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The Effects of Cassava Pomace and Protected Soybean Meal on Dairy Milk Production and Quality

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ABSTRACT

The objective of the study was to determine the effect of cassava pomace and protected soybean meal on dairy milk production and quality of mid lactating dairy cows. This research was conducted at Turen, Malang from January to April 2020. Twelve lactating Friesian Holstein dairy cows were divided into 2 groups so that each group consisted of 6, namely the control and treatment groups. The feed were a combination of forage and concentrate with a ratio of 35:65 in dry matter (DM). The control group received wet concentrate with DM content of 30.58%, 14.87% CP, and 75.06% TDN, while the treatment groups received concentrate with supplementation of cassava pomace 15% of DM ratio and protected soybean meal 45 g/l milk production. The variables observed were nutrient consumption, milk production and quality. Data between the two groups were analyzed using the Independent Sample T-test. The results showed that the addition of waste cassava and protected soybean meal increased (P<0.05) nutrient consumption (DM, OM, CP, CF, EE, and TDN). Milk production in the treatment group was higher (P<0.05) than control group (9.46 vs. 6.07 Ls/head/day). Milk protein production in the treatment group was higher (P<0.05) than control group (0.37 vs. 0.21 L/head/day). The content of milk protein and milk fat between the control and treatment groups was not significantly different (respectively 3.19 Vs 3.28; 4.46 vs 4.42 %). Milk protein and fat production in the treatment group was higher (P<0.05) than control group (0.21 vs 0.37; and 0.50 vs. 0.30 L/head/day respectively). The composition of glucose and blood urea in control and treatment dairy cows were not significantly different. In conclusion, giving cassava pomace and protected soybean meal to dairy cows during mid lactation increased nutrient consumption, milk production, milk protein production, and milk fat production but did not increase percentage of milk protein and fat. The treatment also did not affect blood glucose and nitrogen urea contents.

Keywords: Cassava pomace, Dairy cow productivity, Friesian Holstein, Mid lactation, Protected soybean meal

Introduction

Frisien Holstein is a popular dairy cow breed in Indonesia due to its high milk production compared to other breeds. Dairy industry surely oversees the individual performance of the animals to secure profits. The performance of dairy livestock is determined by two factors, i.e. 30% of genetic and 40% of environment. Widiawati and Mahyudin (2011) proposed that dairy cows with greater genetic potency would not achieve the high performance as expected without optimal feeding management. The nutrient balance, particularly meeting the protein and energy requirement accordingly to the production status would help to reach the genetic potential in terms of the productivity.

Conventional feeding management is considered less efficient and wasteful as the majority of the protein (approximately 60%) are degraded into ammonium in the rumen (Wina and Abdurohman, 2005). Volatile fatty acid (VFA) and NH_3 are products of carbohydrate and protein degradation by ruminal microbes. The rate of carbohydrate digestion that meets the rate of protein degradation increased the rate of microbial protein synthesis (Widyobroto *et al*., 2007). In general, the ruminal microbes would convert feed protein into ammonia in the rumen, while unconverted ones would undergo enzymatic digestion in intestine. An excess feed protein degradation in the rumen would lead to energy loss in form of gas (CO_2 and CH_4) during fermentation and urinal urea, therefore, diminishing the biological value of high quality of the protein feed (Cheeke, 2005).

Ruminal microbes hydrolyze the protein and NPN into peptide and amino acids that then would be further converted into ammonia. The ammonia are utilized by ruminal microbes as main nitrogen source to synthesize microbial protein in the presence of readily-fermented energy source. However, the energy availability is commonly low, so that the ammonia production rate exceeding the rate of ammonia utilization by microbes (Hindratiningrum *et al*., 2011). Energy and protein ratio is needed to be concerned to obtain improved protein efficiency. Hence, protein protection should be made to avoid degradation in rumen (Widyobroto *et al*., 2010). The use of formaldehyde as protective agent is a reasonably effective way to reduce degradation of soybean meal in rumen. Protecting soybean meal with 1% of formaldehyde significantly reduced the protein degradation in rumen as much as 14.81% (Widyobroto *et al*., 1997).

Cassava pomace is solid waste from tapioca production, taking up 2/3 to 3/4 of the total raw material. Cassava pomace contains high metabolizable energy (3000 to 35000 kcal/kg), as well as 1.6 to 2.5% of protein (Yohanista *et al*., 2014). Hindratiningrum *et al*. (2011) reported that ruminal VFA content were increased as a result of wet cassava pomace feeding. Wet cassava pomace has high fermentability which facilitates the acid production, and increases the activity of amylolytic bacteria. Soybean meal is a side product of soybean oil production and widely used as livestock feed due to its high crude protein content.

Soybean meal is one of protein sources with high degradability in rumen, so that its biological value is less available for ruminant. The rate of ammonia production from soybean meal digestion surpasses the rate of its utilization for microbial protein synthesis. As a result, the excess ammonia are diverted to liver where it will be transformed into urea which then be secreted via urine (Puastuti *et al*., 2012). There are several ways to shield feed protein from microbial degradation in rumen. Suhartanto *et al*. (2014) reported tha 1% of formaldehyde on UDP production from soybean meal could protect from ruminal degradation as seen from the reduction of dry and organic matter degradations. Rokhayati (2010) reported that providing protected soy mean meal as much as 25 g/L could increase milk production. Moreover, Sahawaludin *et al*. (2019) recommended giving 60 g/L of protected soybean meal to enhance the milk production.

Supplementation of cassava pomace and protected soybean meal are intended to maintain the consistence of milk production after reaching its peak to avoid significant reduction. Protected soybean meal and cassava pomace supplementations could balance the energy ad protein in rumen. Leondro *et al*. (2019) stated that balanced energy and protein in a feed will optimize the growth of ruminal microbes and milk production. Addition of undegraded protein to the balanced feed will protect protein from rumen digestion. Thus, the protein would be digested and absorbed in the intestines.

Many efforts have been taken to improve the dairy cow performance through enhancements of feed quality and quantity, as well as providing sufficient nutrients required by ruminal microbes. Improving the feed quality can be done by ensuring balanced energy and protein in the feed devoted for both ruminal microbes and their host. Supplementing lactating dairy cows with balanced energy and protein are intended to increase the production and improves the milk quality. In addition, considering quality and price point of feedstuffs as factors in determining the feeding management is expected can enhance the efficiency of cost production. The objective of this study is to evaluate the effects of cassava pomace and protected soybean meal supplementation on dairy cow production.

Materials and Methods

Place and time of study

This study was conducted in Sawahan, Turen, Malang Regency from January to March 2020. The milk analysis was performed at Laboratotry of Quality Assessment at Politeknik Pembangunan Pertanian Malang. Meanwhile, the blood metabolite analysis was completed at Laboratorium Penelitian dan Pengujian Terpadu, Universitas Gadjah Mada. Feed analysis was performed at Laboratory of dairy livestock and milk industry at Faculty of Animal Science Universitas Gadjah Mada.

Materials

12 mid-lactating Friesian Holstein (FH) dairy cows were used on this study. The cows had average of 7 to 11 L/head/day milk production and 500 to 630 kg of bodyweight. The cows were on their first to third lactations, 2.5 to 5 year old with 2 to 3 of BCS, month-4 to 5 of lactating. Forages given to the cows were king grass, cassava by-products, cassava peels, beer solid waste, cassava pomace, soybean meal. Formaldehyde 37% was also used on this study. Other materials include digital scale, milk, milk production scale, cooler, distilled water, cows blood, venoject and vacutainer needle, EDTA tube, cotton ball, alcohol 70%, centrifugator, Eppendorf tube, and proximate analysis instruments.

Methods

This study used 12 mid-lactating Friesian Holstein cows divided equally into 2 groups (control and treatment). The grouping was done equally by considering body weight, BCS, age, lactation period, and milk production. King grass and concentrate were provided 2 times daily

(06.00 a.m. and 2.00 p.m.) in 35:65 ratio (DM basis). Concentrate used on the study were cassava by-products, brewery waste, and cassava pomace (all provided in wet form). The amount of cassava pomace added to the cows feed was 15% of the feed DM, while the amount of protected soybean meal added was 45 g/L milk. The detailed formulation of the feed is provided on Table 1. All cows received ad libitum water access.

The study was performed for 9 weeks which consists of 7 days of adaptation period and 56 days of collection period. Milking was carried out twice daily (06.00 a.m. and 2.00 p.m.) in which the production was recorded. 140 ml samples were collected from each milking. Milk samples were analyzed for fat, protein, non-fat solid and total solid contents. Sample collection was done twice a week for each cow.

Blood was collected from all cows at the beginning and the end of the study. Blood was collected via caudalis artery as many as 3 ml using vacutainer needle and venoject tube. Blood were centrifuged 3000 rpm for 15 minutes to obtain the plasma which then transferred into 1 ml Eppendorf tube. Plasma was stored in -20°C freezer until further blood glucose and urea analysis were carried out.

Statistic analysis

Data on feed, production, milk quality, blood urea, and blood glucose were analyzed on Independent Sample T-test (Astuti, 2007) using Statistical Prog for Social Science (SPSS 25.0.).

Results and Discussion

Results of study are provided on Table 1 to 6. On this study, king grass and concentrate were given to all cows, while cassava pomace and protected soybean meal were given only to cows under treatment group. Soybean meal protection was done using formaldehyde 37% according to Widyobroto *et al*. (1997) and Suhartanto *et al.* (2003), in which formaldehyde 37% was added to 100 g of soybean meal (DM basis).

Nutrient intake

Average of nutrient consumption is presented on Table 3. The results indicate that supplementation treatment delivered a significant effects (P value <0.05) compared to control group on dry matter, organic matter, crude protein, crude fiber and TDN consumptions (17.17 vs 19.84; 15.81 vs 18.42; 2.15 vs 2.37; 3.56 vs 3.66; and 10.67 vs 12.99 kg/head/day respectively). Dry and organic mater consumption of the cows on treatment groups is higher because of the carbohydrate content from cassava pomace and protected soybean meal as protein source which substantially enhance the fermentation process in rumen. The carbohydrate provides carbon backbone, while protein supplies nitrogen for the microbes to grow. Eventually the number of microbes increased and enhanced the ruminal flow rate so that cows consumed more feed. The result is in line with Astuti *et al*. (2009), who reported that organic matter consumption was heavily correlated with dry matter consumption. Increased dry matter consumption increased the organic matter consumption. Vergi *et al*. (2015) added that the nutrient requirement for maintenance and milk production affected the dry matter consumption. Surbakti *et al*. (2013) proposed the same idea that organic matter consumption was aligned with dry matter intake. NRC (2001) described that dry and organic matter consumptions were determined by many factors, i.e. body weight, milk production, and feed quality. The dry matter consumption of lactating cows were ranging from 2.25 to 4.32 of the body weight.

Thaariq (2017) stated that digestion process of the ruminants occurs mechanically inside the mouth, while microbial fermentation digests the feed further. However, the microbes are dependent on the feed consumed by host and require Nitrogen and Carbon skeleton for their growth. Hume (1982) reported that dry matter consumption was determined by the rumen capacity. Moreover, the greater flow rate in emptying the rumen will increase the feed consumption as well.

The result of this study indicated that supplementation improved the crude protein intake significantly. The crude protein consumption of treatment groups was higher than of control group (Table 3; 1.59% difference). This finding is aligned with Widyobroto *et al*. (2008), the difference on crude protein intake was a result of different dry matter consumption and soybean meal supplementation. The dry matter consumption of treatment groups was higher, therefore increased the crude protein intake. Van Soest (1994) showed that crude protein consumption is also determined by the feed palatability, digestibility, ruminal fermentation, digestive enzyme, the metabolism of ruminal microbes, and feed quality.

The calculation for the nutrient requirement is presented on Table 3 in which the balance of crude protein is positive between two groups. The crude protein consumption of both and treatment

Tabel 1. Detailed composition of Friesian Holstein dairy cows feed

No	Feedstuffs	Control (%)	Treatment group (%)
1	King grass	35	35
2	Cassava waste	24	24
3	Brewery waste	24	24
4	Protected soybean meal	-	3
5	Cassava pomace	-	14
	Total	83	100
	Mineral premix	2 tsp	2 tsp

Table 2. Nutrient content of the feedstuffs

Nutrients	King grass	Concentrate	Protected soybean meal	Cassava pomace
Dry matter - DM (%)	22.60	30.58	89.38	34.21
Organic matter - OM (%)	84.60	97.65	92.20	98.21
Crude protein - CP (%)	9.10	14.87	42.58	1.61
Extract ether - EE (%)	2.30	6.19	1.58	7.80
Crude fiber – CF (%)	40.00	5.47	435	6.21
Total digestible nutrient – TDN (%)	44.84	75.06	88.19	83.14

Table 3. Nutrient consumption

Variables	Control (kg/head/day)	Treatment (kg/head/day)
Nutrient Intake		
Dry matter - DM (%)*	17.17±0.14	19.84±0.11
Organic matter - OM (%)*	15.81±0.12	18.42±0.097
Crude protein - CP (%)*	2.15±0.012	2.37±0.027
Crude fiber – CF (%)*	3.56±0.054	3.66±0.03
Extract ether - EE (%)*	0.72±0.003	0.90±0.002
Total digestible nutrient – TDN (%)*	10.67±0.06	12.99±0.07
Nutrient Requirement		
Dry matter (DM)	14.476	15.162
Crude protein (CP)	1.270	1.350
Total digestible nutrient (TDN)	7.499	8.309
Balance		
Dry matter (DM)	(+)2.69	(+)4.68
Crude protein (CP)	(+)0.88	(+)1.02
Total digestible nutrient (TDN)	(+)3.17	(+)4.681

ns : non significant (P>0.05);
* : significant (P<0.05).

groups exceeds the requirement. The excess of crude protein from treatment group is greater than of the control group (P<0.05; 1.075 vs 0.984 kg DM/head/day). Therefore, the crude protein content of the feed has met the requirement to enable optimal growth of the ruminal microbes to provide Nitrogen precursor for milk production. The animals did not need to mobilize body protein to supply the requirement. Clark *et al*. (1992), microbial cell and protein that pass ruminal digestion (by-pass protein) is the main protein and amino acid source for ruminants. Feeding undegraded protein improved the performance of dairy animals.

The consumption of crude fiber increase aligned with the supplementation. Rokhayati (2010) reported that RUDP supplementation elevated the crude fiber consumption compared to groups receiving no supplementation. Pamungkas *et al*. (2013) stated that in terms of metabolic status, feed intake reflects the requirement for energy. Therefore, animals would stop consuming feed once the required energy is supplied. The low crude fiber content facilitated ruminal microbes (bacteria, protozoa, and fungi) to penetrate and digest nutrients.

The feed intake can be restricted by energy requirement, and fiber has a strong relationship with feed intake. The increase of the crude fiber content reduced the digestibility which will lead to animal keep consuming more feed as many as their stomach allow. Dairy cows require crude fiber in their feed to some extent, intended to maintain the functionality of the rumen and milk fat content.

On Table 3 showed that cassava pomace and protected soybean meal supplementation altered the crude fat consumption substantially (P<0.05; 0.72 vs 0.90 kg/head/day). Furthermore, the TDN consumption of the treatment group was also higher compared to control (10.67 vs 12.99 kg/head/day) due to the higher dry matter consumption compared on the treatment group. Van Soest (1994) reported that crude fat consumption were affected by the crude fat content of the forages. The intake of TDN increased along with the the increased level of supplementation. This result is expected as Hanifa (2008), the TDN of feed was determined by feed dry matter, in which greater dry matter resulted in higher TDN content. High TDN consumption demonstrates the high digestibility of the feed since energy is a result of nutrient catabolism.

Milk production and quality

This study found that cassava pomace and protected soybean meal supplementation provided significant difference (P<0.05) on the milk production (Table 4). High milk production on treatment groups was caused by greater feed intake on that group compared to control group (19.84 vs 17.17 kg DM/head/day). This finding is in accordance with Novianti *et al*. (2014), in which feed consumption is one of factors to be considered in order to maintain the milk production, both for the quality and quantity aspects. Rochijan *et al*. (2014) reported that the tendency of high milk production came from the high quality of feed that animals consumed to support the growth of ruminal microbes, as weel as to supply the energy and amino acid requirements for milk synthesis. Widyobroto (2013), reported that optimal microbial protein synthesis could be achieved by providing protein and energy sources that has balanced digestion rate in the rumen, and supplying the animal with by-pass protein.

The effects of cassava pomace and protected soybean meal supplementation on this

Table 4. Milk production and quality

Variables	Control	Treatment
Milk production (L/head/day)*	6.07±1.26	9.46±1.30
Milk production 4% FCM (kg/head/day)*	6.65±1.37	10.74±1.25
Milk protein (%)[ns]	3.19±0.14	3.28±0.12
Milk protein production (kg/head/day)*	0.21±0.07	0.37±0.07
Milk fat (%)[ns]	4.46±0.24	4.42±0.32
Milk fat production (kg/head/day)*	0.30±0.07	0.50±0.90
Lactose (%)[ns]	5.36±0.13	5.43±0.18
Solid non-fat (%)[ns]	8.36±0.64	8.19±0.36
Total solid (%)[ns]	12.58±0.8	12.61±0.67

ns : non significant (P>0.05);
* : significant (P<0.05).

study substantially brought positive effects on milk protein production. The higher milk production leads to higher milk protein production. Chen *et al*. (2011) stated that production and fat content, as well as protein in milk, were sensitive to the amount, composition, and nutrient value of feed given to the animals However, the response to protein composition was not as quick as what milk fat content would be. Millk protein is synthesized in mammary gland from available precursors, mainly methionine and lysine availabilities serving as limiting factor. Widyobroto (2013) added that amino acid source digested in the intestine come from two main sources, i.e. microbial protein synthesized in rumen and rumen-undegraded feed protein. The milk protein production of the treatment groups was higher compared to control group as they received higher protein content on their feed. Protein milk production is higly associated with protein consumption. Protected protein supplementation increases the protein milk production. UDP supplementation enhanced the number of protein in the intestine. Therefore, the increased number of protein available in the instestine is expected to supply the protein requirement for milk protein production (Widyobroto *et al*., 2010).

This study also demonstrated that the supplementation enhanced the milk fat production (P<0.05), but did not alter the fat content. Milk fat production was higher on treatment group (0.50 vas 0.30 kg/head/day), which was a result of higher dry matter and crude fiber consumptions. The milk fat content is a result of nutrient absorption both in rumen and small intestine. In the rumen, crude fiber is converted into VFA which then absorbed via rumen epithelium. Meanwhile, they product of fat metabolism are absorbed by villus of the intestine to the blood circulation. Crude fiber and fat consumption on treatment group was higher compared to control group which lead to significantly affect the milk fat production. Leondro *et al*. (2019) the milk fat production is heavily determined by the short chain fatty acid availability (C2 to C14, C16, and C18). The forage:concentrate ratio determined the availability of short-chain fatty acids. Greater forage consumption that contains crude fiber leads to higher milk fat content.

Andriawan *et al*. (2014) stated that crude fiber intake vitally contributes on fat milk synthesis. Crude fibers (cellulose and hemicellulose) are converted into cellobiose, glucose, and pentose that can be further converted into VFA (acetic acid, propionic acid, and butyric acid). VFA is eventually transformed into milk fat.

Blood Urea Nitrogen

The result of the study presented on Table 5 demonstrates that supplementation did not alter the blood urea level of the cows (P>0.05). However, the level of blood urea nitrogen of the cows are in a normal range, indicating efficient nitrogen utilization. The normal range of blood urea nitrogen of Friesian Holstein cows is 6 to 27 mg/dL (Mitruka, 1981). Blood Urea nitrogen is a final product from nitrogen metabolism by ruminants. Blood urea nitrogen are widely used as indicator of nitrogen utilization, in which high levels reflects inefficiency on the nitrogen utilization (Nousiainen *et al*., 2004). Urea is formed in liver from protein and amino acid catabolism. The excretion of protein/amino acids metabolism product is depended on kidneys. The blood BUN level reflects the balance of production and excretion (Kusumawati and Sardjana, 2006).

Blood glucose

The result of the study presented on Table 6 shows that cassava pomace and protected soybean meal supplementation did not significantly affect blood glucose level at either the beginning or the endo of the study (63.5 vs 62.08; 62.58 vs 62.83 mg/dL; control vs treatment, the beginning and the end of the study). This finding might be caused by the balanced amount of glucose that in and out under normal physiological condition, which is supported by Amirifard *et al*. (2016) who reported that blood glucose level of lactating cows were 67.40 mg/dL (prepartum) and 62.61 mg/dL (postpartum). Moreover, Arora (1989) stated that blood glucose level is maintained through endogenous synthesis for

Table 5. Average blood urea nitrogen

Parameter	Control (mg/dL)	Treatment (mg/dL)
Initial (first week of treatment)[ns]	9.68±1.37	10.18±1.76
End (last week of treatment)[ns]	9.30±1.37	9.75±0.92

ns : nonsignificant (P>0.05);
* : significant (P<0.05).

Table 6. Average blood glucose level

Parameter	Control (mg/dL)	Treatment (mg/dL)
Initial (first week of treatment)^{ns}	63.5±2.25	62.08±2.08
End (last week of treatment)^{ns}	62.58±1.59	62.83±3.18

ns : non significant (P>0.05);
* : significant (P<0.05).

delivering essential body functions. Glucose is required to maintain cell, serve as acetate precursor on fat synthesis, hepatic and adipose fat synthesis through hexose monophosphate cycle outside mitochondria, synthesize glycerol, and serve as citrate precursor on milk. Bondi (1987) stated that high energy consumption increases the blood glucose level. Ganong (1980) stated that the blood glucose balance has a unique dynamic and always in a constant balance under normal physiological condition. The blood glucose level is determined by the number of intake and excreted glucose Factors determining the glucose level includes feed intake, the absorption rate, adipose tissue and other organs, and hepatic glucostatic activity.

Conclusions

Supplementing mid-lactating dairy cows with cassava pomace and protected soybean meal increased nutrient intake, milk production, milk protein and fat production. However, it did not alter milk protein and fat content, blood glucose level, and blood urea nitrogen level.

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