

Research Article

Efficacy of *Murraya paniculata* Leaf Flour in Reducing Subclinical Mastitis in Dairy Goats Fed Date Pulp-Based Diets

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Abstract: Subclinical mastitis is a major concern in dairy production, leading to economic losses and antibiotic dependence, which poses risks of milk residue contamination. As a natural alternative, orange jasmine (*Murraya paniculata*) leaves, rich in flavonoids, exhibit antimicrobial and anti-inflammatory properties. This study investigated the effects of incorporating date pulp and orange jasmine leaf flour (OLF) into the diets of lactating Ettawa crossbred goats on lactation performance and subclinical mastitis indicators. A randomized block design with a 2×2+1 factorial arrangement was applied using 15 primiparous lactating goats distributed across: control diet (35% forage + 65% concentrate), 10% date pulp with or without 1% OLF, and 20% date pulp with or without 1% OLF. Results showed that dry matter intake decreased significantly ($p < 0.05$) compared with control, while dry matter digestibility was influenced by the interaction between date pulp and OLF but remained above the physiological threshold for ruminants. Milk yield and most milk components were not significantly affected, although fat content increased ($p < 0.05$) with OLF supplementation. Hematological parameters and leukocyte differentiation showed no significant differences among treatments, remaining within normal physiological ranges. Notably, the combination of 20% date pulp and 1% OLF resulted in the largest reduction in somatic cell count (up to 68.75%) and lower neutrophil-to-lymphocyte ratio, reflecting improved udder health and reduced systemic inflammation. In conclusion, dietary supplementation with 20% date pulp and 1% OLF represents a promising strategy to enhance udder health and mitigate subclinical mastitis in lactating goats without compromising production performance.

Keywords: Subclinical Mastitis, Dairy Goat, *Murraya paniculata*, Date Pulp, Somatic Cell Count, Phytogetic Feed Additive, Udder Health, Natural Antimicrobial

Introduction

The Ettawa Crossbreed Goat (ECG) is a widely utilized dairy breed, with its productivity largely influenced by the health and nutritional management of the livestock. Optimal health ensures that these goats can reach their full genetic potential, ultimately benefiting farmers through improved milk production and reproductive performance. The nutritional requirements of lactating dairy goats necessitate a balanced diet rich in energy and protein to sustain milk yield and overall physiological functions. Previous studies have demonstrated that alternative feed ingredients, such as

date pulp, a by-product of the date juice industry, can effectively meet the energy requirements of lactating goats. In addition to its role as an energy source, date pulp contains bioactive compounds and antioxidants (Echegaray et al., 2023; Shi et al., 2023) that may help improve metabolic efficiency, reduce oxidative stress, and support immune function, thereby contributing to better udder health (Karageorgou et al., 2023; Onjai-uea et al., 2024). Incorporating up to 10% date pulp in the diet has been reported to reduce energy loss through feces and methane emissions, thereby improving energy utilization efficiency (Yuniarti et al., 2016).

Subclinical mastitis is a persistent challenge in dairy goat production, often occurring without visible clinical symptoms but significantly reducing milk yield and quality (Cobirka *et al.*, 2020). The condition is commonly caused by gram-positive bacteria such as *Staphylococcus* spp., which dominate intramammary infections in small ruminants (Gomes and Henriques, 2016; Omar and Mat-Kamir, 2018). Although antibiotics remain the standard treatment, their overuse has raised concerns regarding antimicrobial resistance and the presence of residues in milk. These issues underscore the urgent need for natural, residue-free alternatives to support udder health in sustainable dairy systems.

One promising phytogetic candidate for natural feed additives is orange jasmine (*Murraya paniculata*) leaves. Orange jasmine leaf is one of the plants that contains several bioactive compounds beneficial to the body. Its use as a feed additive is expected to offer an environmentally friendly alternative. Providing natural feed additives does not leave chemical residues in animal products, making them claimed to be healthier and safer to consume. Orange jasmine leaves contain tannins, which are reported to have diverse effects on body weight, dry matter intake, and organic matter digestibility (Attia *et al.*, 2016; Ramdani *et al.*, 2023).

Tresia *et al.* (2016) reported that orange jasmine leaf extracts, obtained through the infusion method, contain bioactive compounds such as flavonoids (0.53%), tannins (1.35%), and saponins (2.38%), all of which exhibit significant biological activity. Flavonoids, a class of polyphenolic compounds, are particularly notable for their anti-inflammatory and antioxidant properties (Olagaray and Bradford, 2019). The anti-inflammatory effects of flavonoids help mitigate inflammatory responses, while antioxidants play a crucial role in neutralizing free radicals, thereby reducing oxidative stress and enhancing immune function. To date, no published research has evaluated the effects of combining date pulp and Orange jasmine Leaf Flour (OLF) in the diet of lactating dairy goats, particularly on milk production, Somatic Cell Count (SCC), and udder health parameters. However, previous studies have demonstrated that *M. paniculata* possesses strong ovicidal and larvicidal activity against gastrointestinal parasites in goats, indicating its pharmacological potential when administered orally (Tresia *et al.*, 2016). Based on this background, the present study was conducted to test the hypothesis that dietary supplementation with date pulp and 1% OLF would improve udder health, reduce SCC, and maintain or enhance milk yield in lactating dairy goats compared with a control diet.

Materials and Methods

Animals and Experimental Design

This study was conducted over a 39-day experimental period using lactating dairy goats at CV. Cordero Farm, Bogor, Indonesia. The 39-day monitoring period was chosen to capture the critical early postpartum stage when dairy goats are most susceptible to mastitis (McDougall *et al.*, 2010). The study involved 15 primiparous (first) lactating female Ettawa crossbred goats, averaging 63 ± 13.46 kg in body weight and producing 0.86 liters of milk per day. All goats used were in early lactation (2-4 weeks postpartum) to minimize variability across treatments. The goats were housed in individual bamboo and wood pens, each measuring 2×1.5 m², equipped with feeding and drinking facilities. Using a randomized block design, the goats were grouped based on their milk production levels: low (average 308 ml/d), medium (average 416 ml/d), and high (average 500 ml/d).

A 2×2 factorial arrangement with an additional control (+1) was applied. The factors were date pulp inclusion (10% vs 20% of concentrate) and OLF supplementation (0 vs 1%). This resulted in five dietary treatments:

1. Control = 35% forage + 65% concentrate (no date pulp or OLF) as a basic diet
2. D10O0 = 10% date pulp without OLF
3. D10O1 = 10% date pulp with 1% OLF
4. D20O0 = 20% date pulp without OLF
5. D20O1 = 20% date pulp with 1% OLF

Diets were formulated according to NRC recommendations for dairy goats (NRC, 2007). The ingredients and nutrients content of the treatment diet are presented in Table 1. The inclusion level of 1% OLF was selected based on unpublished preliminary observations, which indicated no adverse effects on feed intake or palatability. This fixed dosage was used to assess its practical applicability in a field setting, without performing dose-response comparisons.

Feeding Management

Lactating dairy goats were fed the treatment diets three times daily (morning, noon, and evening) with *ad libitum* access to water. Feed refusals were weighed daily to calculate Dry Matter Intake (DMI). Fecal samples for undigested dry matter determination were collected by total collection during the last six days of the experimental period and stored under air-dried condition until analysis. Milk production was measured twice daily after milking, and feed efficiency was calculated as the percentage of 6% Fat-Corrected Milk (FCM) per kilogram of DMI. Undigested dry matter was determined by collecting feces, and dry matter digestibility was computed by subtracting DMI from dry matter in the feces.

Table 1: Ingredients and nutrients content of the treatment diet

| Parameter | Treatments | | | | |
|---------------------------------|----------------------|--------------------|-------|--------------------|-------|
| | Control ^a | D1000 ^a | D1001 | D2000 ^a | D2001 |
| Ingredients (% DM) | | | | | |
| Forage | | | | | |
| Napier grass | 25 | 25 | 25 | 25 | 25 |
| <i>I. zollingeriana</i> | 10 | 10 | 10 | 10 | 10 |
| Concentrate | | | | | |
| Date pulp | 0 | 10 | 10 | 20 | 20 |
| Tempoh waste | 42 | 31 | 31 | 24 | 24 |
| Copra meal | 15.7 | 16.4 | 16.4 | 18.9 | 18.9 |
| Rice bran | 5.2 | 5.5 | 5.5 | 0 | 0 |
| Premix | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| DCP | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| CaCO ₃ | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Orange jasmine leaf flour (OLF) | 0 | 0 | 1 | 0 | 1 |
| Nutrient contents ^a | | | | | |
| DM (%) | 43.8 | 44.6 | 44.6 | 42.4 | 42.2 |
| CP (% DM) | 14.1 | 13.9 | 13.9 | 13.7 | 13.7 |
| EE (% DM) | 5.2 | 5.0 | 5.0 | 4.5 | 4.5 |
| CF (% DM) | 28.6 | 26.4 | 26.4 | 25.7 | 25.7 |
| NFE (% DM) | 44.2 | 46.1 | 46.1 | 47.6 | 47.6 |
| TDN (% DM) | 61.3 | 61.5 | 61.5 | 60.4 | 60.4 |

^aYuniarti *et al.* (2016); DCP = Dicalcium Phosphate, DM = Dry Matter, CP = Crude Protein, EE = Ether Extract, CF = Crude Fiber, NFE = Nitrogen Free Extract, TDN = Total Digestible Nutrient

Milk Quality Analysis

Milk samples, each amounting to 100 ml per goat, were collected at the beginning and end of the study. These samples were analyzed using a Lactoscan milk analyzer (Milkotronic milk analyzer, made in Bulgaria). The milk samples for SCC analysis were collected twice: on the day before initiating the treatment diet and at the end of the study. These samples were analyzed using the Breed method (Fadillah *et al.*, 2023) at the Veterinary Public Health Laboratory, Faculty of Veterinary Medicine, IPB University.

Blood Profile Analysis

Blood samples were collected before starting the treatment diet and on the last observation day in the morning following the procedure described by Akbari *et al.* (2024). Blood was aseptically drawn from the jugular vein using a disposable syringe and transferred into a Vaculab EDTA tube, then transported in a cool box to the laboratory. The blood profile included hematocrit, hemoglobin levels, erythrocytes, leukocytes, and leukocyte differentiation (neutrophils, lymphocytes, monocytes, eosinophil). Leukocyte differentiation followed the method by de Wildt-Eggen *et al.* (2001).

Data Analysis

Data were analyzed using analysis of variance (ANOVA) under a factorial 2×2+1 design. The model included the fixed effects of date pulp (D), OLF supplementation (O), and their interaction (D x O). In

addition, the control group was compared with the four factorial treatments using an orthogonal contrast analysis. When significant effects were detected ($p < 0.05$), mean differences were separated using Tukey's Honestly Significant Difference (HSD) test. All statistical analyses were performed using SPSS version 25.

In addition, a multiple linear regression analysis was performed to evaluate the relationship between dietary supplementation of date pulp and OLF and the percentage reduction in SCC. The regression model included date pulp and OLF supplementation levels as independent variables, and SCC reduction (%) as the dependent variable. Model fit was assessed using R^2 and p -values, with statistical significance set at $p < 0.05$.

Results and Discussion

Performance of Lactating Dairy Goats

The results of dry matter intake and digestibility, milk production, feed efficiency, and milk quality in lactating dairy goats given date pulp and OLF are presented in Table 2. Dry matter intake in this study ranged from 1.2 to 1.7 kg per goat per day. A significant difference was observed between the control and treatments group ($p < 0.05$), but no significant effects were found for the level of date pulp, OLF supplementation, or their interaction. Dry matter digestibility was above 64% across all treatments.

Although the control group did not differ significantly from the treatments, the level of date pulp significantly

affected digestibility ($p < 0.05$), with higher digestibility observed at 20% compared to 10%. Furthermore, there was a significant interaction between date pulp and OLF

($p < 0.05$) indicating that the effect of OLF depended on the level of date pulp inclusion.

Table 2: The average performance of lactating dairy goats

| Parameters | Control | 10% date pulp | | 20% date pulp | | SEM | P-value | Control vs Treatments | D | O | D*O |
|-------------------------------------|---------|-------------------|-------------------|-------------------|-------------------|-------|---------|-----------------------|------|------|-----|
| | | without OLF | 1% OLF | without OLF | 1% OLF | | | | | | |
| Dry matter intake (kg/head/day) | 1.7 | 1.5 | 1.3 | 1.2 | 1.3 | 0.07 | 0.04 | 0.41 | 0.65 | 0.20 | |
| Dry matter digestibility (%) | 71.2 | 80.1 ^a | 67.4 ^b | 64.8 ^b | 65.7 ^b | 1.66 | 0.72 | 0.01 | 0.03 | 0.02 | |
| Milk production 6% FCM (g/head/day) | 1003.1 | 707.1 | 676.0 | 545.3 | 818.2 | 55.24 | 0.02 | 0.90 | 0.15 | 0.08 | |
| Feed utilization efficiency (%) | 61.4 | 48.4 | 54.1 | 45.1 | 62.1 | 3.23 | 0.29 | 0.65 | 0.06 | 0.29 | |
| Milk components | | | | | | | | | | | |
| Fat (%) | 6.8 | 4.7 | 7.0 | 4.5 | 7.0 | 0.38 | 0.33 | 0.87 | 0.01 | 0.86 | |
| SNF (%) | 9.3 | 10.0 | 9.5 | 9.6 | 10.0 | 0.07 | 0.12 | 0.87 | 0.92 | 0.21 | |
| Protein (%) | 5.1 | 5.3 | 5.2 | 5.1 | 5.5 | 0.07 | 0.27 | 0.89 | 0.43 | 0.22 | |
| Lactose (%) | 3.3 | 3.7 | 3.4 | 3.6 | 3.6 | 0.15 | 0.07 | 0.82 | 0.23 | 0.23 | |

In Table 2, it is observed that the average 6% FCM milk production in this study ranged from 543.7 to 1001.3 gram/head/day. Milk yield was significantly different between the control and treatment group ($p < 0.05$), while the main effects of date pulp and OLF were not significant. In other hand, feed efficiency did not differ significantly among treatments. For milk composition, only fat content showed a significant response. The level of date pulp significantly affected milk fat percentage ($p < 0.05$), whereas OLF and its interaction with date pulp were not significant. Other parameters such as SNF, protein, and lactose did not differ significantly among treatments.

Somatic Cell Count

The SCC is an indicator of the animal's immune system used to identify subclinical mastitis. The SCC serves as the best predictor of intramammary infection and is crucial for assessing milk quality, hygiene, and mastitis control (Sharma *et al.*, 2011; Sumon *et al.*, 2020). Subclinical mastitis, an infection caused by pathogenic bacteria, triggers the mammary gland's immune response. These bacteria produce enzymes and toxins that the white blood cells in the udder attack. This immune response can consequently damage udder cells and milk proteins (Celi and Gabai, 2015).

The average SCC from milk samples taken from the goats at the beginning of the study before they consumed the treatment feeds and at the end of the study after consuming the treatment diets are presented in Fig. 1. The control diet showed an increase in SCC by 2.51%, while the treatment diet containing 10% date pulp without OLF addition (D10O0) and with 1% OLF addition (D10O1) showed increases of 8.42% and

109.09%, respectively. On the other hand, the treatment containing 20% date pulp (D20O0) and 20% date pulp with 1% OLF (D20O1) showed decrease in SCC by 45.45 and 68.75%, respectively.

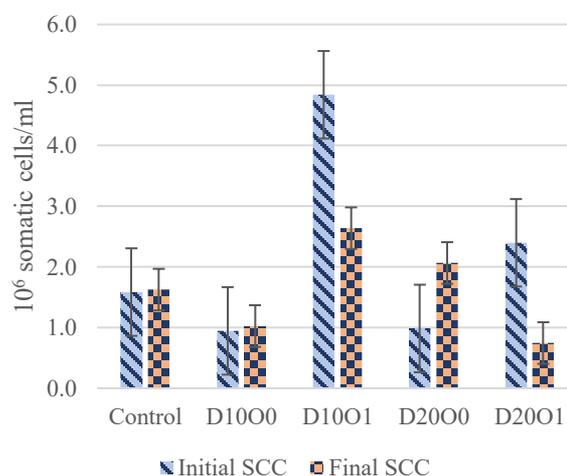


Fig. 1: Average somatic cell count at the beginning and end of the study in lactating dairy goats

The significant reduction observed in D20O1 suggests that higher date pulp inclusion (20%) combined with 1% OLF provides more favorable conditions for antioxidant and anti-inflammatory actions. This is consistent with findings on phytogetic additives such as *Moringa oleifera*, which reduced SCC and improved udder health (Kholif *et al.*, 2016; Nouman *et al.*, 2014). Garlic (*Allium sativum*), known for its allicin content, exhibits potent antibacterial activity and has been reported to lower SCC

and improve milk quality in subclinical mastitis cases (Rathaur *et al.*, 2020). Similarly, neem (*Azadirachta indica*) contains azadirachtin and nimbin, which possess antimicrobial and immunostimulant properties that contribute to mastitis control (Bilal *et al.*, 2024)

The improvement may be partly explained by flavonoids in OLF, which have been shown to downregulate pro-inflammatory mediators such as TNF- α , IL-1 β , and IL-6 (Olagaray and Bradford, 2019). Moreover, higher date pulp levels have been associated with improved antioxidant status in dairy goats, potentially enhancing the action of phytochemical additives. Nutritional inputs and herbal supplements are known to influence immune competence and SCC dynamics (Maggini *et al.*, 2018; Majumdar *et al.*, 2020), though SCC in goats is inherently variable and influenced by udder status and management factors (Jiménez-Granado *et al.*, 2014; Smistad *et al.*, 2021).

The absence of SCC reduction in D1001 despite OLF supplementation may be explained by the lower date pulp inclusion (10%) compared with D2001 (20%). Higher date by-products levels have been associated with improved antioxidant status in dairy goats (Sharifi *et al.*, 2017; Stobiecka *et al.*, 2022), which could create more optimal conditions for the anti-inflammatory effects of OLF. Although this study did not measure cytokine expression or immune biomarkers, previous literature suggests that flavonoids can downregulate pro-inflammatory mediators such as TNF- α , IL-1 β , and IL-6. It is plausible that OLF contributes to immune modulation, resulting in improved udder health through reduced inflammation. Future studies should incorporate immunological assays to confirm this hypothesis.

It should also be noted that SCC represents only one indicator of subclinical mastitis and udder health. The

absence of microbiological validation of milk samples such as detection of *Staphylococcus* spp. or *E. coli* and the lack of additional immunological biomarkers are important limitations of the present study. Future research should therefore integrate SCC measurements with microbial culture, molecular diagnostics, and immune markers to provide a more comprehensive understanding of the effects of OLF and date pulp supplementation.

A multiple linear regression analysis was conducted to evaluate the relationship between dietary supplementation of date pulp and OLF and the percentage reduction in SCC. The model explained 24.8% of the variation in SCC reduction ($R^2 = 0.248$; $p = 0.180$), suggesting a moderate predictive ability. The regression coefficient for date pulp was positive ($\beta = 5.13$; $p = 0.107$), indicating a slight upward trend in SCC reduction as date pulp increased. In contrast, OLF showed a stronger negative association ($\beta = -66.41$; $p = 0.165$), implying a greater contribution to SCC reduction, although neither variable reached statistical significance.

Blood Profile

The results of hematological parameters and leukocytes differentiation are presented in Table 3. Overall, the treatment diets did not significantly affect hemoglobin levels, hematocrit percentage, erythrocyte count, leukocyte count, or leukocyte differentiation ($p > 0.05$).

Hemoglobin concentrations ranged from 8.5 to 10.3 gram/dL, while hematocrit percentages varied between 21.8 and 25.6%. Similarly, erythrocyte counts ranged from $11.5-13.9 \times 10^6/\text{mm}^3$, and leukocyte counts from $12.4-17.7 \times 10^3/\text{mm}^3$. Despite these variations, the mean values for all groups remained within the normal physiological ranges for goats, indicating that dietary supplementation did not disrupt basic hematological balance.

Table 3: Hematological profile of blood in goats, leukocyte differentiation, and neutrophil-lymphocyte ratio

| Parameters | Cont rol | 10% date pulp | | 20% date pulp | | SE M | P-value | | | Normal value | |
|-------------------------------------|----------|---------------|--------|---------------|--------|------|-----------------------|------|------|--------------|----------|
| | | without OLF | 1% OLF | with out OLF | 1% OLF | | Control vs Treatments | D | O | | D*O |
| Hb (g/dl) | 10.2 | 10.3 | 8.5 | 9.1 | 9.1 | 0.27 | 0.22 | 0.56 | 0.09 | 0.10 | 7-15 |
| Hematocrit (%) | 25.6 | 25.2 | 23.6 | 23.9 | 21.8 | 0.57 | 0.22 | 0.14 | 0.09 | 0.80 | 21-35 |
| Erythrocytes ($10^6/\text{mm}^3$) | 13.9 | 11.6 | 12.4 | 13.3 | 11.5 | 0.49 | 0.19 | 0.68 | 0.61 | 0.18 | 9.2-13.5 |
| Leukocyte ($10^3/\text{mm}^3$) | 12.4 | 15.1 | 13.3 | 13.9 | 17.7 | 0.78 | 0.23 | 0.43 | 0.60 | 0.19 | 6.8-20.1 |
| Leukocyte differentiation | | | | | | | | | | | |
| Neutrophils (%) | 60.0 | 41.7 | 49.7 | 55.3 | 53.7 | 2.97 | 0.23 | 0.15 | 0.57 | 0.40 | 17-52 |
| Lymphocyte (%) | 30.3 | 49.7 | 36.0 | 33.0 | 37.7 | 2.87 | 0.27 | 0.16 | 0.37 | 0.09 | 47-82 |
| Monocyte (%) | 3.7 | 3.7 | 3.0 | 5.3 | 3.3 | 0.46 | 0.86 | 0.25 | 0.14 | 0.43 | 0-1 |
| Eosinophil (%) | 6.0 | 5.0 | 11.3 | 6.3 | 5.3 | 0.95 | 0.71 | 0.36 | 0.30 | 0.17 | 1-7 |
| NLR | 2.6 | 0.8 | 1.4 | 1.9 | 1.6 | 0.26 | 0.10 | 0.14 | 0.69 | 0.27 | |

When examining leukocyte differentiation, the proportions of neutrophil (41.7-60.0%), lymphocyte (30.3-49.7%), monocyte (3.0-5.0%), and eosinophil (3.3-11.3%) also showed no significant differences across treatments ($p>0.05$). Nevertheless, numerical patterns were observed. The control group, for instance, displayed the highest neutrophil proportion (60%), which exceeded the upper normal limit (52%). In contrast, goats receiving 10% date pulp with or without OLF supplementation exhibited lower neutrophil levels (41.7-49.7%), which fell within the normal range. Conversely, lymphocyte percentages tended to decline in groups with elevated neutrophils, reflecting the expected inverse relationship between these two leukocyte types during inflammatory response.

The Neutrophil-Lymphocyte Ratio (NLR) further supports this observation. Although differences were not statistically significant ($p>0.05$), NLR values ranged from 1.4-2.6 across treatments. The control group exhibited the highest NLR (2.6), which was well above the reference value of 1 (Rajion *et al.*, 2001; Zahorec, 2021), thereby suggesting greater systemic stress or inflammation. Meanwhile, goats supplemented with 10% date pulp plus OLF showed the lowest NLR (1.4), indicating a possible alleviation of inflammatory status. Interestingly, increasing the date pulp level to 20% without OLF elevated the NLR to 1.9, yet the addition of OLF at the same inclusion level reduced the NLR slightly to 1.6.

The NLR has emerged as a reliable indicator of physiological stress and inflammation in ruminants. Higher NLR values are typically associated with immune response to infection or subclinical conditions such as mastitis (Nazifi *et al.*, 2008). Taken together, these findings suggest that although the observed changes were not statistically significant, the consistent numerical trends point toward a beneficial role of OLF supplementation. In particular, the lower NLR values in OLF-treated groups may indicate reduced systemic inflammation, which is in line with the hypothesized anti-inflammatory function of flavonoid present in *Murraya paniculata*. With this evidence, it appears that dietary phytonutrients can contribute to modulating immune responses in lactating goats through subtle but biologically relevant shifts in neutrophil-lymphocyte dynamics.

Leukocyte Profile and Neutrophil-Lymphocyte Ratio

Beyond the SCC, which primarily reflects local udder infection, hematological indicators such as total leukocyte counts, differential leukocyte profiles, and the Neutrophil-to-Lymphocyte Ratio (NLR) provide complementary insights into systemic immune responses and inflammatory status. These parameters help to clarify whether dietary supplementation not only influences udder-level changes but also modulates whole-body immunity in lactating goats.

Some treatments showed leukocyte counts above normal levels, namely D10O1, D20O0, D10O0, and D20O1. Elevated leukocyte counts are usually caused by infections in the animal's body. Treatment D20O1 resulted in the greatest reduction in SCC. This may suggest that the high leukocyte count in this study is due to the immune defense in the udder caused by inflammation and infection from pathogenic bacteria. As mentioned by Megha *et al.* (2021), inflammation signals the immune system through components such as leukocytes, chemokine, and cytokines to restore the body to homeostasis.

The observed parallel trends in SCC and NLR emphasize this link between local udder inflammation and systemic immune response. Treatment D20O0 and D20O1, which showed reduction in SCC, also exhibited lower NLR values compared to treatments with increased SCC (D10O0 and D10O1). This indicates that dietary supplementation, particularly with OLF, may alleviate both localized mastitis-associated inflammation and broader physiological stress. While SCC reflects the intramammary infection status, NLR provides complementary insight into systemic immune modulation. The concurrent improvements in both parameters support the hypothesis that dietary phyto-genic additives could contribute to overall udder health through multi-level anti-inflammatory effects.

In this study, leukocyte differentiation among treatments did not show significant differences. Neutrophil levels above normal were observed in control, D20O0, and D20O1. The high neutrophil levels are likely due to udder inflammation from mastitis. Neutrophils are the body's frontline defense against pathogens in the immune system (Meglia *et al.*, 2001). Jiang *et al.* (2022) stated that high neutrophil levels in cows with high SCC indicate high blood neutrophil levels. Bacterial invasion causes inflammation, leading to the mobilization of white blood cells and neutrophils to attack and destroy bacteria, releasing soluble antimicrobials to neutralize infection and impact the mammary gland (Fang *et al.*, 2019).

The NLR is widely recognized as a simple and robust parameter for assessing inflammatory status. A high NLR value (greater than 1) indicates physiological stress, inflammation, or infection (Rajion *et al.*, 2001; Zahorec, 2021). The decrease in NLR indicates an improvement in udder inflammation. In this study, the NLR values were 1.7 for D20O0 and 1.42 for D20O1. Secretory cells in the mammary gland alveoli seem healthier and more productive with the addition of 1% OLF in the D20O1 diet compared to D20O0, which only contained 20% date pulp. The addition of OLF may have reduced inflammation or infection in the mammary gland, thereby reducing the occurrence of subclinical mastitis in the diet

with up to 20% date pulp accompanied by 1% OLF in lactating Ettawa crossbreed goats.

While the reduction in SCC is a promising indicator of udder health improvement, this study did not include microbial culture or molecular detection of mastitis-causing pathogens such as *Staphylococcus* spp. or *E. coli*. Thus, the findings should be interpreted cautiously as indirect evidence. Future research incorporating microbial diagnostics such as culture or PCR analysis is recommended to directly link SCC changes with pathogen load.

Milk Production and Quality

Increasing the energy source from date pulp from 10% (D1000) to 20% (D2000) did not result in a significant increase in milk production; however, it notably improved overall animal health, as evidenced by a 45.45% decrease in SCC in the D2000 treatment group. In contrast, the SCC in the D1000 treatment group increased by 8.45%. These findings further substantiate the hypothesis that the addition of orange jasmine leaf powder can enhance udder health.

The correlation between SCC and milk quality has been well-documented in the literature, with several researchers highlighting a negative correlation between these two parameters (Deshapriya *et al.*, 2019; Malik *et al.*, 2018). This negative correlation is primarily attributed to pathological changes within the animal's body, particularly inflammation of the udder (Deshapriya *et al.*, 2019; Sharma *et al.*, 2011). In the present study, although overall milk quality components did not differ significantly between treatment groups, the stability of milk quality was maintained even in the presence of mastitis indications

A notable exception was observed in the fat content of the milk. Animals supplemented with 1% OLF exhibited significantly higher milk fat content compared to those not receiving the supplement. This finding suggests that OLF holds potential not only for reducing SCC but also for maintaining milk production and enhancing milk quality components, particularly fat content. Although basic milk quality parameters such as fat, protein, lactose, and SNF were measured, this study did not assess other quality indicators such as milk pH, total bacterial count, or sensory attributes. These parameters are important for providing a more comprehensive evaluation of milk quality and should be included in future assessments to better understand the practical implications of dietary interventions using OLF.

From an economic perspective, the use of 20% date pulp and 1% OLF may offer practical benefits to farmers. Date pulp is an agro-industrial by-product that is locally available at low cost, while orange jasmine

leaves can be sourced from non-conventional plants with minimal competition with human food resources. Although this study did not include a detailed cost-benefit analysis, the potential reduction in SCC may lower veterinary treatment cost and milk rejection due to mastitis. Future economic evaluations are needed to assess the feasibility of OLF-based feeding strategies under different production systems. Operationally, the incorporation of 1% OLF in dairy goat diets can be easily applied in smallholder systems, as it does not require specialized equipment or complex processing, thereby supporting its potential adoption in practical feeding management.

Although the sample size was limited (n = 15), the use of a randomized block design helped control for individual variation, maintaining sufficient analytical power to detect biologically meaningful differences. Additionally, the diagnosis of subclinical mastitis relied solely on SCC without microbiological validation, which may limit the robustness of the findings. The study was conducted over a 39-day period, focusing on the early postpartum phase; however, future studies should also consider the risk of mastitis closer the weaning period. Although this window provided useful observations, extending the monitoring period into late lactation or near weaning could capture additional mastitis risks. Addressing these limitations in future research, along with economic evolutions, will be essential to strengthen the feasibility of OLF-based feeding strategies.

Conclusion

The findings of this research indicate that a diet containing 20% date pulp supplemented with 1% OLF as a natural feed additive can significantly enhance the health condition of lactating dairy goats, particularly those suspected of subclinical mastitis. This health improvement is evidenced by a substantial reduction in SCC in milk by 68.75%, thereby demonstrating the efficacy of this dietary intervention in mitigating udder health issues. Moreover, the incorporation of orange jasmine leaf powder and date pulp into the feed did not adversely affect the overall performance and productivity of lactating Ettawa crossbreed goats, underscoring its potential as a beneficial and sustainable feed additive in dairy goat nutrition.

To strengthen these findings, future studies should incorporate microbiological analyses of milk to confirm reduction in mastitis-causing pathogens, along with longer experimental periods that span different lactation stages. A more detailed stratification of experimental animals based on parity and physiological status is also recommended to improve the homogeneity and precision of treatment effects. Furthermore, assessing the economic and operational feasibility of implementing this feeding

strategy at the farm level will be crucial for promoting its adoption among smallholder dairy goat farmers.

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Author's Contributions

Dwierra Evvyernie: Conceptualization, funding acquisition, data curation, methodology, supervision, project administration, validation, and writing original draft.

Endah Yuniarti: Data curation, investigation, formal analysis, writing review and edited.

Rika Zahera: Formal analysis, visualization, writing review and edited.

Anuraga Jayanegara: Supervision and writing review and edited.

Ethics

All procedures involving animals in this study were conducted in accordance with institutional ethical guidelines for the care and use of animals in research and were approved by the Animals Ethics Board of IPB University.

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