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# Effects of *Cinnamomum verum* Supplementation on Physicochemical and Sensory Properties of Goat Milk Yogurt

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**ABSTRACT**

Yogurt made from goat's milk has a pungent odor that persists in the product. Cinnamon is high in cinnamaldehyde, a compound responsible for its sweet, slightly spicy flavor, distinctive aroma, and warming sensation, all of which can enhance the flavor of goat milk yogurt. The present study aimed to evaluate the physicochemical and sensory properties of goat milk yogurt products supplemented with cinnamon. A completely randomized design was employed, with five treatment groups and four replications for each. The control group included goat milk yogurt without cinnamon, and the remaining treatment groups included goat milk yogurt with cinnamon at concentrations of 0.1%, 0.2%, and 0.3%. The physicochemical characteristics, including fat content, moisture content, viscosity, pH, and acidity, as well as sensory attributes (color, aroma, taste, texture, and overall acceptability) were evaluated. The present results indicated that different cinnamon concentrations influenced the fat content, moisture level, and pH of the yogurt, but did not affect its acidity or viscosity. Sensory evaluation of the goat milk yogurt demonstrated that cinnamon addition impacted the yogurt's color, aroma, taste, texture, and overall acceptability. The 0.2% cinnamon increased fat and pH levels, decreased moisture, and did not alter acidity or viscosity. The current findings suggest that 0.1% cinnamon enhanced the aroma of goat milk yogurt without reducing acceptability, whereas higher concentrations of cinnamon may be less favored.

**Keywords:** Cinnamon, Goat milk, Physicochemical, Sensory, Yogurt

## INTRODUCTION

Yogurt is a dairy product produced through the fermentation of milk by lactic acid bacteria (LAB; Ichimura, 2024; Liu and Peng, 2024). Milk used in yogurt production can be derived from different animals, including cows, goats, and buffaloes, each imparting unique physicochemical and sensory qualities to the final product (Andiç et al., 2026; Jankowska et al., 2026). Cow's milk is widely used as the primary substrate in yogurt production; however, milk from other species, such as goats, may serve as an alternative raw material, possessing distinctive physicochemical properties (Wang et al., 2023; Demirhan et al., 2026). Goat milk has been reported to offer several health benefits due to its bioactive compounds, including potential benefits for cardiovascular health, lipid metabolism, and immune function (dos Santos et al., 2023). Goat's milk has several advantages, including a high content of essential minerals such as calcium and phosphorus, as well as vitamins A, E, and B complex. In addition, goat's milk contains bioactive compounds with natural antimicrobial properties, such as lactoferrin-derived peptides and other bioactive peptides (ALKaisy et al., 2023; dos Santos et al., 2023).

Nevertheless, goat milk is frequently associated with a distinctive goaty aroma, primarily due to short-chain fatty acids, which can reduce consumer acceptability (Clark and García, 2017). Flavor plays a critical role in the consumer acceptability of dairy products; thus, natural flavoring substances are commonly added to improve the sensory quality of goat milk products (Li et al., 2024). Cinnamon (*Cinnamomum verum*) is a potential natural additive, known for distinctive aromatic compounds such as cinnamaldehyde and eugenol, which contribute to its warm, pleasant flavor. These compounds can reduce unpleasant odors and improve the overall sensory acceptability of dairy products (Alonso et al., 2024).

*Cinnamomum verum* is widely recognized as a culinary spice employed internationally, including in Indonesian cuisine, where it serves as a flavor-enhancing ingredient across various food products (Rao and Gan, 2014; Spence,



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2024). In addition to its culinary applications, cinnamon is rich in phenolic and volatile bioactive compounds, including cinnamic acid, eugenol, and linalool, which are known for their potent antioxidant properties (Guo et al., 2024; Karimirad et al., 2025). Cinnamon contains essential oil compounds such as cinnamaldehyde and eugenol, which contribute to a sweet, spicy aroma and a warming sensation (Ranasinghe et al., 2013). Flavonoids are widely recognized for their diverse biological activities, including antioxidant, antimicrobial, anti-inflammatory, antifungal, and antidiabetic effects (Shamsudin et al., 2022; Hao et al., 2024). Therefore, *Cinnamomum verum* extract can be used as an alternative food additive to reduce the pungent aroma of goat milk in yogurt production. The present study aimed to investigate the physicochemical and organoleptic characteristics of goat milk yogurt containing *Cinnamomum verum*.

## MATERIALS AND METHODS

### Ethical approval

The experimental laboratory study was designed to evaluate the physicochemical and sensory qualities of goat milk yogurt with the addition of cinnamon extract. The present study was conducted in accordance with the guidelines of the Department of Animal Husbandry, Faculty of Agriculture, University of Lampung, Indonesia.

### Study materials

The materials used in the present study included fresh goat milk collected from CV Telaga Rizky Metro City, Lampung Province, a commercial starter culture containing *Lactobacillus bulgaricus*, *Streptococcus thermophilus*, *Lactobacillus acidophilus*, and *Bifidobacterium* ($1\times10^{10}$CFU.g$^{-1}$; PT. Diamond Cold Storage, Indonesia), dried cinnamon extract, 0.1 N NaOH solution, distilled water, and a 1% phenolphthalein (PP) indicator. The equipment used in the present study consisted of an autoclave, gas stove, pot, beaker, stirrer, refrigerator, dropper, measuring flask, Erlenmeyer flask, funnel, filter paper, a sieve, a thermometer, a digital scale, a Bunsen burner, tissue, scissors, rubber gloves, tweezers, a stainless steel sieve, sterile glass bottles, a digital pH meter (EZ-9909, China), and a Brookfield viscometer (Brookfield Engineering Laboratories, USA).

### Study design

The experiment was arranged in a completely randomized design (CRD) with four treatment levels and five independent replicates per treatment, resulting in a total of 20 experimental units. The control group comprised goat milk yogurt without cinnamon extract (P0), while the experimental groups consisted of cinnamon extract at 0.1% (P1), 0.2% (P2), and 0.3% (P3), expressed as a percentage (v/v) relative to the 250 mL volume of goat milk per unit.

### Study procedure

#### *Process of making cinnamon extract*

The process of preparing cinnamon extract followed the modified procedure outlined by Widiyanto et al. (2013), which involved reducing the size of the cinnamon pieces by pounding them to facilitate grinding, then grinding them into a fine powder using a blender. The cinnamon powder was filtered using a 40-mesh sieve to obtain fine cinnamon powder (Figure 1a) and macerated using methanol at a ratio of 1:6. The mixture was left to stand for two days and subsequently filtered using Whatman No. 1 filter paper (11 µm pore size) to obtain the extract (Figure 1b) by evaporation using a rotary evaporator at a constant temperature of 50°C (Figure 1c). The process was continued until all methanol had evaporated, resulting in the formation of cinnamon oleoresin, a concentrated extract containing both volatile and non-volatile bioactive compounds (Jayaprakasha et al., 2007; Ranasinghe et al., 2013). Subsequently, the filtrate was left to harden and then oven-dried at 40°C for approximately 24 hours, after which it was ground in a mortar (Figure 1d).

#### *Making yogurt*

The equipment for making yogurt was sterilized. Cinnamon extract was added to 250 mL of goat milk according to the treatment concentrations, followed by pasteurization at 85°C for 15 seconds with continuous stirring (Hanum et al., 2021). The mixture was subsequently cooled to a temperature of 43-45°C (Wanniatie et al., 2022) and inoculated with a 10% LAB starter culture, followed by thorough mixing (Kirana et al., 2025). Fermentation was carried out at room temperature for 48 hours (Kirana et al., 2025). After fermentation, the yogurt was stored under refrigeration for seven days before analysis. The resulting product was evaluated for fat content, moisture content, pH, total titratable acidity, viscosity, and sensory properties (AOAC, 2005; Tamime and Robinson, 2007; Lawless and Heymann, 2010).

(a) (b) (c) (d)

**Figure 1.** Preparation and extraction of bioactive compounds from cinnamon. **a**: Cinnamon powder filtering process, **b**: Filtration of the yield, **c**: Filtrate evaporation, **d**: Cinnamon extract grinding.

***Sample analysis***

Fat and moisture contents were analyzed according to the standard methods of the Association of Official Analytical Chemists (AOAC, 2005). Total titratable acidity was determined by titration, following the AOAC method for measuring lactic acid content (AOAC, 2005). The pH was measured using a digital pH meter (EZ-9909, China). A 50 mL sample was transferred into a 100 mL beaker. Before measurement, the pH meter was calibrated using a standard buffer solution at pH 4 and then gently dried with tissue paper. The electrode was then immersed in the sample, and the pH was noted (AOAC, 2005).

Viscosity was measured using a Brookfield viscometer (Brookfield Engineering Laboratories, USA). A spindle was immersed in the yogurt sample, rotated at a constant speed, and the resistance torque was measured. The torque value directly correlated with viscosity and was expressed in centipoise (cP). All measurements were conducted under controlled temperature conditions (Rao, 2013; Brookfield Engineering Laboratories, 2017).

Sensory evaluation was conducted using a hedonic test with 28 panelists (Lawless and Heymann, 2010). Approximately 30 g of yogurt was weighed and placed in cups labeled with random codes. Each panelist received four samples with different treatments and was asked to evaluate the samples using a structured questionnaire based on a 5-point hedonic (Likert-type) scale (Lawless and Heymann, 2010). The following criteria included color (1: Typical white milk to 5: Brownish white), aroma (1: Typical fermented milk to 5: Very cinnamon-like aroma), texture (1: Very thin to 5: Very thick), taste (1: Very little cinnamon flavor to 5: Very strong cinnamon flavor), and overall acceptability (1: Very dislike to 5: Very like).

**Statistical analysis**

Data on physicochemical properties, including fat content, moisture content, viscosity, pH, and total titratable acidity, were subjected to one-way analysis of variance (ANOVA). When significant effects were detected ($p < 0.05$), mean comparisons were performed using the least significant difference (LSD) test. Sensory evaluation data, collected on a 5-point hedonic scale, were analyzed with the nonparametric Kruskal Wallis test. When significant differences were

observed ($p < 0.05$), pairwise comparisons were conducted with the Mann–Whitney U test, with appropriate adjustment for multiple comparisons. All statistical analyses were performed using SPSS version 21 (IBM Corp., Armonk, NY, USA).

## RESULTS AND DISCUSSION

The effects of adding *Cinnamomum verum* at different levels on the physicochemical properties of yogurt are presented in Table 1. The average scores for the addition of *Cinnamomum verum* on the organoleptic quality of cow's milk yogurt are presented in Table 2.

**Table 1.** Physicochemical qualities of goat milk yogurt containing *Cinnamomum verum*

| *Cinnamomum verum* concentration / Parameter | P0 | P1 | P2 | P3 |
|---|---|---|---|---|
| Fat (%) | $12.50 \pm 3.70^{b}$ | $13.00 \pm 3.60^{b}$ | $17.30 \pm 5.40^{c}$ | $7.90 \pm 0.50^{a}$ |
| Water (%) | $81.96 \pm 2.23^{b}$ | $81.52 \pm 1.74^{b}$ | $78.13 \pm 0.77^{a}$ | $85.57 \pm 0.91^{c}$ |
| pH | $4.00 \pm 0.02^{b}$ | $4.00 \pm 0.01^{b}$ | $4.04 \pm 0.01^{c}$ | $3.95 \pm 0.01^{a}$ |
| Total acid (%) | $0.72 \pm 0.07$ | $0.76 \pm 0.08$ | $0.73 \pm 0.07$ | $0.62 \pm 0.07$ |
| Viscosity (cP) | $14670 \pm 2166.4$ | $12058 \pm 1848.5$ | $12720 \pm 1928.2$ | $11283 \pm 788.7$ |

P0: Control group containing 0% *Cinnamomum verum* concentration, P1: 0.1% *Cinnamomum verum* solution, P2: 0.2% *Cinnamomum verum* solution, and P3: 0.3% *Cinnamomum verum* solution. $^{abc}$ Means different superscript letters on the same row indicate significant differences ($p < 0.05$).

**Table 2**. Average score of goat milk yogurt's organoleptic test containing *Cinnamomum verum*

| *Cinnamomum verum* concentration / Parameter | P0 | P1 | P2 | P3 |
|---|---|---|---|---|
| Color | $1.25 \pm 0.441^{a}$ | $3.86 \pm 0.525^{b}$ | $4.00 \pm 0.000^{b}$ | $4.00 \pm 0.000^{b}$ |
| Aroma | $1.14 \pm 0.525^{a}$ | $2.75 \pm 0.585^{b}$ | $3.71 \pm 0.713^{c}$ | $4.11 \pm 0.786^{c}$ |
| Taste | $1.07 \pm 0.378^{a}$ | $3.07 \pm 0.766^{b}$ | $4.21 \pm 0.738^{c}$ | $4.32 \pm 0.819^{c}$ |
| Texture | $3.68 \pm 0.670^{b}$ | $3.46 \pm 0.693^{b}$ | $2.93 \pm 0.766^{a}$ | $3.14 \pm 0.891^{a}$ |
| Overall acceptability | $3.79 \pm 0.995^{c}$ | $3.25 \pm 0.967^{b}$ | $2.96 \pm 1.138^{a}$ | $2.79 \pm 1.343^{a}$ |

P0: Control group containing 0% *Cinnamomum verum* concentration, P1: 0.1% *Cinnamomum verum* solution, P2: 0.2% *Cinnamomum verum* solution, and P3: 0.3% *Cinnamomum verum* solution. $^{abc}$ Means different superscript letters on the same row indicate significant differences ($p < 0.05$).

### Fat

The addition of cinnamon in yogurt production had a significant effect on fat content ($p < 0.05$). The control group did not differ significantly from Group P3 ($p > 0.05$). However, there was a significant difference in yogurt fat content between the control group and groups P1 and P2 ($p < 0.05$). Adding 0.2% cinnamon (P2) increased fat content to 17.30% ± 5.40, compared to the control group (12.50% ± 3.70). However, increasing the cinnamon concentration to 0.3% (P3) reduced fat content. This finding was consistent with those of Günes-Bayir and Bilgin (2019), who reported that yogurt containing 0.3-2.5% cinnamon demonstrated a proportional decrease in fat content.

### Water

The present results demonstrated that the addition of cinnamon extract significantly affected the moisture content of yogurt ($p < 0.05$). The water content of Group P1 demonstrated no significant difference from the control group ($p > 0.05$), but differed significantly from groups P2 and P3 ($p < 0.05$). Pectin, a polysaccharide in cinnamon, can absorb water and increase water-holding capacity/viscosity (Chandel et al., 2022). The addition of 0.2% cinnamon in Group P2 increased the viscosity (12720 cP ± 1928.2) and retained water in yogurt (78.13% ± 0.77). Meanwhile, increasing the cinnamon concentration to 0.3% increased the water content (85.57% ± 0.91), thereby reducing the viscosity of yogurt (11283 cP ± 788.7). In addition to pectin, polyphenols in cinnamon, including proanthocyanidins and tannins, can bind to milk proteins, such as casein, forming complexes. This interaction does not directly bind water, unlike oligosaccharides; however, the formation of protein-polyphenol complexes modifies the matrix structure, enhancing the system's ability to retain water (Tosif et al., 2021).

### pH

The present results indicated that the mean pH of goat milk yogurt with different cinnamon concentrations ranged from 3.95 to 4.04 (Table 1), which was consistent with the range outlined by INS (2009; 3.80-4.50). The addition of

cinnamon to goat milk yogurt significantly affected the yogurt's pH ($p < 0.01$). Group P0 demonstrated no significant difference in pH compared to Group P1 (0.1%), but differed significantly from groups P2 (0.2%) and P3 (0.3%).

The addition of cinnamon affected the pH of yogurt, depending on the concentration used. At a concentration of 0.1%, there was no significant effect on pH. However, increasing the concentration to 0.2% increased the pH, which might be due to the presence of active compounds in cinnamon, such as cinnamaldehyde and eugenol. These compounds exhibit antimicrobial activity and can inhibit LAB growth, thereby reducing acid production (Hyldgaard et al., 2012; Ranasinghe et al., 2023). Conversely, at a concentration of 0.3%, the pH decreased, possibly due to the dominance of cinnamic acid compounds, which disrupted the balance of the fermentation process. Therefore, adding cinnamon at specific concentrations can alter the yogurt's pH, either raising or lowering it depending on the amount used. Hastuti and Rustanti (2014) stated that cinnamon extract contains cinnamaldehyde, an acidic compound, so adding higher concentrations can create a more acidic environment.

**Total acid**

The present results indicated that the average total acidity of goat milk yogurt with cinnamon inclusion ranged from 0.62% to 0.76% (Table 1). The addition of cinnamon at concentrations ranging from 0.1% to 0.3% did not significantly influence the total acidity of goat milk yogurt ($p > 0.05$). Group P1 had a higher average acidity of 0.76%, while Group P3 had a lower acidity of 0.62%. According to INS (2009), the total acidity level of yogurt ranges from 0.5-2.0%, which indicates that the present values were within the established standard limits.

Cinnamon extract at 10% concentration has been shown to lower the pH of yogurt to around 4.65 (Marnianti et al., 2021), and this decrease in pH was accompanied by an increase in total titratable acidity due to lactic acid production during fermentation (Lindasari, 2013). However, the present result demonstrated a different trend, in which groups P1, P2, and P3 had lower pH values, and the average total acid content was low (Table 1). A decrease in pH does not necessarily correspond to an increase in total titratable acidity, as these two parameters reflect different aspects of acidity. The discrepancy might be due to the antimicrobial activity of cinnamon compounds, which can affect LAB and alter fermentation processes (Lucey, 2002; Choi et al., 2016). This condition can occur because lactic acid produced during yogurt production is a weak acid, resulting in a low pH (Rahmawati, 2021). The titration method used to measure total acid was designed to detect only strong acids, such as lactic acid, and to exclude weak acids or phenolic compounds, such as cinnamic acid, from cinnamon. Therefore, despite the decrease in pH, phenolic and other bioactive compounds derived from cinnamon were not included in the measurements of total titratable acidity. This was because the method primarily quantified organic acids, such as lactic acid, thereby yielding comparatively low total acidity values (Lucey, 2002; Tamime and Robinson, 2007). An increase in total acidity does not necessarily result in a proportional decrease in pH. This phenomenon can be attributed to the buffering capacity of milk proteins and the incomplete dissociation of lactic acid, a weak organic acid, which limits the concentration of free hydrogen ions ($H^+$) in the solution despite the accumulation of total acids (Lucey, 2002; Tamime and Robinson, 2007). Mursyida and Wati (2021) indicated that a low concentration of $H^+$ ions suggested that the acid in the product was not completely dissociated, thereby classifying it as a weak acid.

**Viscosity**

The current results indicated that the average viscosity of goat milk yogurt with different cinnamon concentrations ranged from 11,283 to 14,670 cP (Table 1). The current results demonstrated that different cinnamon concentrations did not significantly affect yogurt viscosity ($p > 0.05$). However, despite the lack of a significant effect, a decrease in viscosity was observed in Group P3. The highest average viscosity was observed in Group P0 at 14670 cP, while the lowest average viscosity was observed in Group P3 at 11283 cP. The viscosity values obtained in the present study (11,283-14,670 cP) were within the typical range reported for yogurt, which generally ranges from approximately 1,000 to over 10,000 cP depending on composition and consistency (Lucey, 2002; Hoxha et al., 2023). Higher doses of cinnamon extract within each treatment group yielded different viscosity values, which tended to decrease. The decrease in viscosity values might be attributed to the antimicrobial activity of cinnamon compounds such as cinnamaldehyde and eugenol, which can inhibit LAB, thereby reducing lactic acid production and affecting protein coagulation (Lucey, 2002; Burt, 2004; Upadhyay et al., 2016). According to Lindasari et al. (2013), the properties of the active compounds in cinnamon can affect the protein structure and gel matrix in yogurt.

The viscosity results of the present study indicated that cinnamon at 0.1-0.3% did not affect viscosity. Nevertheless, the viscosity values had a relatively high range across all treatment groups, indicating that the produced yogurt exhibited excellent consistency and was consistent with typical yogurt characteristics. The current results demonstrate higher values than those reported by Savitry and Setiani (2017), who documented a viscosity range of 1815-9012 cP in liquid skim milk yogurt containing tomato juice. According to Dobozi et al. (2023), increased lactic acid production enhances

casein coagulation by lowering pH, thereby facilitating the formation of a protein gel network that influences yogurt viscosity.

**Sensoris**

***Color***

The organoleptic evaluation on a 1-5 scale revealed that the addition of cinnamon extract significantly affected the color of goat milk yogurt ($p < 0.05$). The mean color score for Group P0 (1.25) was described as white, typical of milk, whereas groups P1 (3.86), P2 (4.00), and P3 (4.00) exhibited a brownish-white appearance. Further analysis utilizing the Mann–Whitney test revealed significant differences between Group P0 and all treatments containing cinnamon ($p < 0.05$). Conversely, no significant differences were observed among P1, P2, and P3 ($p > 0.05$). This finding suggested that adding 0.1% cinnamon extract was sufficient to enhance the yogurt's visual color intensity. Cinnamon contains phenolic compounds, such as tannins, which can contribute to browning reactions, resulting in a brownish-white color when added to goat milk yogurt (Rizki et al., 2024). Phenolic compounds, such as cinnamaldehyde in cinnamon, can interact with milk proteins through the Maillard reaction, a reaction between sugars and proteins that can improve the sensory quality of fermented products (Mehanna et al., 2014). Color changes during yogurt processing are more probably caused by ingredient additions and physicochemical interactions rather than Maillard reactions, which typically occur at higher temperatures (Yu et al., 2020). Figure 2 illustrates the color variations in goat milk yogurt after adding cinnamon extract.


**Figure 2.** Yogurt color after addition of *Cinnamomum verum* based on treatment levels. **a**: Control group, **b**: 0.1% *Cinnamomum verum*, **c**: 0.2% *Cinnamomum verum*, **d**: 0.3% *Cinnamomum verum*

***Aroma***

The organoleptic evaluation on a 1-5 scale indicated that the addition of cinnamon extract significantly influenced the aroma of the goat milk yogurt ($p < 0.05$). The average aroma score increased with the addition of cinnamon extract, with Group P0 (1.14), P1 (2.75), P2 (3.71), and P3 (4.11). The Mann-Whitney test indicated significant differences between Group P0 and all cinnamon treatments ($p < 0.05$), as well as between P1, P2, and P3 ($p < 0.05$). However, there was no significant difference between P2 and P3 ($p > 0.05$). Increasing the cinnamon concentration to 0.2% and 0.3% (P2 and P3) significantly intensified the cinnamon aroma in the yogurt

The organoleptic test results indicated that adding cinnamon extract to goat milk yogurt enhanced its floral aroma without compromising the typical sour flavor of fermented products. This effect was attributed to the bioactive compounds in cinnamon, such as linalool, eugenol, and cinnamaldehyde, which have floral, spicy, and warm aromatic characteristics (Pratiwi and Subarnas, 2020). Furthermore, the distinct aroma of cinnamon can enhance the overall warm and spicy aroma profile of yogurt (Boycheva et al., 2011; Honestin et al., 2021).

***Texture***

The organoleptic quality evaluation, conducted using a 1-5 scale, indicated that the addition of cinnamon extract significantly affected the texture of goat milk yogurt ($p < 0.05$). The highest mean texture scores were observed in groups P0 (3.68) and P1 (3.46), both characterized by a thick consistency, whereas the lowest scores were recorded in groups P2 (2.93) and P3 (3.14), which exhibited a slightly thick texture. The Mann-Whitney test indicated a significant

difference between groups P0 and P1 with P2 and P3 ($p < 0.05$). However, there was no significant difference between groups P2 and P3 ($p > 0.05$). Increasing the concentration of cinnamon extract decreased panelists' texture ratings of the yogurt.

The decrease in viscosity of goat milk yogurt in groups P2 and P3 likely results from interactions between cinnamon polysaccharides and milk proteins, which interfere with the formation of a stable gel structure (Hege et al., 2020). Excess polysaccharides can interfere with protein-protein interactions in the gel structure, leading to a weaker structure and a thinner texture (Li et al., 2023; Leal et al., 2024). Polysaccharides isolated from *Cinnamomum cassia* are mainly composed of glucose and arabinose and have been reported to exhibit significant biological activities (Zhang et al., 2024). Conversely, at lower concentrations, such as 0.1% cinnamon, acceptable texture formation was still supported because the gel was more stable. In addition, the decrease in viscosity was attributed to antimicrobial compounds in cinnamon, such as cinnamaldehyde and eugenol, which could inhibit LAB growth (Kusumawati et al., 2019). Eugenol exhibits antibacterial activity by disrupting bacterial cell membranes, potentially inhibiting LAB and thereby influencing fermentation processes in yogurt (Burt, 2004; Upadhyay et al., 2016).

***Taste***

The results of organoleptic quality testing using a 1-5 scale demonstrated that adding cinnamon extract significantly affected the taste of goat milk yogurt ($p < 0.05$). The average taste scores for each treatment were 1.07 in Group P0 for neutral taste, 3.07 in Group P1 for slightly cinnamon-flavored, and 4.21 and 4.32 in groups P2 and P3, respectively, for strongly cinnamon-flavored. The Mann-Whitney test demonstrated statistically significant differences between groups P0, P1, P2, and P3 ($p < 0.05$). However, there were no significant differences between P2 and P3 ($p > 0.05$). Cinnamon plays an important role in reducing the rancid taste and excessive acidity in goat milk yogurt. Cinnamon can improve the sensory properties of yogurt by eliminating undesirable flavors, such as sourness and goaty odor, thereby increasing overall acceptability (Lindasari, 2013; Legowo et al., 2024).

As the concentration of cinnamon extract increased, panelists reported a stronger cinnamon flavor. The active compounds, cinnamaldehyde and eugenol, in cinnamon play an important role in creating the sweet, warm flavor (Kusumawati et al., 2019). Adding cinnamon extract balanced the sourness of fermentation with its sweet flavor, resulting in a more layered flavor (Marnianti et al., 2021). However, excessively high concentrations can produce a dominant warm flavor and disrupt the flavor balance (Ramayanti et al., 2018). Therefore, the selection of the concentration is very important for maintaining the organoleptic quality of yogurt.

***Overall acceptability***

The hedonic test results demonstrated that yogurt without cinnamon extract (P0) was the most preferred yogurt by the panelists, receiving the highest scores for color (4.29), which was typical of milk, aroma (3.79) typical of fermented milk, texture (3.86) described as thick, and taste (2.79) with minimal cinnamon flavor. Group P1 (0.1%) remained acceptable to the panelists, whereas groups P2 (0.2%) and P3 (0.3%) demonstrated a decline in preference.

The decrease in color preference in groups P2 and P3 was due to a shift toward a darker shade caused by the addition of cinnamon. Consistent with the findings of Rohman and Maharani (2020), consumers tend to prefer bright, fresh colors because colors that are closer to the base ingredients, such as milk or fruit additives, are considered more natural and healthier (Gitama, 2020). Furthermore, in terms of aroma, cinnamon was considered too dominant, reducing the expected freshness of yogurt (Dyah and Larasati, 2022). In terms of texture, the interaction between milk proteins and cinnamon polysaccharides can alter the structure of yogurt, thereby reducing its viscosity (Smykov, 2020). Similarly, in terms of taste, the score was relatively low due to the addition of high concentrations of cinnamon, which enhanced the spicy and warm flavors that consumers disliked (Setiawan et al., 2019). Ramayanti et al. (2018) reported that using high concentrations of cinnamon extract can decrease preference. Wijaya and Carolina (2022) suggest that this decline in acceptance may be due to the panelists' age, with those aged 22-25 years generally being less familiar with spicy flavors. Preference for sweet taste was generally higher among adolescents and young adults and was influenced by individual factors, including gender and biological variation (Guarneri et al., 2025).

## CONCLUSION

The observed changes in physicochemical properties of goat milk yogurt might be attributed to interactions between bioactive compounds in cinnamon and the milk matrix during fermentation. The increase in fat content and pH at 0.2% of cinnamon suggested a potential modulation of microbial activity and protein-fat interactions. Meanwhile, the reduction in moisture content might be attributable to structural changes in the yogurt gel that enhance water retention within the matrix. Meanwhile, the absence of significant effects on the acidity and viscosity of goat milk yogurt indicated

that the addition of cinnamon did not substantially interfere with LAB activity or gel structure formation. For sensory evaluations, the acceptability of yogurt with 0.1% cinnamon indicated that low concentrations were sufficient to enhance aroma without adversely affecting taste and texture, whereas higher concentrations produced a strong flavor that reduced consumer preference. It is recommended that studies be continued by increasing the storage period to determine the effectiveness of cinnamon in maintaining the physicochemical and sensory characteristics of yogurt.

## DECLARATIONS

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**Authors' contributions**

Veronica Wanniatie contributed to the study design, analysis, and data interpretation, edited the manuscript, revised the final version, and coordinated the authors. Ema Nurlatifah made major contributions to the study design, realization, and supervision of laboratory investigations, data analysis and interpretation, and manuscript editing. Nandini Fitaloka made major contributions to the study design, realization, and supervision of laboratory investigations, data analysis and interpretation, and manuscript editing. Ratna Ermawati made contributions to the study design and revised the final edition of the manuscript. Arif Qisthon and Ali Husni made contributions to the study design, analysis, and data interpretation. All authors have read and approved the final edition of the manuscript to be published.

**Availability of data and materials**

The data to support this study's findings are available upon reasonable request from the corresponding author.

**Competing interests**

The authors have not declared any conflicts of interest.

**Ethical considerations**

This article is not submitted anywhere else, and the findings are analyzed and written under the supervision of all authors. All authors wrote the article and checked the last draft of the manuscript for the similarity index. The authors declared that no AI tools were used for writing and preparing the article. The authors accept the full responsibility of originality of the manuscript in the entire publication process.

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