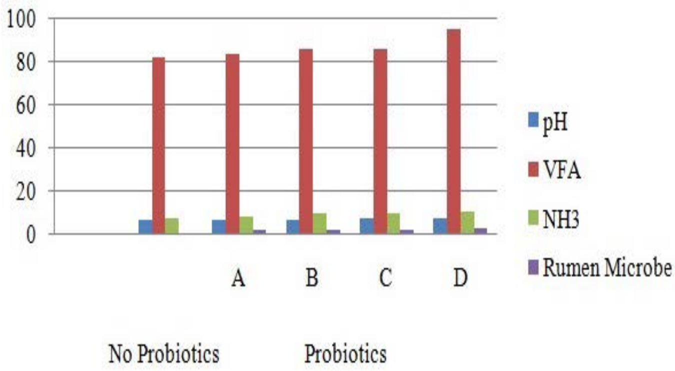

Figure 1: Effect of probiotic supplementation on characteristics of rumen fluid of goat fed with ration based on the palm oil industry by-product

The result of statistical analysis showed that there was no significant difference (P <0.05) between milk protein, fat, SNF, and lactose of Etawa Dairy Goat from all ration treatments. From the table above, it is shown that the milk protein and milk fat of Etawa Goat fed with treatment rations from mixed by-product of palm oil industry are not significantly different (P <0.05, non significant) with mean for protein and fat respectively 4.78% and 5.24% , whereas for solid non fat and milk lactose are respectively 11.91% an 4.84%. The result shows that the protein content of 13.76% complied the nutritional adequacy for Etawa dairy goat, thus good quality of milk was achieved.

Protein and Fat of Milk

From Table 4, milk protein content obtained in this study was in good range, which is 4.62% - 4.91%, while the fat content of milk is 5.10% - 5.55%. From this study, normal range of protein and fat of milk was obtained.

According to Zurriyati et al (2011), the protein of milk content exceeding 4.29% is included in premium class. Arief et al. (2018) also get the same results as the research. The high content of goat milk protein is caused by a given feed that meets the requirements of defined nutritional content consisting of forage and concentrate where the concentrate is derived from palm oil industry byproduct. It also means that palm oil industry by-product can be used as mixed feed ingredients for dairy goat concentrate ration. Quality of feed will increase solid non fat in milk, in which milk protein is one component of solid non fat. Further explained by Sukarini (2010) that the concentration will increase milk protein, thus more energy will be available for the formation of amino acids derived from microbial proteins. Increased availability of amino acids will contribute to the increase in milk protein synthesis where high protein consumption is influenced by concentrate feed ingredients.

Judging from the fat content of milk, the result is quite good and in accordance with the Indonesian National Standard of milk quality (SNI, 2008) where the minimum fat content of goat milk is 3.0%. Furthermore, Thai Agricultural Standard (TAS, 2008) stated that goat milk included in the premium class is if milk fat content exceeds 3.0%. The good content of milk fat is because of good feeding, consisting of forage and concentrate. Forage feed is a source of milk fat and fiber that produces acetate, in which higher acetate will increase synthesis of fatty acids, thus increased milk fat content (Makin, 2011).

Further explained by Ace and Wahyuningsih (2010) that the milk fat content is influenced by acetic acid derived from forage, with coarse fibers acting as precursors. Forage eaten by livestock will then undergo a fermentative process in the rumen into a Volatile Fatty Acid that is acetate, propionate and butyrate. Acetate enters the blood and converted into fatty acids, enters the cells of udder and finally secreted into milk fat (Suhardi, 2011).

Lactose and Solid Non Fat

Lactose is a milk carbohydrate consisting of glucose and galactose (Ensminger, 2002). Milk lactose levels are associated with milk production where elevated lactose levels indicate an increase in milk production because lactose plays a role in osmoregulators in the mammary gland.

The results of the study indicate that ration consisting of various by-products of palm oil industry does not affect the milk lactose content (nonsignificant, P <0.05). The mean level of milk lactose in this study was 4.84%, which was slightly lower than the milk lactose content of Subaghiana (1998) in which he obtained lactose milk levels of 5.05%. Mean of milk lactose content on this study is higher than Indonesian National Standard (SNI, 1998) that is 2 - 3%, but almost the same with lactose level of Subaghiana (1998) and Arief et al. (2018) in which they found4.64 - 5.46% asmean lactose content of goat milk .

From Table 4 it appears that SNF levels are not significantly different (P <0.05). Level of SNF without milk fat depends on milk protein and milk lactose, in which the milk fat and milk protein content causes unsignificant different level of SNF between treatments (P <0.05). The results of this study are in accordance with the opinion of Utari et al. (2012) that milk SNF levels depend on protein and milk lactose, in which the milk protein and milk lactose levels keep the levels of SNF to be no different.

The no difference in milk SNF content is because of the rations given have the same nutritional content. Bruhn (2006) said that several factors that cause no difference in milk quality are the same feed quality, breed, and maintenance system. The type of feed affects the milk quality produced, while quality of feed will affect the metabolism of livestock that will later influence nutrient and energy availability for milk component synthesis. Haenlein (2002) found that feeding and management factor determined 50% of milk nutrient component, thus good feeding and farm management will lead to good nutrition composition. The treatments effect on quality of milk can be seen in Figure 2.

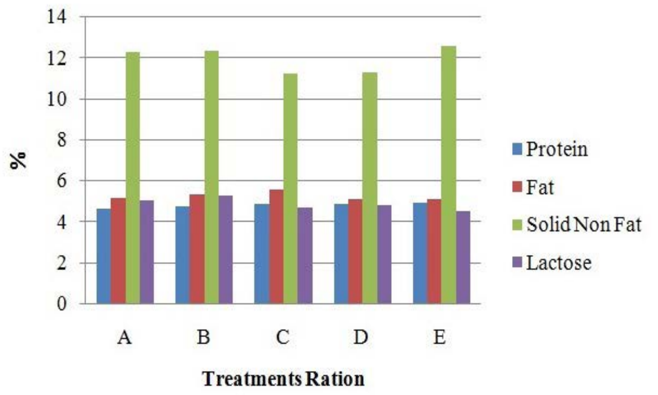

Figure 2: Effects of Treatment Ration on Milk Quality of ECD Goat

CONCLUSION

From the description above, we can conclude that the palm oil industry by-product, namely palm kernel cake, palm oil sludge and palm fiber can be used as a feed ingredient for etawa crossbred dairy goats ration. The by-product of palm oil industry ration for dairy goat have no effect on rumen fluids characteristics and quality of milk in terms of protein, fat, solid non fat and lactose of milk.

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CONFLICT OF INTEREST

The authors declare no conflict of interest in this article.

AUTHORS CONTRIBUTION

All authors contributed equally.

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