Effects of undegradable dietary protein on milk production and composition of lactating dairy cows

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Abstract. This experiment was conducted in order to evaluate the effect of undegradable dietary protein (UDP) level on milk production and composition of 24 lactating dairy cows. Treatments consisted of T0: control diet without UDP (forage and concentrate were offered in total mixed ration); T1: control diet without UDP (forage and concentrate were offered separately); T2: control diet + UDP 40 gr/L milk + mineral mix; and T3: control diet + UDP 60 gr/L milk + mineral mix. Data were analyzed using analysis of variance (ANOVA) and the differences between treatment means were examined by duncan multiple range test (DMRT). The results showed that UDP supplementation significantly (p<0.05) affected nutrient consumption (dry matter, organic matter, crude protein and total digestible nutrient). In addition, UDP supplementation significantly increased milk production and 4% FCM production (p<0.05). A higher level of milk production and 4% FCM yield in animals fed with T2 and T3. Thus, UDP supplementation may be an alternative supplement for the lactating dairy cows.

1. Introduction
Nutrition management in transition period had received much attention in the dairy research. Transition period is a crucial phase of the dairy animals, due to high demand of nutrient. In this phase, various factors influence the milk production, reproductive performance and economics of dairy production. During transition period, a number of physiological changes and stress related to last trimester fetal growth, parturition and lactation along with dietary change modify the dairy metabolism drastically, causing metabolic, productive and reproductive disorders. To overcome such problems, researchers have tried to use various feed supplements in dairy diet, such as Asparagus racemosus, poly-herbal galactogogue biscuits, sunflower oil and Gambier leaf [1–4], with the aim at improving the productive and reproductive health.

In dairy management, current feeding standards focus on protein sources as nutrient for both rumen microbes and the animal [5]. At early weeks of lactation, cows experience a negative nutrient balances, especially for energy and protein, because nutrient intake is less than required to support the milk production [6]. Cows with protein deficiency will mobilize skeletal muscles and other protein sources, it may ranging from 8 to 21 kg during the 5 to 6 weeks postpartum [7–8].

It has been established that undegradable dietary protein (UDP) can prevent protein degradation in the rumen, so that it can be used directly by animals through absorption in the small intestine. A balanced level of energy and protein sources in the rumen is important to optimize the microbial
protein synthesis and increase the supply of protein to be absorbed in the small intestine. A higher UDP in lactating dairy feed is expected to lead a better milk production and quality, as well as reproductive performance.

Previous studies reported positive milk production responses when dietary Crude Protein (CP) levels increased with rumen undegradable protein (RUP) [9,10]. In addition, [11] reported that increasing dietary CP levels from calving to 150 d after calving increased Dry Matter Intake (DMI) and milk production and reduced BHB concentrations, but it had no effect on non esterified fatty acids (NEFA) concentrations. The aim of this study was to assess the effect of UDP on milk production and milk composition in lactating Friesian Holstein cows.

2. Materials and methods

2.1. Animal, diets and experimental design
This experiment was carried out on a commercial dairy herd at National Livestock Dairy Breeding Center and Forage (BBPTU) Baturaden, Central Java, Indonesia. Twenty-four Holstein cows were used in this study. The animals were selected based on Body Condition Score (BCS), ranging from 2.5 to 3, and body weight, ranging from 550 to 650 kg, and average of milk production (15 L/d). The animals were assigned in a completely randomized design with 4 dietary treatments. The four diets were T0) control diet without UDP (forage and concentrate were offered in total mixed ration), T1) control diet without UDP (forage and concentrate were offered separately), T2) control diet + UDP 40 gr/L milk + mineral mix, and T3) control diet + UDP 60 gr/L milk + mineral mix. Adaptation to the diets was conducted for 2 weeks at 1 month before parturition. Feed intake during 100 days after parturition were evaluated. The diets were given in both forage and concentrates (Table 1). The observed variables were feed intake and nutrient digestibility (dry matter, organic matter, crude protein, crude fiber and total digestible nutrient), milk production, 4% Fat-Corrected Milk (FCM) yield, and milk composition (milk fat, protein, lactose, solid non fat, total solid and density).

Table 1. Ingredient composition of the dietary treatments

| Ingredient, % of DM | T1 % | T2 and T3 % | Proportion |
|---------------------|------|-------------|------------|
| Forage              | 50   | 50          | 50         |
| Concentrate:        |      |             |            |
| Coconat meal        | 20   | 19          | 9.5        |
| Soybean meal        | 12   | 12          | 6          |
| Pollard             | 25   | 25          | 12.5       |
| Corn gluten feed (CGF) | 18  | 17          | 8.5        |
| Corn gluten meal (CGM) | 2   | 2           | 1          |
| Cassava waste pulp  | 21   | 20          | 10         |
| Mineral mix         | 2    | 5           | 2.5        |
| Total               | 100  | 100         | 100        |

2.2. Statistical analysis
Data were analyzed using analysis of variance (ANOVA) and the differences between treatment means were examined by duncan multiple range test (DMRT).

3. Results and discussion

3.1. Dry matter and nutrient intake
Chemical composition of treatment diet is presented in Table 2. The results showed that the levels of CP and TDN among the dietary treatments were relatively balanced. In this study, the dietary treatments were supplemented with protected-protein. This supplementation was aimed to increase milk
production and quality. It was known that protein deficiency in lactating dairy cows decreased in milk production and milk protein content. Dietary supplementation containing balanced energy and protein will optimize the proliferation of rumen microbes and milk synthesis. Addition of rumen undegraded protein in a balanced energy and protein diet will protect the protein from rumen microbes digestion. Thus, the protein will be digested and absorbed in the small intestines of the animals.

**Table 2. Chemical composition of experimental diets based on DM (%)**

| Item (%)                      | Forage | T0     | T1     | T2 and T3 | Undegraded protein |
|-------------------------------|--------|--------|--------|-----------|--------------------|
| Dry matter                   | 15.00  | 19.87  | 88.33  | 88.65     | 83.51              |
| Organic matter               | 83.64  | 88.00  | 92.31  | 89.62     | 92.76              |
| Crude protein                | 15.95  | 13.00  | 20.55  | 20.06     | 29.36              |
| Crude fiber                  | 34.46  | 38.36  | 12.66  | 12.25     | 4.67               |
| Crude fat                    | 2.69   | 1.05   | 3.59   | 3.50      | 1.46               |
| Total digestible nutrient    | 52.20  | 64.13  | 71.85  | 69.69     | 92.87              |

* = TDN was analyzed based on Hartadi et al. [12].

Nutrient consumption of the animals among the dietary treatments is presented in **Table 3**. The results showed that the dietary treatments significantly affect the consumption of dry matter, organic matter, crude protein and total digestible nutrient (p<0.05). The organic matter consumption is in line with DM consumption. A higher consumption of DM will lead to a higher consumption of organic matter. Based on NRC [5], the requirement of DM for producing 10 kg of milk is 12.4 kg. [13] reported that nutrient intake in cattle was influenced by several factors such as the physical and physiological conditions of the animals, feed quality and the environment. Also, [14] explained that DM intake is affected by physiological status of the animals.

**Table 3. Nutrient consumption among the dietary treatments**

| Parameter                      | Treatment | T0     | T1     | T2     | T3     | Significance |
|--------------------------------|-----------|--------|--------|--------|--------|--------------|
| DM (kg/cow/day)                | 11.73±1.77 | 16.54±1.34 | 16.99±1.39 | 17.92±0.67 | *      |
| OM (kg/cow/day)                | 11.21±1.68 | 15.29±1.26 | 15.47±1.29 | 15.68±0.64 | *      |
| CP (kg DM/cow/day)             | 1.66±0.25  | 2.74±0.14  | 2.98±0.21  | 3.12±0.11  | *      |
| CF (kg DM/cow/day)             | 4.89±0.74  | 4.39±0.69  | 4.38±0.60  | 4.38±0.37  | ns     |
| TDN (kg DM/cow/day)            | 7.91±1.20  | 11.56±0.88  | 11.21±0.92  | 11.23±0.45  | *      |

**ab =** different superscript in the same row indicates significant difference (p<0.05).

* = significance difference (p<0.05).

ns = non significance (p>0.05).

As shown in **Table 3**, Cows treated with non-TMR feeding systems (T1, T2 and T3) had higher nutrient consumptions (DM, OM, CP and TDN) compared to animals fed with TMR feeding systems (T0). This was because non TMR had higher feeding frequency (3 times a day) compare to TMR (2 times a day) that affected on feed and nutrient consumption. Although there was a significant differences on nutrient consumptions between T1, T2 and T3, cows fed with UDP supplementation (T2 and T3) had a higher consumption of DM, OM, CP and TDN.

In this present study, the UDP supplementation had a significant effect on TDN consumption. The highest TDN consumption was observed in T1, followed by T3, T2 and T0. [15] reported that a higher level of TDN in diet leads to the increase in the TDN consumption. Furthermore, it was found that TDN consumption is affected by DM intake [16]. The higher level of DM intake will lead to the higher level of TDN intake. [17] reported that the consumption of DM was related to the digestibility.
of DM, OM, CF and CP. However, [18] reported that DM consumption was not affected by CP content in the diet. [16] reported that TDN consumption was influenced by the dietary intake. TDN was related to the supply of energy that is needed by the animals. A higher consumption of TDN provides more energy supply that will be used for the metabolism.

3.2. Milk production and composition

The averages of milk production and composition among the dietary treatments are presented in Table 4. The results showed that the UDP supplementation had significant effects on milk production and 4% FCM yield (p<0.05). A high milk production is an important parameter on the profitability of dairy farm. In this study, it was found that the animals fed with UDP supplementation had a higher levels in milk production and 4% FCM yield. The higher milk production in the groups that received UDP supplementation was due to the effect of higher amount of slowly-degraded feed in the rumen, that resulting more optimal proliferation of rumen microbes. [16] reported that a significant lack of energy in the diet reduce milk production. Furthermore, conversion of 4% FCM yield is strongly influenced by milk production and milk fat content. A balanced diet supplementat can increase milk production because of the availability of precursors for milk synthesis.

| Parameter | Treatment | Significance |
|-----------|-----------|--------------|
| Milk production (kg/cow/day) | T0 | T1 | T2 | T3 | ns |
| Milk fat (%) | 3.78±0.25 | 3.72±0.21 | 3.65±0.14 | 3.63±0.10 | ns |
| Milk protein (%) | 2.63±0.05 | 2.71±0.03 | 2.77±0.02 | 2.81±0.03 | ns |
| Milk lactose (%) | 3.80±0.14 | 3.81±0.33 | 3.81±0.11 | 3.83±0.14 | ns |
| Solid non fat (%) | 7.34±0.53 | 7.45±0.15 | 7.54±0.37 | 7.57±0.15 | ns |
| Total solid (%) | 11.12±0.37 | 11.17±0.23 | 11.20±0.29 | 11.21±0.12 | ns |
| Density | 1.025±0.00 | 1.025±0.00 | 1.024±0.00 | 1.036±0.07 | ns |

* = significance difference (p<0.05).
s = non significance (p>0.05).
ab = different superscript in the same row indicates significant difference (p<0.05).

As it is presented in Table 4, milk production between non-TMR (T1, T2 and T3) and TMR feeding system (T0) was significantly different (p<0.05). By changing in feed management from TMR to non TMR systems, the milk production increased by about 6 to 7 liter. Although there was no significant differences between UDP supplementation (T2 and T3) and non UDP supplementation (T1), animals fed with UDP supplementation (T2 and T3) showed an increase in milk production.

In this study, UDP supplementation did not affect milk composition (p>0.05). This was due to the similar consumption of crude fiber among treatments. The concentration of milk fat depends on the availability of short-chain fatty acids (C2 to C14, C16 and C18), which was determined by the balance composition between forage and concentrate. A higher crude fiber in the diet can increase milk fat. In contrast, animals with a higher intake of concentrate will produce milk with a lower content of fat. In this study, although there was no significant differences in milk composition among dietary treatments, the use of UDP supplementation tended to improve milk quality.

4. Conclusion

It can be concluded that UDP supplementation had significant effects on nutrient consumption (DM, OM, CP and TDN), milk production and production 4% FCM. Thus, UDP supplementation may be an alternative supplement for the lactating dairy cows.
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