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Research Article

Nutrient Utilization and Milk Yield of Dairy Cows Fed a Diet Containing Monensin, Garlic Peel and Organic Minerals During the Lactation Period

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Abstract | The objective of this research was to determine nutrient intake, nutrient digestibility, milk yield, and milk quality of dairy cows that consumed feed supplemented with monensin, garlic peel (*Allium sativum*), and organic minerals. Twenty-one Friesian Holstein dairy cows with 644±72 kg body weight received dietary treatments consisting of: T0: basal feed + 0.3 g/d monensin; T1: basal feed + 30 ppm garlic-peel powder; and T2: basal feed + 30 ppm garlic peel powder + organic minerals (1.5 ppm Cr, 0.3 ppm Se, and 40 ppm Zn-lysinate). Allocation of dietary treatments followed a completely randomized design with seven replicates per treatment. Results showed that supplementation with monensin, garlic peel, and organic mineral did not significantly affect nutrient intake (DM, OM, CF, CP, NDF, ADF, TDN), nutrient digestibility (DM, OM, CF, NDF, ADF, TDN), milk yield, or milk quality. However, treatment significantly decreased crude protein digestibility ($P<0.01$). The conclusion was that supplementation with garlic peel can replace monensin in feed for dairy cattle.

Keywords | Monensin, Garlic peel, Organic minerals, Nutrients, Dairy cattle

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INTRODUCTION

Increasing the efficiency of ruminal fermentation is one of the goals of ruminant nutrition. Energy loss during ruminal fermentation accounts for 6–10% of gross energy intake due to the formation of methane from hydrogen and CO_2 by methanogens (Cottle et al., 2011). Such energy loss should be minimized in order to enhance rumen fermentation efficiency. For decades, monensin (an ionophore antibiotic) has been used for ketosis prevention and for increasing production in dairy cows. Monensin improves feed digestibility, shifts the volatile fatty acid (VFA) profile toward propionate at the expense of acetate, decreases methanogenesis, decreases amino-acid fermentation and ruminal ammonia concentration, increases hepatic gluconeogenesis, and increases energy supply to the animal (Azzaz et al., 2015). However, since monensin use may leave residues in meat and dairy products, some researchers have suggested the use of herbal supplements, one of which is garlic, as alternatives to enhance ruminal fermentation efficiency (Jayanegara and Palupi, 2010; Wanapat et al., 2013). Garlic had been shown to modify microbial population structure in the rumen by reducing the population of gram-positive *Prevotella* sp., a bacteria species that plays a role in protein degradation and amino-acid deamination (Wang et al., 2016).

Other inputs that may be used to enhance the efficiency of ruminal fermentation are minerals, particularly trace elements. Some trace elements are able to modify VFA and ammonia concentrations in the rumen by serving as activators for enzymes related to carbohydrate and protein degradation and fermentation (Prayitno et al., 2013). For example, selenium has been reported to positively affect the ruminal environment, increase total VFA production, and stimulate the growth of rumen microbes (Kišidayová et al., 2014). Trace elements also influence the metabolic efficiency of ruminants. Despite these findings, there have been limited studies of the combining of garlic and trace-element supplementation. The objective of this study, therefore, was to evaluate the effects of combined garlic peel and organic mineral supplements on nutrient intake, nutrient digestibility, milk production, and milk quality in lactating dairy cows. Monensin was used as an additive in the control diet since the combination of garlic peel and organic minerals was intended to replace an ionophore of this type.

MATERIALS AND METHODS

Experimental Procedure

This experiment was approved by the Faculty of Animal Science, Jenderal Soedirman University, Indonesia. The study used 21 Friesian Holstein dairy cows with 644±72 kg body weight. The cows were kept in individual cages and fed with total mixed rations that consisted of grass and concentrate with a 70:30 ratio as the basal feed (containing 63.9% total digestible nutrient and 12.85% crude protein). The study treatments consisted of T0: basal feed + 0.3 g/d monensin; T1: basal feed + 30 ppm garlic-peel powder; and T2: basal feed + 30 ppm garlic-peel powder + organic minerals (1.5 ppm Cr, 0.3 ppm Se, and 40 ppm Zn-lysinate). Treatments started at 30days pre-partum. Feed was offered twice a day, at 6 a.m. and 1p.m. Feed and feces were collected using a total collection method for five days, oven-dried at 60°C for 48h, then composited and ground for further analysis. Milk yield was collected at 5 a.m.and3p.m. and was recorded daily during the six-week post-partum period. Milk was weighed, sampled, and composited for composition analysis, using Lactoscan type Z435,to obtain milk fat, protein, lactose, solid non-fat, and density data.

Data Analysis

Data were analyzed using analysis of variance (ANOVA) for the three dietary treatments and seven replicates, according to a completely randomized design. When a parameter showed a significance effect at $P<0.05$, a post-hoc test, namely Duncan's multiple range test, was applied to the data in order to compare the means for the different treatments.

RESULTS AND DISCUSSION

Feed Intake

The dietary treatments did not affect intake of DM, OM, crude fat, CP, CF, energy, NDF, or ADF) (Table 1). This may indicate that supplementation with monensin, garlic peel, orgarlic peel plus organic minerals did not affect the ruminal ecosystem. A similar finding is reported by Wanapat et al. (2013), who found that herbal supplementation did not affect DM intake or nutrient digestibility, except for crude protein. Yang et al. (2007) state that dairy cattle fed with essential oil or garlic oil did not demonstrate different dry matter intake. Odongo et al. (2007) also mention that there was no difference in intake between feed supplemented with monensin and a control, because the nutrient composition did not change.

Table 1: Nutrient intake (kg/d) of dairy cows across dietary treatments

Intake	T0	T1	T2
Dry matter	10.13±1.77	9.76±1.84	9.34±0.44
Organic matter	8.15±1.4	7.88±1.46	7.50±0.37
Crude fat	0.20±0.04	0.19±0.04	0.19±0.01
Crude protein	1.35±0.22	1.42±0.31	1.29±0.02
Crude fiber	2.37±0.47	2.35±0.35	2.13±0.17
Energy (Mcal/kg DM)	32.7±5.81	29.6±4.33	28.7±4.24
NDF	6.73±1.21	6.75±0.72	6.07±0.44
ADF	2.98±0.60	2.96±0.47	2.67±0.23

T0: basal feed + 0.3 g/d monensin;T1: basal feed + 30 ppm garlic-peel powder;and T2: basal feed + 30 ppm garlic-peel powder + organic minerals (1.5 ppm Cr, 0.3 ppm Se, and 40 ppm Zn-lysinate).

Feed intake in dairy cattle is correlated with NDF and the digestibility of forage (Laconi and Jayanegara, 2015). Riaz et al. (2014) state that NDF was negatively correlated with feed intake. Osborne et al. (2004) state that monensin supplementation increased NDF intake or digestibility. However, some studies report non-significant effects or even a decrease from monensin supplementation, assumed tobe due to different supplementation levels (Broderick and Radloff, 2004) and forage: concentrate ratios or different lactation period (Plaizier et al., 2000). Plaizier et al. (2000) report that ionophores such as Rumensin or monensin increased NDF and ADF digestibility in forage-rich feed but did not significantly affect it in concentrate-rich feed, because NDF and ADF level in the forage was higher.

Nutrient Digestibility

Supplementation with monensin, garlic peel, and garlic plus minerals (Cr, Se, and Zn-lysinate) did not significantly affect nutrient digestibility except for crude protein digestibility (Table 2). This may indicate that monensin, garlic peel and garlic plus minerals played equivalent roles in ruminal ecosystems, although via different mechanisms. Moumen et al. (2016) state that ionophores such as monensin lowered acetate proportion and increased propionate in the rumen, thereby decreasing methane emission. The decreased acetate indicated a decrease in fibrolytic bacteria that impacted on fiber digestibility in the rumen (Rira et al., 2016). The function of monensin is to minimize ion transfer through the cell membrane. Gram-negative bacteria (starch-fermenting bacteria) are more resistant to monensin than gram-positive bacteria (fiber-degrading bacteria) (Azzaz et al., 2015). Decrease in fiber digestibility will decrease hydrogen production, which in turn will suppress rumen degradability (Jayanegara et al., 2016). This finding is in line with another study which suggests that hydrogen accumulation obstructs degradability in the rumen (Olijhoek et al., 2016). Apparently, monensin increases the ability of lactate-utilizing bacteria to convert hydrogen into propionate as well as the bioactive compounds present in garlic.

Table 2: Nutrient digestibility (%) of dairy cows across dietary treatments

Digestibility	T0	T1	T2
Dry matter	73.6±4.26	73.6±9.05	71.2±7.30
Organic matter	76.1±2.87	76.8±8.37	73.1±7.01
Crude fat	77.3±10.3	73.0±22.2	74.5±11.6
Crude protein	92.7±2.68[c]	79.5±6.7[a]	81.7±6.63[ab]
Crude fiber	69.7±4.80	68.5±9.01	64.8±10.4
NDF	77.7±2.89	76.1±8.01	73.5±7.13
ADF	63.3±5.10	64.4±8.56	61.3±7.70
Energy	72.5±5.99	65.3±5.38	69.2±4.57

Different superscripts within the same row are significantly different at P<0.05.
T0: basal feed + 0.3 g/d monensin; T1: basal feed + 30 ppm garlic-peel powder; and T2: basal feed + 30 ppm garlic-peel powder + organic minerals (1.5 ppm Cr, 0.3 ppm Se, and 40 ppm Zn-lysinate).

Garlic modifies the microbial population profile in the rumen and reduces the contribution of gram-positive *Prevotella* sp. (*P. ruminantium* and *P. bryantii* in particular) while maintaining normal conditions. *Prevotella* sp. is a bacteria species that plays a role in protein degradation and amino-acid deamination. The deamination process might correlate with the limited supply of hydrogen, and since hydrogen is a prominent substance in methane formation, decreasing methane production will likely decrease dry matter intake and nutrient digestibility (Mills et al., 2003). The decreasing protein degradation resulting from garlic or garlic plus organic mineral supplementation indicates that protein is mostly absorbed in the small intestine. This is in accordance with the findings of Wanapat et al. (2013) and Prayitno et al. (2013), which suggest that garlic supplementation lowers crude protein digestibility. On the other hand, *Selenomonas ruminantium* is a gram-negative bacteria that can harness lactate as a source of energy. This bacteria is also part of the key pathway to succinate-propionate production for stimulating increasing concentration of propionate (McAllister et al., 2011; Meissner et al., 2010).

Table 3: Milk yield and milk composition across dietary treatments

Parameter	T0	T1	T2
Milk yield (kg, 4% FCM)	20.7±4.48	21.4±11.9	16.1±3.37
Milk component (%)			
- Fat	4.81±0.80	4.90±0.32	4.96±0.56
- Protein	3.34±0.11	3.20±0.10	3.46±0.17
- Lactose	5.02±0.17	5.13±0.15	5.19±0.26
- Solid non-fat	9.13±0.31	9.36±3.61	9.17±0.14
Total solid	13.9±1.02	14.3±0.46	14.1±0.76
Production (g/d)			
- Fat	1,015±331	1,073±676	814±272
- Protein	1,893±438	2,227±1,185	1,447±127
-Lactose	1,041±241	1,093±597	831±134
-Solid non-fat	1,893±438	2,000±1,185	1,447±127
Total solid	2,884±211	3,047±98	2,278±123

T0: basal feed + 0.3 g/d monensin;T1: basal feed + 30 ppm garlic-peel powder;and T2: basal feed + 30 ppm garlic-peel powder + organic minerals (1.5 ppm Cr, 0.3 ppm Se, and 40 ppm Zn-lysinate).

Milk Production and Quality

Dietary treatments did not significantly affect milk production and quality (Table 3). Mineral supplements along with garlic peel did not increase milk yield, and this is assumed to be the result of antagonistic effects of the combined ingredients. This result was in contrast to our previous study, which found that garlic plus organic minerals increased milk yield by up to 30% (Prayitno et al., 2013). Furthermore, monensin supplementation did not improve milk yield as mentioned by Odongo et al. (2007), in that the milk yield of dairy cattle fed with 24 mg/kg DM monensin was similar to that of the control (19.7 vs 19.1 kg/d). Milk production and quality are affected by the nutrient content of feed. However, dietary treatments did not significantly affect milk production and quality in this study, because of the equal performance of monensin and garlic peel in reducing acetate and increasing propionate. Busquet et al. (2006) report that 300 mg/l of garlic oil in ruminal fluid: buffer mixture was effective in lowering acetate and increasing propionate as compared to yucca extract, tea tree oil, and cinnamaldehyde. Ionophores such as monensin may lower acetate proportion and increase propionate in the same way as garlic, leading to methane decrease (Azzaz et al., 2015). Acetate decrease may lower milk fat but increase milk lactose and therefore milk quality remains the same. Duplessis et al. (2017) report that the milk yield of dairy cattle was significantly affected by the amount of glucose which can be produced from propionate in the rumen. Acetate and β-hydroxybutyrate are harnessed in the formation of fatty acids attached to glycerol to form milk fat. Acetate is crucial for dairy cattle because it is used in the rumen as an energy source (Urrutia and Harvatine, 2017). Acetate which is synthesized into oxaloacetic acid enters the lipid cycle along with triglycerides and fatty acids. Glycerol is used as an energy source (Syahniar et al., 2016) while acetate becomes a short chain fatty acid and undergoes glycolysis into ATP with glucose.

The mechanism of propionate conversion into lactose is affected by minerals, particularly Cr and Se. Cris a trace mineral that performs physiologically in glucose metabolism by increasing the insulin activity potential (Leiva et al., 2015).The optimum performance of secretory cells for normal function needs to be maintained by supplementing with selenium. As the physiological form of selenium, glutathione protects membrane cells and sub-cells against oxidative damage, including in the secretory cells of mammary glands (Miranda et al., 2011). Propionic acid undergoes gluconeogenes is in the liver, and this produces glucose that is carried by the blood to the secretory cells of udder glands to be used for milk lactose synthesis (Udén and Danfaer, 2008). A high ratio of propionate to acetate will increase lactose production. Lactose synthesis commences with one glucose molecule ina pair of glucose molecules entering the udder being converted into galactose. Galactose is then condensed with glucose to form lactose by the action of lactose synthetase enzyme (Udén and Danfaer, 2008).

CONCLUSION

Supplementation with monensin, garlic peel, and organic minerals did not affect nutrient intake (DM,OM,CP,CF, energy, NDF, and ADF), nutrient digestibility (DM,OM,CF, energy, NDF, and ADF), milk production, or milk quality of lactating dairy cows. However, supplementation with garlic peel and garlic peel plus organic minerals decreased the digestibility of crude protein. Supplementation of garlic peel can therefore replace monensin in the feed of dairy cattle.

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CONFLICT OF INTEREST

All authors declare that there is no conflict of interest.

AUTHORS CONTRIBUTION

CHP designed and performed the experiment, and wrote the first draft of the manuscript; YS conducted data and statistical analyses, and revised the manuscript; AJ reviewed data analysis and revised the manuscript.

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