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Organoleptic and Physicochemical Profile Comparison of Cow Milk Yogurt and "Eggurt" Made from Different Egg Whites

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***Abstract*— Yogurt is a widely consumed fermented dairy product known for its distinctive flavor, nutritional value, and health benefits. To expand its nutritional profile and enhance textural qualities, this study explores the use of egg whites as an alternative ingredient in yogurt production. The research compares the sensory and physicochemical properties of traditional milk yogurt with "eggurt" a yogurt variant made using different egg white sources: free-range chicken, caged chicken, and duck eggs. Four samples were prepared, including one control (milk yogurt) and three "eggurt" variants. Sensory quality was evaluated through organoleptic testing using a structured Likert scale to assess attributes such as color, surface gloss, aroma, mouthfeel, and flavor. Physicochemical analysis included moisture content, total dissolved solids, viscosity, ash content, and acidity measurements. Results showed that free-range "eggurt" was most like milk yogurt in terms of texture and flavor, displaying balanced viscosity and minimal surface liquid separation. In contrast, caged "eggurt" exhibited increased surface liquid, higher ash content, and stronger acidity, while duck eggurt was noted for its excessive thickness, very high viscosity, and pronounced acidity. These textural and compositional differences, despite the higher production costs, suggest that free-range "eggurt" is the most promising alternative, offering a comparable sensory experience to traditional yogurt while enhancing texture and overall quality.

***Keywords*— yogurt alternative, egg yogurt, egg white, organoleptic testing, sensory evaluation, physicochemical properties

I. Introduction

Yogurt is a widely appreciated fermented dairy product known for its unique flavor, nutritional richness, and health benefits. It is produced through the fermentation of milk by lactic acid bacteria, primarily *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Yogurt is a type of weak protein gel induced by acidification, providing benefits such as improved gastrointestinal health, reduced blood cholesterol, and enhanced immune function (Sidira et al., 2017). In recent years, consumer interest in functional foods has increased, leading to the development of new yogurt varieties with enhanced flavors and health benefits that appeal to a broader audience (Mohammadi-Gouraji et al., 2019).

Traditionally, yogurt's gel-like texture is achieved through the acid-induced coagulation of milk proteins, particularly casein (Aryana & Olson, 2017). However, as consumer demand for novel and nutritious products increases, there has been a shift towards incorporating alternative ingredients beyond dairy, such as soy, nuts, and plant extracts (Barukčić et al., 2022; Ozturkoglu-Budak et al., 2016; Qiu et al., 2021; Y. Zhang et al., 2024). Several previous studies have explored the incorporation of alternative ingredients into yogurt to enhance its nutritional value and appeal. For instance, Qiu et al. (2021) examined the use of edible flower extracts to improve antioxidant properties, while Mohammadi-Gouraji et al. (2019) investigated the effects of spirulina extract on the antibacterial and physicochemical properties of yogurt. Despite the breadth of innovations in yogurt formulations, the incorporation of egg whites as a protein-rich alternative remains underexplored, highlighting a unique area for further investigation.

Eggs, particularly egg whites, stand out as promising additions to yogurt production due to their high protein content, which is approximately four times higher than that of milk. The proteins in egg whites, mainly albumin, are known for their excellent gel-forming properties, making them suitable for developing acid-induced gels like those found in traditional set yogurt (Zang et al., 2023). This gel-forming ability suggests that egg whites could significantly enhance both the texture and the nutritional profile of yogurt. Egg whites offer a viable, protein-rich alternative to conventional dairy-based ingredients while maintaining desirable sensory qualities.

In the context of ingredient availability, Indonesia presents a unique opportunity for utilizing eggs in yogurt production. With substantial annual production figures for caged chicken eggs (6,117,905.40 tons), free-range chicken eggs (388,461.90 tons), and duck eggs (358,220.20 tons), the country has an abundant supply of diverse egg varieties (Direktorat Jenderal Peternakan dan Kesehatan Hewan, 2023). In comparison, the annual production of cow milk was recorded at 837,223.19 tons in 2023, highlighting a significant gap between egg and milk supply. Additionally, projections indicate a surplus in egg production by the end of 2024, suggesting a sustainable source of raw materials for innovative food products (Direktorat Ketersediaan Pangan, 2024). The diverse availability of eggs could serve as a cost-effective and resource-efficient alternative to traditional dairy ingredients, addressing both market demand and sustainable production needs.

Studies incorporating eggs into yogurt mainly focused on the addition of whole egg liquid, highlighting improvements in yogurt texture and gel strength. (Yang et al., 2024; J. Zhang et al., 2023)However, these studies primarily used whole eggs rather than isolated egg whites and did not differentiate the effects of specific egg types on yogurt properties. Moreover, there is limited research analyzing the impact of different egg white varieties—such as free-range, caged, and duck eggs—on the sensory and physicochemical characteristics of yogurt. Zang et al. (2023) demonstrated the potential of egg proteins in forming stable acid-induced gels but did not consider the variability among different egg sources or their comparative effects on yogurt quality.

This study aims to address this gap by comparing the sensory quality and physicochemical properties of yogurt made from cow milk with "eggurt," a yogurt alternative made from different types of egg whites (free-range chicken, caged chicken, and duck eggs). Specifically, organoleptic tests will assess sensory characteristics, while physicochemical analyses will examine water content, total dissolved solids, viscosity, ash content, and acidity levels. This comparative analysis is intended to determine if egg-based yogurts can achieve quality comparable to traditional cow milk yogurt, potentially providing a viable dairy alternative. Additionally, considering Indonesia's surplus egg production, this study highlights a practical approach to utilizing locally abundant resources for innovative yogurt formulations, providing valuable insights for the food industry and potential avenues for product diversification.

II. METHODS

This study employed an experimental research design to compare the sensory quality and physicochemical properties of traditional cow milk yogurt with egg-based yogurt alternatives, referred to as "eggurt," made using different types of egg whites (free-range chicken, caged chicken, and duck eggs). The research was conducted in several stages, including sample preparation, sensory evaluation, physicochemical analysis, production cost analysis and statistical analysis. The methods were based on existing literature with necessary adaptations to suit the specific requirements of this study.

A. Sample Preparation

Full-cream cow's milk, sterilized using ultra-high temperature (UHT), was obtained from Ultrajaya Milk Industry (Jawa Barat, Indonesia). Fresh free-range eggs, caged eggs, and duck eggs were purchased from the local market Pasar Pagi Rawamangun (Jakarta, Indonesia). A yogurt starter culture containing Lactobacillus bulgaricus and Streptococcus thermophilus in a 1:1 ratio, obtained from Sukanda Djaya (Jawa Barat, Indonesia), was used to initiate the fermentation for both yogurt and eggurt production.

The preparation of "eggurt" followed a modified method adapted from Indratiningsih et al. (2011). Four types of samples were prepared: a control sample (traditional cow milk yogurt) and three eggurt variants made from different egg white types. For the control sample, 400 mL of full-cream cow's milk was mixed with 40 g of milk powder and 40 g of granulated sugar. This mixture was pasteurized at 85°C for 30 minutes. For the eggurt variants, each type of egg white was pasteurized separately at 63°C for 5 minutes before being incorporated into the milk mixture along with the starter culture. All mixtures were then incubated at 42°C for 20 hours to facilitate fermentation and curd formation.

B. Sensory Evaluation

The sensory evaluation was designed to assess the organoleptic attributes of the samples using a structured Likert scale. The method was adapted from Zang et al. (2023) to include attributes specific to egg-based yogurt products. The evaluated sensory qualities included color, surface gloss, consistency, surface liquid amount, yogurt aroma, mouthfeel, sweetness, acidic fermentation taste, milky flavor, and potential egg-like off-flavors. The evaluation involved 30 semi-trained panelists aged 18 to 25, who rated each attribute on a 5-point Likert scale ranging from strong dislike to strong like, as shown in Table 1. The results of the sensory evaluation provided valuable insights into consumer perception of the different yogurt and eggurt samples.

Table 1. Likert scale questionnaire instrument for the organoleptic test.

Sensory quality	Likert scale				
	1	2	3	4	5
Color	Grayish white	Creamy white	Yellowish white	Milky white	Very milky white
Surface gloss	Dull	Not glossy	Slightly glossy	Glossy	Very glossy
Thickness	Not thick	Less thick	Slightly thick	Thick	Very thick
Surface liquid amount	Very much	Much	Somewhat much	Little	Very little
Yogurt aroma	Very weak	Not strong	Less strong	Strong	Very strong
Softness (mouthfeel)	Not soft	Less soft	Slightly soft	Soft	Very soft
Sweetness	Very unsweet	Not sweet	Less sweet	Slightly sweet	Sweet
Fermented sourness	Very unsour	Not sour	Less sour	Slightly sour	Sour
Milky flavor	Very weak	Not strong	Slightly strong	Strong	Very strong
Egg-like flavor	Very weak	Not strong	Slightly strong	Strong	Very strong

C. Physicochemical Analysis

The physicochemical properties of the samples were analyzed following the guidelines set by the Indonesian

National Standard (SNI 01-2891-1992). Moisture content was determined using an oven drying method in which samples were dried and weighed until a constant weight was achieved. Ash content was measured by ashing samples in an electric furnace at 550°C until only inorganic residue remained(Badan Standardisasi Nasional, 1992). Both analyses were used to determine the basic composition of the yogurt and eggurt samples.

Additional physicochemical properties were evaluated using specialized instruments. Total dissolved solids (TDS) were measured in degrees Brix with an Atago N1 alpha refractometer (ATAGO, Tokyo, Japan). Acidity was determined with an AD110 pH meter (Adwa Instruments, Szeged, Hungary), and viscosity was measured using a Brookfield RVT viscometer (AMETEK Brookfield, Massachusetts, USA) with spindle No. 2 at 4 rpm.

D. Production Cost Analysis

The production cost for each yogurt and eggurt variant was calculated based solely on the direct materials used, as the labor and indirect costs (e.g., equipment, rent, and depreciation) were consistent across all samples. The direct materials included full-cream cow's milk, sugar, powdered milk, yogurt starter, free-range chicken eggs, caged chicken eggs, and duck eggs. The prices of these materials were sourced from the local market during the first week of August 2024. Total production costs for each variant were calculated by summing the costs of these materials for each treatment. The cost per unit volume (liter) was then determined to compare production costs among the yogurt and eggurt samples.

E. Statistical Analysis

Data analysis involved both descriptive and inferential statistical methods. The sensory quality data, based on the Likert scale ratings, were summarized using mode and median values for each attribute. The physicochemical data, presented as mean values, were analyzed using one-way ANOVA to test for differences among the sample groups. The assumption of homogeneity was first tested using Levene's test. If the assumption of homogeneity was met, standard ANOVA was performed; otherwise, Welch's ANOVA was applied. Post hoc comparisons using the Games-Howell test were conducted for any statistically significant differences to identify specific group differences. This robust statistical approach ensured that the findings were reliable and accounted for variations in sample properties.

III. Results and Discussion

The sensory evaluation comparing milk yogurt (control group) and the eggurt variants (free-range, caged, and duck eggurt) revealed a mix of consistent findings and notable distinctions. As shown in Table 2, sensory attributes such as color, surface gloss, yogurt aroma, sweetness, fermented sourness, milky flavor, and egg-like flavor showed no significant variation across the samples. This consistency indicates that the inclusion of egg whites did not alter these particular sensory characteristics. On the other hand, the physicochemical properties (shown in Table 3) revealed distinct differences, underscoring the impact of egg addition on texture and composition, and suggesting correlations between these properties and the sensory experience of the products.

In terms of color, as depicted in Figure 1, there were no statistically significant differences between the eggurt variants and milk yogurt. However, visual analysis suggested that caged eggurt and duck eggurt had a slightly more "yellowish white" appearance compared to the control. This aligns with previous research showing that increasing the amount of liquid whole egg can intensify the yellow hue of yogurt (Yang et al., 2024). While the statistical tests did not confirm significant changes in color, the subtle visual differences might still influence consumer perception, hinting at a perceptible shift in appearance due to the egg addition.

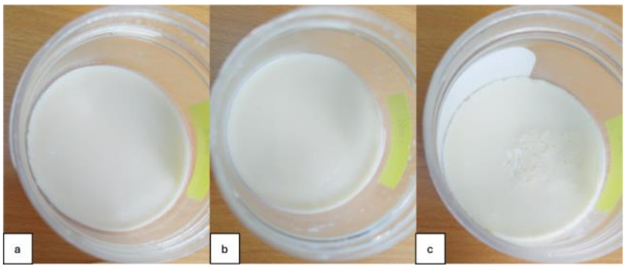

Figure. 1. Appearance of Eggurt Variants: (a) Free-range Eggurt, (b) Caged Eggurt, and (c) Duck Eggurt

Textural differences were evident, particularly in thickness and viscosity. Duck eggurt was notably rated as thicker than milk yogurt, indicating a firmer consistency, with free-range eggurt also showing increased thickness. This sensory perception was mirrored in the physicochemical analysis, in which duck eggurt displayed the highest viscosity (4967 cP), followed by free-range eggurt (2900 cP). The lower viscosities of milk yogurt and caged eggurt reinforced these findings. The connection between perceived thickness and actual viscosity highlights the impact of egg incorporation, especially duck egg, in enhancing the textural properties. Higher protein content in duck eggurt likely contributed to the development of a denser gel matrix, creating a firmer and thicker product (Chaiyasit et al., 2019).

The effect of egg whites, particularly albumin, on viscosity was profound. The addition of albumin boosted the yogurt's viscosity, leading to a thicker and more stable texture (Ko, 1995; Yang et al., 2024). This can be attributed to the protein's ability to create a robust three-dimensional network within the yogurt matrix, enhancing its structural stability (Yang et al., 2024). Furthermore, yogurt enriched with egg white exhibited shear-thinning behavior—a hallmark of non-Newtonian fluids—indicating that the gel network maintains stability under low shear conditions (Cui-hua et al., 2023). The higher gel hardness observed in duck egg albumen compared to chicken albumen supports the role of egg proteins in improving texture (Chaiyasit et al., 2019).

A closer look at the surface liquid amount revealed clear

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Table 2. Comparison of sensory quality among milk yogurt and different eggurt types (free-range, caged, and duck eggurt)

Sensory quality	Type of eggurt			
	Milk yogurt (control group)	Free-ranged eggurt	Caged eggurt	Duck eggurt
Color	Milky white[1]	Milky white[1]	Yellowish white[1]	Yellowish white[a,1]
Surface gloss	Glossy[a,1]	Glossy[1]	Slightly glossy[1]	Glossy[1]
Thickness	Not thick[1]	Not thick[2]	Not thick[1]	Thick[a,3]
Surface liquid amount	Very little[1]	Very little[1]	Somewhat much[2]	Much[3]
Yogurt aroma	Strong[1]	Less strong[1]	Strong[1]	Less strong[1]
Softness (mouthfeel)	Very soft[1]	Very soft[1]	Soft[1]	Soft[2]
Sweetness	Less sweet[1]	Sweet[1]	Less sweet[1]	Sweet[1]
Fermented sourness	Less sour[a,1]	Less sour[1]	Slightly sour[1]	Slightly sour[1]
Milky flavor	Strong[1]	Strong[1]	Slightly strong[1]	Strong[1]
Egg-like flavor	Very weak[1]	Very weak[1]	Not strong[a,1]	Very weak[1]

a. Multiple modes exist. The smallest value is shown.
b. Different superscript numbers within each characteristic indicate statistically significant differences among the eggurt types, as determined by post-hoc analysis ($p < 0.05$).

differences among the samples. Duck eggurt had a higher amount of surface liquid compared to milk yogurt, while caged eggurt was rated as having "somewhat much" liquid, contrasting with the "very little" surface liquid observed in milk yogurt. This finding aligns with the physicochemical data, in which milk yogurt had the highest water content and caged eggurt the lowest, indicating variations in moisture retention. The inverse relationship between water content and surface liquid suggests that higher water content in yogurt leads to less visible surface liquid, while lower water content might increase the likelihood of syneresis.

Egg white addition has been shown to enhance water holding capacity (WHC), particularly when used at higher concentrations, improving the product's moisture retention (Yang et al., 2024). However, this improvement can diminish over time due to syneresis, as evidenced by the gradual reduction in moisture content during storage of egg-enriched yogurt (Djilali et al., 2021). Thus, while egg white initially helps stabilize moisture content, prolonged storage may lead to increased separation of liquid, impacting the texture and overall stability of the eggurt.

Regarding mouthfeel, duck eggurt was perceived as "soft," a firmer texture compared to the "very soft" mouthfeel of milk yogurt. The improved firmness is likely due to the inclusion of egg whites, which contribute to better gel formation and structure. Egg white proteins are known to enhance coagulation, leading to a more cohesive and stable product with reduced risk of syneresis (Djilali et al., 2021). This highlights the role of egg white in improving the structural integrity of eggurt, distinguishing it from traditional milk yogurt.

Flavor attributes, including sweetness, sourness, milky flavor, and egg-like flavor, did not show significant differences among the eggurt variants. The presence of egg white did not notably alter the flavor profile, suggesting that its impact on taste was minimal. However, at higher concentrations, egg white was reported to impart a subtle, delicate taste, enhancing the overall flavor complexity without dominating the typical yogurt notes (Yang et al., 2024). These results imply that egg white addition may improve the texture of eggurt without compromising its familiar yogurt taste.

Significant differences in ash content were observed, with duck eggurt showing the highest values compared to milk yogurt and free-range eggurt. This increase in ash content can be attributed to the higher mineral content of egg whites, which add essential minerals to the yogurt matrix (Gogo, 2012). However, a decrease in mineral content over time was noted during storage, likely due to interactions between the mineral elements and other yogurt components, such as proteins and lipids. Additionally, a reduction in total dry matter was attributed to nutrient consumption by lactic acid bacteria during fermentation (Djilali et al., 2021).

While total dissolved solids (TDS) did not differ significantly across the samples, the addition of egg white generally increased the total solids content due to its high protein and mineral contributions. The elevated total solids content improved the WHC, reducing moisture loss and enhancing the stability of the yogurt (Gogo, 2012). These findings indicate that while TDS remained consistent, the overall increase in total solids contributed positively to the product's texture and stability.

Acidity (pH) levels varied notably among the samples, with duck eggurt having the lowest pH, indicating a stronger acidic taste. Caged eggurt also had a lower pH compared to milk yogurt, reflecting a more pronounced sourness. This suggests that the type of egg used can influence the final acidity and perceived sour taste of the product. The buffering capacity of egg white proteins appeared to slow down the acidification process, delaying the reduction in pH (Djilali et al., 2021; Yang et al., 2024). Higher egg white content was associated with a less acidic yogurt, likely due to the enhanced buffering effect (Ko, 1995), whereas lower buffering capacity led to increased lactic acid production and higher acidity (Lyu et al., 2023).

Table 3. Physicochemical properties of eggurt variants

Physicochemical properties	Type of eggurt			
	Milk yogurt (control group)	Free-ranged eggurt	Caged eggurt	Duck eggurt
Water content (%)	80.12^{1}	76.29^{1}	63.96^{1}	70.50^{1}
Total dissolved solids (°Bx)	25.00^{1}	24.67^{1}	24.33^{1}	24.67^{1}
Viscosity (cP)	2450^{1}	2900^{2}	2650^{1}	4967^{3}
Ash content (%)	1.17^{1}	1.50^{1}	1.83^{2}	2.59^{1}
Acidity (pH)	4.93^{1}	4.93^{1}	4.88^{2}	4.84^{3}

a. Different superscript numbers within each properties indicate statistically significant differences among the eggurt types, as determined by post-hoc analysis ($p < 0.05$).

Overall, the results highlight the interconnected nature of sensory and physicochemical properties in both yogurt and eggurt variants. Increased viscosity was linked to thicker textures, while greater sourness correlated with lower pH values. Additionally, higher water content was associated with less surface liquid, suggesting effective moisture retention. Yogurt enriched with egg white scored well on sensory evaluations, especially when moderate egg addition was used, resulting in a balanced texture and mouthfeel (Ko, 1995). Panelists preferred smooth-textured products, further supporting the enhancement of texture through egg white addition, which promotes a cohesive gel matrix (Gogo, 2012). These insights underscore the potential of eggurt as a potential alternative to traditional milk yogurt, offering unique textural benefits without compromising flavor.

Among the three eggurt variants, free-range eggurt showed the closest resemblance to milk yogurt, with a slightly thicker texture and higher viscosity, making it a well-balanced alternative without being excessively thick. It retained similar sensory characteristics, including color, sweetness, and milky flavor, while maintaining stable moisture retention and a minimal amount of surface liquid. In contrast, caged eggurt exhibited less favorable properties, characterized by a higher amount of surface liquid, elevated ash content, and stronger acidity, which could affect the overall quality and consumer acceptance. Duck eggurt, although offering the thickest texture and highest viscosity, presented some drawbacks, including excessive thickness and a large amount of surface liquid, alongside stronger acidity, making it less ideal as a direct replacement for milk yogurt due to its pronounced textural differences. Thus, free-range eggurt emerges as the most promising alternative, providing a texture and flavor profile closest to that of traditional milk yogurt without the issues associated with excessive thickness or undesirable acidity.

The production cost analysis revealed that the direct material costs per liter varied significantly among the yogurt and eggurt variants. Milk yogurt had the lowest production cost at Rp26.096,00 per liter, followed by caged eggurt at Rp29.290,00 per liter, and duck eggurt at Rp32.680,00 per liter. Free-range eggurt had the highest production cost at Rp 36.860,00 per liter, primarily due to the higher price of free-range chicken eggs. These results indicate that the inclusion of eggs, particularly free-range chicken eggs, substantially increases production costs compared to traditional milk yogurt. The findings are consistent with other studies, who reported cost variations based on added ingredients in yogurt production. While the costs of eggurt variants are higher, they remain competitive with commercial yogurt prices, which range between Rp35.000,00 and Rp120.000,00 per liter, depending on flavor and type (Sulistyowati et al., 2024). This highlights the economic feasibility of eggurt as a premium yogurt alternative, particularly for free-range eggurt, which combines innovative formulation with competitive market pricing.

This study has several limitations that should be acknowledged. Firstly, the research did not explore the effects of varying concentrations of egg whites on the sensory and physicochemical properties of eggurt. Investigating a range of egg white concentrations could provide a more comprehensive understanding of the optimal formulation that balances desirable texture and flavor without compromising stability. Additionally, the study did not assess changes in pH and acidity levels over an extended shelf-life period. Monitoring these parameters

Table 4. Breakdown of direct material costs for milk yogurt and eggurt variants (per liter)

Items	Price	Amount per L	Milk yogurt	Free-ranged eggurt	Caged eggurt	Duck eggurt
Full-cream cow milk	Rp21.700,00/ L	800 mL	Rp19.096,00	Rp17.360,00	Rp17.360,00	Rp17.360,00
Sugar	Rp17.500,00/ kg	80 gr	Rp1.400,00	Rp1.400,00	Rp1.400,00	Rp1.400,00
Powdered milk	Rp30.000,00/ kg	80 gr	Rp2.400,00	Rp2.400,00	Rp2.400,00	Rp2.400,00
Starter	Rp80.000,00/ kg	40 gr	Rp3.200,00	Rp3.200,00	Rp3.200,00	Rp3.200,00
Free-ranged chicken egg	Rp62.500,00/ kg	200 gr	-	Rp12.500,00	-	-
Caged chicken egg	Rp34.000,00/ kg	145 gr	-	-	Rp4.930,00	-
Duck egg	Rp52.000,00/ kg	160 gr	-	-	-	Rp8.320,00
		Total price per L	Rp26.096,00	Rp36.860,00	Rp29.290,00	Rp32.680,00

during storage would be essential to determine the stability of the eggurt, especially since the buffering capacity of egg proteins may alter the product's acidity profile over time.

Another limitation of this study is the absence of microbial analysis, which would help evaluate the impact of egg white addition on the growth and activity of lactic acid bacteria, crucial for the fermentation process and potential probiotic benefits. Furthermore, the sensory evaluation relied on semi-trained panelists, which may not fully reflect the preferences of general consumers. Including a broader, more diverse panel of tasters could provide better insights into consumer acceptance. Lastly, the use of a single yogurt starter culture might have limited the exploration of interactions between different bacterial strains and egg components. Future research should consider testing multiple starter cultures to examine their potential effects on the sensory and health properties of eggurt, thereby providing a more holistic understanding of this innovative product.

IV. Conclusion

This study demonstrates that eggurt, particularly when made with free-range chicken egg whites, can serve as a promising alternative to traditional milk yogurt. Free-range eggurt showed strong similarity to milk yogurt in sensory and physicochemical properties, displaying a balanced texture, moderate viscosity, and effective moisture retention. While its production cost per liter was higher than milk yogurt, it remains competitive within the commercial yogurt market. The results address the research gap by highlighting the potential of free-range chicken egg whites, instead of caged chicken egg or duck egg, in achieving high-quality, yogurt-like characteristics. These findings underscore the opportunity to utilize egg whites in yogurt production, encouraging further refinement of eggurt formulations. Future studies should investigate varying egg white concentrations and assess microbial stability and safety over extended shelf-life and its impact on consumer health, which would provide valuable insights for the broader application of eggurt in the food industry.

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