Helium: Journal of Science and Applied Chemistry
https://journal.unpak.ac.id/index.php/he_jsac
Volume 4, Number 2, December 2024, Page 46 - 54
e-ISSN: 2776-4508; p-ISSN: 2776-1711
Publisher : Universitas Pakuan

A Study on the Addition of Sweet Orange (*Citrus sinensis L*) to Reduce Goaty Odor in Goat Milk-Based Yogurt

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***Article history:** received: 13-11-2024; revised: 29-11-2024; accepted: 26-12-2024; published: 27-12-2024*

ABSTRACT

This study aimed to reduce the goaty odor in goat milk yogurt by adding sweet orange (*Citrus sinensis L*). Yogurt was prepared with varying concentrations of sweet orange: 0%, 5%, 10%, and 15% (v/v). The yogurt characteristics analyzed included organoleptic properties, pH, lactic acid, protein, and moisture content. Results showed that adding 15% sweet orange was most effective in reducing goaty odor and increasing consumer preference. The yogurt pH remained stable at 4, while lactic acid content increased to 1.35% compared to the control (1.26%). Protein content decreased with increasing orange concentration, while moisture content increased. This study concludes that adding sweet oranges effectively reduces the goaty odor in goat milk yogurt, although attention should be paid to the decrease in protein content. These findings open opportunities for developing more appealing goat milk yogurt products for Indonesian consumers.

Keywords: *Citrus sinensis L*; goat milk; goaty odor; lactic acid; milk fermentation

1. INTRODUCTION

Fermentation is an ancient method of milk preservation that has been practiced for over 10,000 years in the Middle East [1]. This technique is one of the earliest recorded methods for processing and producing food. Today, milk fermentation aims to extend shelf life, enhance flavor, and create various dairy products [2]. One such product from milk fermentation is yogurt.

Yogurt is a highly popular food enjoyed worldwide. The fermentation process of milk into yogurt is assisted by good bacteria such as *Lactobacillus bulgaricus* and *Streptococcus thermophilus* [3]. Besides having a distinct and delicious flavor, yogurt is known for its digestive health benefits, as it contains probiotics that promote gut health. Yogurt contains vitamin B1, which has a structural formula similar to that of allopurinol [4]. Allopurinol is a compound commonly used to suppress uric acid production in patients by inhibiting the activity of the xanthine oxidase enzyme. Goat's milk can also enhance zinc absorption [5], and its processed products play an essential role in meeting the macro and microelement needs in the human diet [6]. In general, yogurt is made from cow milk, but some researchers have reported that it can also be made from goat milk [7] and plant-based milk. The production of yogurt from goat milk to eliminate the goat's odor by adding jackfruit pulp has been conducted by Sampurno A. (2020). The results of the study indicated that the addition of jackfruit pulp could increase the total sugar content, lower the pH, and reduce the lactic acid content [8].

Goat milk consumption among the public is relatively low. This is due to the "goaty flavor" of goat's milk, which comes from short-chain fatty acids such as lauric acid, caproic acid, caprylic acid, and capric acid [9]. In addition, the compound *4-ethyl octanal*, which is released into the air by goats, is responsible for the characteristic goat odor that attaches to the milk [10]. This is one reason many people are reluctant to consume goat milk, even though its nutritional content is far superior to cow milk.

In essence, goat milk has superior nutritional content, with approximately 4.3 grams of protein per 100 milliliters, higher than cow milk (about 3.2 grams per 100 milliliters) [11]. Goat milk is easier to digest because it can better neutralize stomach acid, and its therapeutic properties benefit human health and nutrition [6]. Additionally, goat milk possesses natural antiseptic properties that can suppress the growth and development of bacteria in the body thanks to its fluoride content, which is 10–100 times higher than cow milk [12].

The fat globules in goat's milk are smaller compared to those in cow's milk, and combined with its higher content of short- and medium-chain fatty acids, it is more easily digested [13]. Goat milk is also rich in minerals such as potassium (K), calcium (Ca), chlorine (Cl), phosphorus (P), selenium (Se), zinc (Zn), and copper (Cu), which are essential for metabolism, growth, and development, particularly in children [14]. Phosphorus in goat milk is even believed to help treat certain kidney disorders, such as nephrotic syndrome, kidney infections, and high uric acid levels [6].

However, proper processing is needed to eliminate its pungent odor and increase consumer interest in goat's milk. One effective method is by processing it into yogurt. Making yogurt can not only reduce the characteristic odor of goat's milk but also preserve its nutritional value while adding probiotic benefits that are good for digestive health[15]. Processing goat milk into yogurt is expected to remove the fishy odor (goaty aroma) and the savory taste derived from caproic acid in goat's milk when it is processed into yogurt with added sweet orange (*Citrus sinensis L*)[16] .

Sweet orange (*Citrus sinensis L*) contains various compounds contributing to its aroma, flavor, and health benefits. Limonene provides the characteristic fresh orange scent, while citral, which consists of neral and geranial, offers a strong citrus aroma and flavor. Citric acid can also aid in the fermentation process [17]. Citric acid plays a role in maintaining optimal fermentation conditions and enhancing the stability of goat's milk yogurt during production and storage [18]. Additionally, sweet orange extract contains flavonoids and other antioxidants, which offer health benefits, such as protecting against free radicals and boosting immunity.

For these reasons, the study focuses on adding sweet orange (Citrus sinensis L) extract to produce goat's milk yogurt by using *Lactobacillus bulgaricus* and *Streptococcus thermophilus* as starters. This approach is expected to reduce the goaty odor of goat's milk and improve the flavor of the resulting yogurt, providing additional health benefits for consumers.

2. METHODS

2.1. Tools and Materials

The tools used for this research were an analytical balance, spatula, stainless steel pot, hotplate, measuring cylinder, titration set, thermometer, evaporating dish, desiccator, and oven.

The materials used in producing goat's milk yogurt with sweet orange extract included goat's milk obtained from pure Etawa goats at Elfitra Farm in Tabing Banda Gadang, Nanggalo District, Padang City, West Sumatra. The milk was filtered beforehand to remove any physical impurities that may have been mixed in during the milking process. Other ingredients included Biokul yogurt (plain yogurt) containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, sweet oranges, and granulated sugar. The materials used for yogurt analysis included 0.5% $CuSO_4 \cdot 5H_2O$ in 1% Na-K tartrate, 2% Na_2CO_3 in 0.1N NaOH, Folin–Ciocalteu reagent, NaOH, phenolphthalein indicator (PP), and distilled water.

2.2. Procedures

The experiment was designed with the concentration of sweet orange extract added as the independent variable and the quality of the resulting yogurt as the dependent variable. The sample codes used in this study are presented in **Table 1**.

Table 1. Sample Codes for Goat Milk Yogurt

No	Sample	Sample Code
1	Yogurt (control)	EL0
2	Yogurt + 5 % Sweet Orange	EJ1
3	Yogurt + 10 % Sweet Orange	EJ2
4	Yogurt + 15 % Sweet Orange	EJ3

2.2.1. Production of Goat Milk Yogurt

Measured 1 liter of goat's milk is filtered and then poured into a pot, where 100 grams of sugar is added. The milk mixture is pasteurized at 61-70°C for 20-30 minutes. The pasteurized milk is then divided into four portions of 200 ml each, placed in separate containers. Sweet orange juice is added in varying concentrations of 0%, 5%, 10%, and 15% (v/v). Next, the mixture is pasteurized for 5 minutes while stirring until well combined. It is then transferred to coded plastic containers according to the treatment applied. A yogurt starter culture is added at a rate of 10 grams, followed by gentle stirring. The containers are sealed tightly and incubated at 40°C for 24 hours.

After fermentation, the goat milk yogurt is transferred into packaging and stored in the refrigerator for 24 hours.

2.2.2. Analysis of the Characteristics of Goat Milk Yogurt

2.2.2.1. Organoleptic Testing

Organoleptic testing involves collecting data on consumer preferences from 20 participants regarding the yogurt product. The parameters assessed include aroma, taste, and texture. The evaluation uses a scale that reflects the degree of preference, categorized as follows:

1 = Dislike
2 = Slightly Like
3 = Like
4 = Very Much Like

2.2.2.2. Lactic Acid Content Testing

The total acid number is conducted by using an acid-base titration method. A 1-gram sample of used cooking oil was added to 10 mL of distilled water in an Erlenmeyer flask, followed by three drops of *phenolphthalein* (PP) indicator. The sample is titrated with 0.1 M NaOH until the endpoint of the titration is reached. The acidity is calculated by using the following equation:

$$AV = \frac{ml\ KOH \times N\ KOH \times BM\ KOH}{Weight\ of\ Sample}$$

2.2.2.3. pH Testing of Yogurt

The pH was tested using a universal pH indicator immersed in the sample. The results were indicated by a color change on the universal pH indicator, which was then compared with the standard color scale provided on the indicator packaging.

2.2.2.4. Protein Content Testing

The protein content is measured by using the Lowry method. This method relied on the use of copper sulfate as a complexing agent. To conduct the protein content test, 5 grams of the sample is diluted in 50 mL of distilled water. Then, 1 mL of the sample is pipetted and mixed with Lowry reagent, which contains a mixture of *Folin-Ciocalteu* reagent and copper salt reagent.

A calibration curve is created using standard serum albumin solutions at concentrations of 100 ppm, 200 ppm, 300 ppm, 400 ppm, 500 ppm, and 600 ppm, measured with a UV-Vis spectrophotometer at a maximum wavelength of 750 nm. The protein concentration in the sample is determined by comparing the sample's absorbance values against this calibration curve to calculate the protein content.

2.2.2.5. Water Content Testing

The moisture content in yogurt affects its texture, flavor, and consistency. Inaccurate moisture levels can create a conducive environment for the growth of microorganisms, such as bacteria, which can lead to product spoilage. The moisture content is determined by oven-drying 5 grams of the sample at 110°C for 6 hours. The moisture content can be calculated by using the following equation:

$$\%\ Water\ Content = \frac{Dry\ Mass\ of\ Sample}{Wet\ Mass\ of\ Sample} x100\ \%$$

3. RESULTS AND DISCUSSION

This study aims to create yogurt from goat milk with sweet orange juice. Goat milk tends to have a lower fat content than cow milk, allowing the resulting yogurt to have a smoother texture and be more easily digestible, especially for individuals

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sensitive to cow milk [5]. Additionally, the addition of sweet orange juice aims to reduce the characteristic goaty aroma of goat milk.

The bacteria used in producing goat milk yogurt are a mixture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. These bacteria are chosen for their ability to convert lactose (milk sugar) into lactic acid [19]. This process produces the characteristic sour taste of yogurt but also aids in forming a thick and creamy texture. The fermentation of yogurt occurs under anaerobic conditions, meaning without the presence of oxygen. In these conditions, electron transfer through the enzymes in the cell membrane does not happen directly, as it does in aerobic respiration [20]. Oxygen, which serves as the final electron acceptor in the aerobic respiratory electron transport chain, is absent in this system [19]. The addition of granulated sugar provides sufficient nutrients for the growth of lactic acid bacteria, accelerating their growth. As a result, the degradation of sugar occurs more quickly, leading to a higher concentration of lactic acid [12].

The research results on goat milk yogurt with the addition of sweet orange extract show significant findings, particularly in reducing the typical goaty aroma often associated with goat milk. In yogurt with a sweet orange extract concentration of 15% (EJ15), goat milk's usually strong goaty aroma was successfully eliminated. In contrast, the goaty aroma in the control (EL0) was still detected, indicating a clear difference between the two samples.

The goaty aroma in goat milk is usually caused by volatile compounds such as short-chain fatty acids, especially caproic acid, caprylic acid, and capric acid [21]. These compounds produce a distinctive and often sharp aroma that is frequently unappealing to consumers. When the sweet orange extract is added, this goaty scent may be lessened because its constituents, flavonoids, essential oils, and citric acid, act to counteract or bind the volatile substances that generate the stench.

Sweet orange essential oil, especially limonene, serves as an aroma-masking agent, hiding offensive odors with the crisp orange aroma [22]. Additionally, citric acid in oranges can reduce the volatility of short-chain fatty acids, thereby decreasing the intensity of the goaty aroma [23]. The combination of various active compounds in this orange extract works synergistically to reduce or cover up the overpowering goaty smell in goat milk; several active ingredients work in concert.

3.1. Organoleptic Test Results

The results of the organoleptic analysis of goat milk yogurt indicate that increasing the concentration of sweet orange tends to improve the ratings for aroma, texture, and flavor.

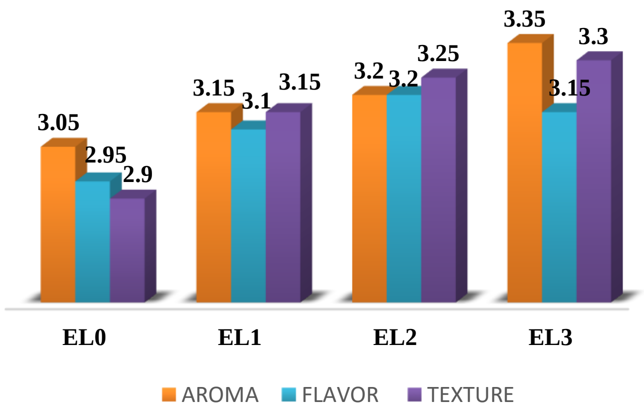

Figure 1. Organoleptic Results for Aroma, Flavor, and Texture of Goat Milk Yogurt

The improvement in the aroma is influenced by compounds like limonene and citral, which give oranges their unique citrus scent and impact the improvement in the aroma. After fermenting, goat milk's naturally occurring gamey or "goaty aroma" becomes less noticeable or disappears. This is due to the presence of citric acid, which helps enrich the overall aroma, creating a more complex and appealing scent profile. The organoleptic test results showed that consumers highly preferred the aroma of the yogurt with the addition of sweet orange. Adding sweet orange successfully eliminated the goat-like smell in the goat milk yogurt, which was successfully removed by adding sweet orange. Numerous substances, including lactic acid, pyruvic acid, oxalic acid, and volatile acids (formic acid, acetic acid, and propionic acid), are produced during the fermentation process and also help to change the yogurt's aroma [16][24].

The increasing flavor enhancement in this product is attributed to the addition of sweet orange juice. As the concentration of orange juice increases, the sweet and tangy flavor of the orange

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becomes more dominant, enriching the overall taste of the yogurt. In addition to lessening the distinctive goat flavor frequently present in goat milk yogurt, the panelists found that adding orange juice produced a more balanced and refreshing flavor. The higher the concentration of orange, the stronger and richer the flavor created, making the product more enjoyable and appealing to consumers.

The fermentation process in yogurt production is characterized by an increase in lactic acid levels and a decrease in pH, leading to the coagulation of casein and resulting in a thicker texture compared to milk [18]. However, the viscosity of the yogurt changes when sweet orange juice is added. Because orange juice contains water, it thins out the yogurt and makes it less viscous than yogurt without orange juice [25]. Organoleptic analysis indicates that including sweet orange juice enhances the yogurt's texture, making it smoother and less thick. Despite this reduction in viscosity, the addition of sweet orange juice positively influences the organoleptic quality of the product, resulting in a softer texture that is more appealing and preferred by consumers.

3.2. Lactic Acid Content Analysis

The analysis of lactic acid content revealed a slight increase in lactic acid levels with the addition of sweet orange. After the incorporation of sweet orange at concentrations ranging from 5% to 15%, the lactic acid content increased to 1.35%, compared to 1.26% in the control sample.

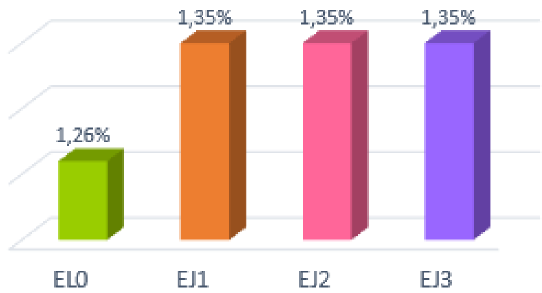

Figure 2. Percentage of Lactic Acid Content in Goat Milk Yogurt

According to the observed trend, lactic acid levels increased when sweet orange juice was added up to a 5% concentration. However, beyond this point, further increases in sweet orange concentration did not significantly affect lactic acid levels. The stability of lactic acid levels at higher sweet orange concentrations is likely attributed to the lactic acid formation mechanism having reached its optimal limit under the fermentation conditions present during yogurt production [26][27].

Additionally, high concentrations of citric acid can affect the stability of other enzymes, thereby disrupting the overall fermentation process. Lactic acid bacteria (LAB), such as *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, are capable of metabolizing citric acid from orange juice through specific metabolic pathways [26]. When it metabolizes citric acid, the bacteria's energy is diverted toward processing citric acid rather than fully fermenting lactose (milk sugar) into lactic acid. This shifts the main metabolic pathway from lactic acid production to the formation of other compounds [28]. High levels of citric acid may act as an enzyme inhibitor, mainly targeting enzymes involved in lactose metabolism, such as lactate dehydrogenase (LDH). LDH is a key enzyme responsible for converting pyruvate (an initial product of sugar fermentation) into lactic acid [29].

The resulting yogurt's lactic acid concentration meets SNI 2981:2009 requirements for both with and without the addition of sweet orange juice, which specifies a total acid range of 0.5–2%. This suggests that including sweet orange juice does not compromise the product's compliance with regulatory quality standards.

3.3. Yogurt pH Test Results

The pH test results for goat milk yogurt indicate that the pH values across all treatments (EL0, EJ1, EJ2, and EJ3) tend to remain constant at approximately 4 despite adding sweet orange at varying concentrations.

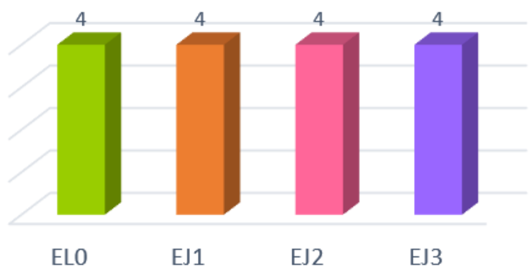

Figure 3. pH Test Results of Goat Milk Yogurt

The pH of the resulting yogurt, measured at 4, meets the SNI 2981:2009 standard, which requires a minimum pH of 3.8 and a maximum pH of 4.4. The increase in the amount of sweet orange juice added has no appreciable changes in the pH levels of goat milk yogurt. This stability is most likely caused by the yogurt's natural acidity, which cannot be significantly changed by the small amounts of sweet orange juice added [30]. The acquired data did not clearly show insignificant pH variations. This was ascribed to the poor sensitivity and precision of the universal indicator paper used for pH measurement. The universal indicator paper provides only a general color range, making it challenging to identify slight changes in pH. Additionally, the accuracy of pH measurement using this method can be affected by subjective interpretation of color changes [31].

3.4. Protein Content Analysis

The protein concentration in the samples was determined by comparing their absorbance values against the calibration curve, which allows for the calculation of protein content within the samples.

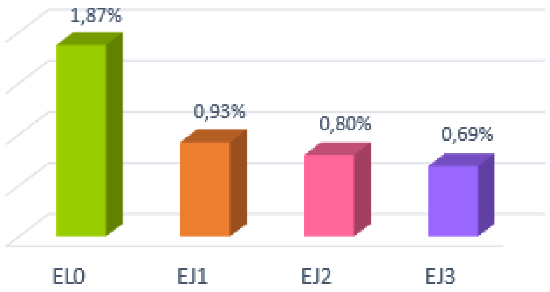

Figure 5. Percentage of Protein Content in Goat Milk Yogurt

The protein content in goat milk yogurt decreased with the increase in sweet orange added. In the control sample (EL0), the protein content was recorded at 1.87%. However, there was a noticeable drop in protein content after adding sweet orange. Citric acid, the fruit's predominant acid, is found in sweet oranges and can denaturize milk proteins [32]. Citric acid lowers the pH of the solution, which in turn disrupts the three-dimensional structure of the protein, leading to a loss of functionality and stability [33]. Casein, which is usually stable at a pH of around 6.6 to 6.7, begins to denature when the pH drops below this range, especially as it approaches its isoelectric point (around pH 4.6) [34]. Sweet orange juice has a pH of about 3.5, so the more sweet orange juice added before the fermentation process, the more acidic the milk becomes, ultimately leading to the denaturation of casein protein [35]. Consequently, the increased amount of sweet orange added reduces the protein content of the resulting yogurt.

Furthermore, the pasteurization process of milk at 70 °C also contributes to the denaturation of proteins in goat milk, particularly casein and whey proteins [36]. Casein, which is first dissolved in micellar form, starts to separate into a non-micellar form at this temperature, which could cause coagulation [37]. Whey proteins like β-lactoglobulin and α-lactalbumin also undergo structural changes when heated to this temperature. Because of the disruption of hydrogen bonds and hydrophobic interactions, proteins lose their three-dimensional structure [38]. The process of protein denaturation is a significant factor in the final yogurt's decreased protein level. Therefore, it is crucial to control pasteurization temperatures carefully to prevent excessive protein denaturation, which could affect the nutritional quality and texture of the yogurt [33] .

3.5. Analysis of Water Content

The water content analysis in goat milk yogurt indicated that the water content increased with more significant amounts of sweet orange.

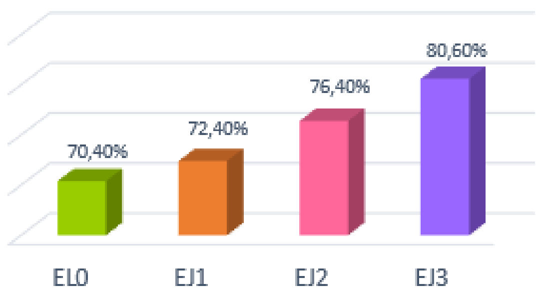

Figure 6. Percentage of Water Content in Goat Milk Yogurt

The increase in water content observed in the yogurt is attributed to the high water content of the sweet orange, which significantly contributes to the overall water content in the yogurt. Sweet oranges contain approximately 87.2 grams of water per 100 grams of fruit. Some sources suggest that the water content can reach up to 85% of the total weight of the fruit [25]. This high water content from the sweet orange extract influences the yogurt's final texture, making it less viscous and contributing to a smoother mouthfeel. The incorporation of sweet orange not only affects the flavor and aroma but also plays a key role in altering the moisture balance of the product.

Additionally, the denaturation of proteins due to the decrease in pH upon the addition of citrus acid causes the proteins in the yogurt to bind to water less effectively [39]. This results in more water remaining in the yogurt mixture, and according to the investigation, adding more sweet orange to goat milk yogurt results in a higher water content.

4. CONCLUSION

The addition of sweet orange extract (Citrus sinensis L.) in goat milk yogurt production effectively reduces the goaty aroma, with a 15% concentration yielding the most preferred aroma and flavor, as it masks the characteristic smell of goat milk while maintaining optimal fermentation conditions in line with SNI 01-2981-2009. However, excessive citrus addition may lower the protein content, affecting nutritional value. To address this, milder, less acidic orange varieties and lower pasteurization temperatures are recommended to prevent protein denaturation. These findings highlight potential improvements in developing goat milk yogurt with enhanced sensory appeal and preserved nutritional quality, catering to consumer preferences in Indonesia.

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