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Short and Medium-chain Fatty Acid Profile of Goat Milk Fed with Pineapple Peel Silage

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ABSTRACT

This study aims to determine the profile of short-chain fatty acids (SCFA) and medium-chain fatty acids (MCFA) in goat milk-fed pineapple peel silage. The pineapple waste was milled and mixed with 5% (w/w) of rice brand, put into an anaerobic plastic bag, and stored for 21 days to produce pineapple peel silage. The materials used in this research were 12 female Etawa cross-breed dairy goats allocated into randomized block designs with four kinds of feed treatments and three groups of lactation periods. The feed treatments were P1 (60% forage + 40% concentrate); P2 (30% forage + 30% pineapple peel silage + 40% concentrate); P3 (15% forage + 45% pineapple peel silage + 40% concentrate); P4 (60% pineapple peel silage + 40% concentrate). Forage contains native grass and rubber leaves. The concentrate consists of 58% bran, 25% fine corn, 6% soybean meal, 9% coconut meal, 1% mineral mixture, and 1% salt. The variables observed were feed consumption, fat milk, and short-chain and medium-chain milk fatty acids. The data obtained were analyzed using ANOVA, and if there were differences between treatments, a Duncan test. The result of this study showed that the use of pineapple peel silage as a forage source had affected the feed consumption ($P<0.05$) but did not significantly affect SCFA acid and MCFA profile ($P> 0.05$) in goat milk. Using pineapple peel silage as forage replacement up to 45 % in Fed, the dairy Ettawa cross-breed (EC) goat's diet significantly affects the short-chain and medium-chain fatty acids profile. The content of short-chain fatty acids and medium-chain fatty acids in goat's milk decreases, and there is no musty smell due to the addition of pineapple peel silage in the feed.

Keywords: fatty acid, goat milk, pineapple peel silage

INTRODUCTION

Goat's milk is a nutritional source, is rich in protein, fat, and vitamins, and is easy to digest compared to cow's milk. Various factors, including genetics, feed management, and the environment, can influence goat milk quality. One type of goat popular in Indonesia is the Ettawa cross-breed (EC) goat, which is known to produce good milk and has high nutritional quality, especially its fatty acid composition. Various factors, including the type of feed given, can influence the fatty acid profile of goat's milk. The composition of EC dairy goat milk fed with pineapple peel flour and probiotics was protein 3.6-3.9%, fat 3.7 - 4.2%, total solids 12.4 - 12.6%, lactose 2.6 - 3.3%, total saturated fatty acids 35.2 - 48.3%, total unsaturated fatty acids 22.2 - 30.1% (Raguati, 2016). Milk EC goats' average protein levels were 3.48 – 3.78%, fat 3.04 – 4.73%, and lactose 3.29 – 3.70% (Maulidya et al., 2023). The composition of goat milk varies, influenced by nation (type), milk production, level of lactation, quality, and quantity of nutrients feed (Stergiadiss et al., 2019; Kuswanto et al., 2022).

Goat milk contains lower concentrations of C12:0, C14:0, C16:0, and Na: K ratio and higher concentrations of polyunsaturated fatty acids (PUFA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) (Stergiadiss et al., 2019). Yakan et al. (2019) asserted that changes in the composition of goat milk fatty acids depend on the feeding system, concentration, and different lactation stages. The feed highly affects the fatty acids of milk (Kuswanto et al., 2022; Mollica et al., 2021; Salama et al., 2020; Juráček et al., 2020; Djordjevic et al., 2019).

Agricultural waste that has the potential as a substitute for forage feed is pineapple waste. In 2023, the pineapple yield in Indonesia reached 3156576 tons (BPS, 2024). BPS (2024) reported that the pineapple crops in Jambi Province in 2023 reached 32756 tons. Products from the pineapple industry are by-products, such as peel, crown, core, stem, and leaf. Pineapple waste has been used as animal feed (Raguati, 2016; Roda and Lambri, 2019). Bacillus pumilus St. L1 from pineapple peel is a probiotic (Raguati et al., 2015). Since the pineapple waste contains much water and is easily rotten, the waste is processed into silage. Ensiling has been considered for more extended storage of those materials. Ensiling pineapple waste improves the economics of feeding and overcoming the disposal problem (Gowda et al., 2015). Pineapple waste silage

(PWS) could be used as the source of roughage replaced in NGS in Myanmar's local cattle productive performances (Kyawt et al., 2020). This experiment utilized pineapple peel silage for EC.

Fatty acids, especially short-chain fatty acids (SCFA) and medium-chain fatty acids (MCFA), have important roles in health and nutrition. SCFAs, such as acetic, propionic, and butyric acids, are produced through fiber fermentation in the rumen and can contribute to digestive health, nutrient absorption, and metabolic regulation. MCFA, on the other hand, has antimicrobial properties and can improve digestibility and support the growth of beneficial microbes in the digestive tract. fatty acids (FA) (as butyric acid and conjugated linoleic acid (CLA), among others), phospholipids, and sphingolipids from milk globule membranes are potential anticarcinogenic agents (Alcala et al., 2017). Caprylic acid, caproic acid, and capric acid are natural saturated fatty acids in the milk of various mammals (Akgül et al., 2020).

This study aims to evaluate the effect of feeding pineapple peel silage on the profile of short-chain and medium-chain fatty acids in EC goat milk. It is hoped that the results of this research will provide useful information in developing a more efficient and sustainable feeding system and improving the quality of EC goat milk, which in turn can support increasing the productivity of goat farming in Indonesia.

MATERIALS AND METHODS

This research was at the Guyub farmer group, Pondok Meja Village, Muaro Jambi Regency. Milk fatty acids were analyzed with a GC instrument in the Central Chemistry Laboratory, IPB, Bogor.

The material used was 12 EC goats that were lactating (first lactation, second lactation, third lactation) and had a body weight of 25 kg. The tools used consist of feed containers, drinking containers, grinding machines, scales, incandescent lamps, ovens, electric scales, grinders, label paper, plastic, milk containers, filters, Erlemeyers, and measuring cups for milk sample bottles. Milk Analysis: Milk analysis using gas chromatography.

The treated feed consists of forage (native grass and rubber leaves), pineapple peel silage, and a concentrate of 58% rise bran, 25% fine corn, 6% soybean meal, 9% coconut meal, 1% mineral mix, and 1% salt (Raguati, 2016). The feed is prepared with the benchmark requirement of 14.5% protein and 65% TDN. The amount of ration given is calculated based on the standard dry matter requirement of 4% of body weight.

Research Methods

This study employed a randomized block design of four treatments and three groups (lactating period). The treatment was composed of (a) P1: (60% forage + 40% concentrate); (b) P2: (45% forage + 15% pineapple peel silage) + 40% concentrate; (c) P3: (30% forage + 30% pineapple peel silage) + 40% concentrate; and (d) P4: (0% forage + 60% pineapple peel silage) + 40% concentrate.

Research Variables

The variables measured in this research are the consumption of dry matter, fat, short-chain fatty acids, and medium-chain fatty acids in the milk of EC. Milk fatty acids were analyzed with a GC instrument in the Central Chemistry Laboratory, IPB, Bogor. Were tested with AOAC (2012). The Composition of Treated Feed is in Table 1.

Table 1. The Composition of Treated Feed (%)

Feed	P1	P2	P3	P4	Forage	PPS	Concentrate
DM	90.22	88.29	86.63	83.31	90.47	79.40	89.18
CP	14.58	13.17	11.77	8.96	15.94	6.58	12.55
Fat	3.56	3.78	3.69	3.84	3.25	3.73	4.03
CF	20.46	15.66	14.4	13.8	25.52	17.14	12.89
Ash	7.06	6.97	6.9	6.74	6.50	5.98	7.92
EMWN	56.09	56.90	64.48	64.48	51.76	79.07	62.58
TDN	65.54	65.54	66.49	66.49	62.25	72.08	70.48

P1 (60% forage + 40% concentrate); P2 (30% forage + 30% pineapple peel silage + 40% concentrate); P3 (15% forage + 45% pineapple peel silage + 40% concentrate); P4 (60% pineapple peel silage + 40% concentrate). DM; dry matter, CP: crude protein, CF: crude fiber, EMWN: extract material without nitrogen, TDN: total digestible energy, PPS: pineapple peel silage.

Data Analysis

The information collected was analyzed using variance based on a randomized block design. The effect of experimental rations on the measured parameters was analyzed using variance analysis. Differences between treatments were measured using Duncan's multiple-range test (Steel and Torrie, 1991).

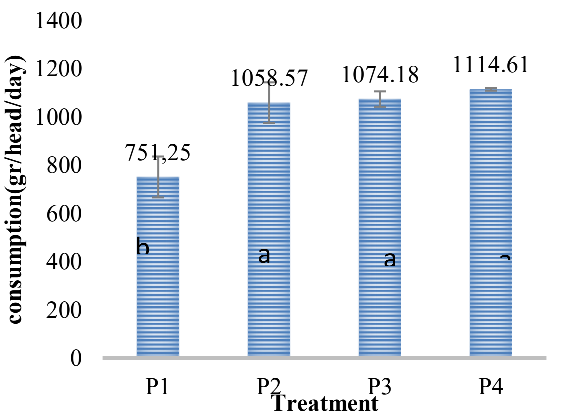
Procedure for Making Pineapple Peel Silage

The pineapple peel that has been collected is chopped and then added with bran as much as 5% of the amount of pineapple skin, put in a plastic bag, compacted and tied, and left for a week. Before being given to livestock, first dry it in the sun.

RESULTS AND DISCUSSION

Effect of Treatment on Feed Consumption DM

High feed consumption has a positive effect on milk production as well as the quality of the milk produced. Factors that influence the level of feed consumption are palatability, digestibility, retention time, crude protein content, organic matter content, and the physiological condition of the livestock. The effect of the treatment on the feed consumption of the research fodder substances is shown in Figure 1.



P1 (60% forage + 40% concentrate); P2 (30% forage + 30% pineapple peel silage + 40% concentrate); P3 (15% forage + 45% pineapple peel silage + 40% concentrate); P4 (60% pineapple peel silage + 40% concentrate).

Figure 1. The feed consumption of EC goats treated with pineapple peel silage (g DM/head/day).

The analysis of variance showed that the treatment had a significant effect ($P < 0.05$) on the feed consumption DM of CE goats. The goats fed without silage (P1) had a lower feed consumption than those fed with pineapple waste silage (P2, P3, P4). It indicates that animal rations containing pineapple peel silage (PPS) can increase feed consumption compared to those without PPS. Silage feed can increase feed dry matter consumption, milk composition, and milk fatty acids. Goats are a type of livestock that has the habit of choosing the food to consume. Olfactory stimuli (sense of smell) are significant for ruminant animals when consuming feeds (Kyawt et al., 2020).

The degree of feed consumption was also affected by the rate of feed digestion and depended on the body weight of the goats. Feed ingredients containing high crude fiber can affect fiber digestibility due to a negative correlation between the digestibility of crude fiber and that of organic matter. Indigestible crude fiber can inhibit rumen microbial activity and prevent digestive enzyme activities of digesting food nutrients. The high fiber in feed causes digestion time so long that it will affect the digestion rate and reduce feed consumption (Salama et al., 2020; Hamzaoui et al., 2021). Average feed consumption ranges from 751.25 - 1114.61 grams/head/day. This result is higher than the results of Raguati (2016) in which the feed consumption DM of PE goats fed with pineapple peel and probiotics gained from pineapple waste varied from 393.952 to 442.425 grams/head/day.

The treatment of replacing pineapple peel silage (PPS) in forages for 15 – 60 % of the ration did not show a significant difference ($P > 0.05$) in feed consumption. Feed consumption tends to increase when the amount of PPS in the diet increases. Since the treatments used PPS, contained a similar amount of crude fiber, the feed consumption level was not significantly different. High feed consumption affects milk production and milk quality, such as fat and fatty acid. Substitution of corn silage (CS) with cactus-alfalfa mixed silage (CABS) affects feed consumption, milk production, and composition (Ravari et al., 2022).

Short-Chain and Medium-Chain Milk Fatty Acid Profile

The Fatty acids in milk are important determinants of milk quality. The milk fat of goats contains short-chain fatty acids (SCFA) and medium-chain fatty acids (MCFA) which are synthesized in the mammary gland. Tuminah (2009) pointed out that Saturated Acid fingers based on the length of the carbon chain were divided into 3 types; short-chain fatty acid (C2 - C6), medium-chain fatty acids (C8 - C12), and long-chain fatty acid (C14 – C24). Short-chain and medium-chain fatty acids in goat milk were assumed to make the milk easily digestible and create a distinctive taste and smell. Caprylic, caproic acid and capric acid were Saturated fatty acids (SFAs). Caprylic acid, caproic acid, and capric acid are natural saturated fatty acids in the milk of various mammals (Akgül et al., 2020). The profile of milk fatty acids produced from the provision of pineapple peel silage as a replacement for forage in the ration can be seen in Table 2.

Table 2. The fatty acids profile of goat milk fed with a ration of pineapple peel silage (%)

Types of fatty acids	Treatment				SE	P value
	P1	P2	P3	P4		
Caproic Acid C6:0	1.47	1.36	1.47	1.42	0.112	0.8867
Caprilic Acid, C8:0	1.81	1.68	1.97	1.83	0.138	0.5456
Capric Acid, C10:0	6.21	5.64	6.88	6.41	0.514	0.4376
Undecanioc Acid, C11:0	0.04	0.03	0.07	0.04	0.015	0.4530
Fat	4.93	3.37	3.41	4.24	0.849	0.5497

P1 (60% forage + 40% concentrate); P2 (30% forage + 30% pineapple peel silage + 40% concentrate); P3 (15% forage + 45% pineapple peel silage + 40% concentrate); P4 (60% pineapple peel silage + 40% concentrate).

The analysis of variance showed that the treatment had no significant effect (P> 0.05) on fat and fatty acids such as caproid acid, caprilic, capric, and decanoic Acid. It indicates that neither the rations containing the PPS up to 45% as forage replacement nor those without the PPS have a significant positive effect on the fatty acid value of EC goat milk. Good quality pineapple peel silage (Table 1.), which supports rumen digestion, resulting in changes in the fatty acid profile of milk. The concentration of caproic, caprylic, and capric fatty acids in goat and sheep milk is higher than in cow's milk (Djordjevic et al., 2019). Goat milk is widely used as bath soap to keep the body healthy. Goat milk cosmetics are beneficial for maintaining healthy skin and are effective in various skin diseases (Voloshyna et al., 2021). Short-chain and medium-chain fatty acids in the human digestive system are absorbed through the intestinal wall without undergoing hydrolysis and enzymatic processes. Then the acids are metabolized in the liver where these acids are only processed to produce energy, not cholesterol or adipose tissue.

The average fatty acids in this study were 1.68 - 1.97 % of caprilic acid, 5.64 - 6.88 % of caproid acid, and 0.03 - 0.07% of undecanoic acid. Goat milk contains more volatile fatty acids than cow's milk, which causes the aroma of goat's milk to be spicier. The higher the use of pineapple peel silage, the lower the value of short-chain and medium-chain fatty acids in Etawah cross-breed (CE) goat milk. The average was less than 11%. The low levels of short-chain and medium-chain fatty acids found in this research cause the texture of the milk to become softer and more fragrant. The fatty acids of caprilic and lauric contributed to the goaty aroma and taste of goat's milk. Short-chain fatty acids in livestock products, such as goat milk, were the metabolic output of volatile fatty acids (VFA) which took elongation or the addition of carbon atoms in the fatty acid chain in the liver (Tasse and Aka, 2013). In udder epithelial cells, acetic and butyric acids are converted into short-chain fatty acid. Acetic acid, butyric, fatty acids, and glycerol are beneficial for synthesizing milk fat. Short-chain fatty acids (C4 and C6) in goat milk rely on the chemical composition of the forage.

In this study, the pungent smell of goat milk was enervated, and it seemed like the smell of cow's milk due to the low level of caproic acid in the milk which was 1.36 - 1.47% on average. Using pineapple peel silage in feed can reduce the pungent odor in goat's milk due to decreased levels of caproic acid. The content of milk caproid acid from goats fed with elephant grass and natural grass was 3.02% and 3.34% (Tasse and Aka, 2013). The major difference in fat between goat's milk and cow's milk was the percentage of specific short-chain and medium-chain fatty acids, such as fatty caproic acid (C6), caprylate (C8), and caproid (C10). Those acids in goat's milk were higher than those in cow's milk. Medium Chain Triglyceride (MCT)is more in goat's milk. MCT can also inhibit or limit cholesterol deposition, dissolve cholesterol gallstones, and contribute to the normal growth of babies (Getaneh et al., 2016). Some fatty acids are more prevalent in specific species of ruminants. Such is the case of caproic acid (6:0), caprylic acid (8:0), and capric acid (10:0) milk goat, due to their characteristic smell. Cheeses made with cow milk have a lower content of these fatty acids than those made with either sheep or goat milk (Vieitez et al., 2016). Few differences in components of nutrient milk among ruminant species exist, proteins, liposoluble vitamins, and phospholipids of the milk fat globule (MFG), in addition to the triacylglycerols (TAG), which are the major constituents of the MFG core (Bernard et al., 2018). These three saturated fatty acids (C6, C8, and C10) had similar biological effects and antiviral activity. Caprylic acids were reported to have antitumor activity in mice and had a neutral saturated fatty acid. Fatty acids (FA) (as butyric acid and conjugated linoleic acid (CLA), among others), phospholipids, and sphingolipids from milk globule membranes are potential anticarcinogenic agents (Alcala et al., 2017).

CONCLUSION

Using pineapple peel silage as forage replacement for up to 45 % of Fed dairy cross-breed Etawah goats' diet significantly affects the short-chain and medium-chain fatty acid profiles. The content of short-chain fatty acids and medium-chain fatty acids in goat's milk decreases, and there is no prengus smell due to the addition of pineapple peel silage in the feed.

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