In-vivo Test of Calcium Soap from Palm Fatty Acid Distillate (PFAD) in Three Cow Farms

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Abstract. Palm Fatty Acid Distillate (PFAD) is a by-product of Crude Palm Oil (CPO) refinery. As the largest CPO producer, Indonesia exported an abundant amount of PFAD without further processing. The use of calcium soap as a supplement for ruminant feed will increase the productivity of dairy cows in Indonesia. Hence, this study reported in-vivo tests that were conducted to determine the effect of calcium soap supplementation on dairy cows. The result showed that feeding calcium soap to dairy cows could increase productivity and extend the lactation period. The milk quality also improved by the increase of fat content and density which lead to an increase in milk prices. Based on the field observations in three animal husbandries, calcium soap improved the health and fertility of cows.

1. Introduction
As the world's largest producer of palm oil, Indonesia covers 58% of total Crude Palm Oil (CPO) production [1]. The process of refining CPO will produce about 4% of Palm Fatty Acid Distillate (PFAD) [2], most of which are exported abroad without further processing. Following the Indonesian Palm Oil Association (GAPKI), Indonesia produced PFAD at ca. 1 million tons in 2018. One of the promising applications of PFAD is used as the source of calcium soap that could increase the productivity of dairy cows.

Currently, the supply of fresh milk raw materials from local dairy farmers in Indonesia was only able to meet around 23% of the needs of the domestic milk processing industry (852,000 tons per year) [3]. The average production of cow's milk in Indonesia in 2018 was only 17.2 L of milk/cow/day with a production period of 241 days in 1 year [4].

Early in the breastfeeding period, insufficient feed intake to meet energy needs causes the cows to become malnourished. Therefore, dairy cows are forced to use food reserves from the body to support milk production. This often results in metabolic disorders and also leads to low milk acquisition [5]. Fat is an essential source of energy for cows, but fat intake directly to cows can interfere with the degradation of fibers by microbes. Decomposed fat in the rumen is toxic to certain microbes and reduced the microbe population as well as the digestion of cattle in the rumen [6]. This negative effect can be prevented by giving fat in the form of calcium soap. This is because fat does not directly...
decompose in the rumen and will only degrade in the abomasum so that the fatty acids are then absorbed by the small intestine. Therefore, calcium soap is often referred to as the intake of protected fat [7].

The fat content in PFAD could reach 81.7% [8] that makes PFAD can potentially be used as a raw material for the production of calcium soap. Research shows that supplementing calcium soap feed from PFAD to dairy cows will increase total SNF (breastfeeding ability) and total milk production [9]. 500 g of rumen-protected fat (Megalac®) intake could increase milk production by 2.3 liters/cow/day. Moreover, based on research work of a team of University of Florida (USA), Holstein cows, with addition of 450 g of Megalac®/day for 120-days from calving, resulted higher conception and pregnancy rates. Therefore, this study aims to determine the effect of calcium fat produced from PFAD on the quantity and quality of Indonesia dairy cows through in vivo testing in three different cow farms.

2. Materials and Method

2.1. Calcium soap production
The production of calcium soap from PFAD refers to the method previously prepared by Handojo et al. [10]. PFAD was reacted with CaO or Ca(OH)₂ by the modified fusion method to form calcium soap.

2.2. In-vivo test
In-vivo tests were carried out in several cow husbandries in Java, Indonesia, those of: (1) UPTD Balai Pengembangan Ternak Sapi Perah dan Hijauan Pakan Ternak Cikole, Lembang, West Java; (2) CV. Irs Global Perkasa, a local cow farm in Cihideung, Lembang, West Java; and (3) KUD Karangploso, Malang, East Java.

At CV. Irs Global Perkasa, a cow farm owned by local people in Cihideung, Lembang, an in-vivo test was carried out on first time calving cows by giving 600 grams of calcium soap/cow/day for 120 days. Meanwhile, at UPTD Balai Pengembangan Ternak Sapi Perah dan Hijauan Pakan Ternak Cikole, Lembang, in-vivo tests were carried out on second time calving cows with lactation period between 61 to 120 days by giving calcium soap as much as 600 grams/cow/day. Each group consists of two cows with different treatments: (1) addition of calcium soap supplement during feeding and (2) regular feeding without calcium soap addition. At KUD Karangploso, Malang, East Java, around 440 grams of calcium soap/cow was given to 40 cows for 20 days. In contrast to the in-vivo method in West Java, all cows were given calcium soap supplementation to obtain total milk production. The quantity of milk produced by KUD was measured for each cow per day.

In all cow farms, dairy cows were not given calcium soap for a certain amount of time for the conditioning stage. During the evaluation, all cows were given the same feed and changes in milk quality and production could be assumed due to the influence of calcium soap. Milk from cows was then analyzed using a Lactoscan analyzer to obtain the chemical content of milk, such as fat content and total solids. The amount of milk produced every day was also recorded to obtain the production profile.

3. Results and Discussion
Based on Figure 1 and Figure 2, calcium soap supplementation could increase productivity and extend the lactation period of dairy cows owned by both cow farms in Lembang, West Java.
Figure 1. In-vivo test results at cow farm of CV. Irs Global Perkasa in Cihideung, Lembang.

Figure 2. In-vivo test results at Cow Farm of UPTD Balai Pengembangan Ternak Sapi Perah dan Hijauan Pakan Ternak Cikole, Lembang.

Figure 3. In-vivo test results at Cow Farm of KUD Karangploso, Malang.

Figure 1 shows that calcium soap supplementation for 30 days could increase milk production by about 18%, compared with control cows, which only increased by about 3%. Further supplementation, as shown in the curves up to 120 days, could restrain the rate of decline in milk production compared
to controls. Meanwhile, as shown in Figure 2, with the calcium soap supplementation, the rate of decline in milk production was not as sharp as controls. For example, around the dry period, cattle without treatment experienced a decrease in the rate of milk production by 69%, while cattle with calcium soap supplementation only had a decrease in production rate of 3%.

Table 1. The effect of addition of calcium soap on milk quality.

|                  | Average fat content (%) | Average density (g/cm³) | Average milk price (Rp/L) |
|------------------|-------------------------|-------------------------|---------------------------|
| Before           | 4.03                    | 1.0247                  | 5,386                     |
| After 10 days    | 4.04                    | 1.0246                  | 5,374                     |
| After 20 days    | 4.10                    | 1.0250                  | 5,454                     |

Figure 3 shows that intake of 400 grams of calcium soap/cow/day could increase cow's productivity by around 10-14% for 20 days. Furthermore, milk quality improved as indicated by the increase in fat content and average milk density, which then increased the selling price (from Rp 5,386) as shown in Table 1. Sklan et al. [11] found out that more milk and fat were produced by cows, which were given calcium soap supplementation for 60 days. The bypass fat intake of 300 grams/day/cow significantly increased milk production efficiency (30.22%) compared to controls (27.03%) and increased fat corrected milk by 24.01% over controls [12].

PFAD contains 38-45% palmitic acid (C16:0), 37-42% oleic acid (C18:1), 8-10% linoleic acid (C18:2), and 3-5% stearic acid (C18:0) [13]. Since the high content of saturated fatty acids in PFAD, calcium soap made from PFAD did not have a negative effect on digestion in the rumen, intake of calcium soap actually increases the quantity and quality of milk. Saturated fatty acids increased the percentage of milk fat by 5.1%, while unsaturated fatty acids decreased the percentage of milk fat by 8.0% [14]. Intake of BERGAFAT T-30 produced from palm oil (includes approximately 8% oleic acid which softens milk fat and also includes palmitic acid and stearic acid up to 85% with a melting point of 56-60°C) did not show a decrease in feed intake so that supplementation of BERGAFAT T-30 did not affect fermentation in the rumen of cattle [15]. Feeding a palmitic acid-enriched fat supplement (~85% palmitic acid, 2% dry matter) increased the concentration of milk fat from 3.88 to 4.16% and fat yield from 1.23 to 1.32 kg/day compared to cows without supplementation [16].

4. Conclusion
The findings of the current study indicate that supplementation of calcium soap from PFAD increased milk production up to 18% and prolong the milk lactation period of dairy cows. In addition to the quantity of milk, milk quality also increased by the increase of fat content and density which lead to improving milk prices after feeding calcium soap for 20 days.

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