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Fortified Fermentation: Improving Microbial Viability and Texture of Egghurt Using Skim Milk Powder

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Abstract

This study aimed to evaluate the effect of skim milk powder incorporation on the microbiological, physicochemical, and sensory characteristics of *egghurt*, a fermented egg-based product. The experiment was conducted using varying skim milk concentrations of 0%, 5%, 10%, 15%, and 20% (w/w). Parameters analyzed included water activity (a_w), pH, total lactic acid bacteria (LAB), total microbial count, and sensory attributes. Results showed that increasing skim milk concentration decreased *egghurt* water activity from 0.954 to 0.934 and slightly increased pH from 5.46 to 5.62, indicating higher total solids and buffering capacity. The total LAB count rose significantly from 5.92 to 7.70 log CFU/mL, while total microbial counts ranged from 8.81 to 9.40 log CFU/mL. Sensory evaluation revealed no significant differences in color, aroma, or flavor across treatments; however, texture improved significantly with skim milk addition, increasing from 2.24 to 3.24 on a 5-point scale. Incorporation of *egghurt* with up to 20% skim milk powder effectively enhanced its microbial viability, physicochemical stability, and textural quality, while maintaining acceptable overall sensory characteristics. The incorporation of skim milk offers a practical formulation approach to develop stable, nutritious, and consumer-acceptable egg-based fermented products with potential functional food value.

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Introduction

Chicken eggs are among the most accessible sources of high-quality animal protein and play a vital role in supporting community nutrition. However, market fluctuations often result in a drastic decline in egg prices during periods of oversupply. This condition not only reduces farmers' income but also increases the likelihood of food waste involving a nutrient-dense commodity (Bonadonna et al., 2018). To overcome this issue, value-added processing of eggs is required to stabilize both their price and quality. One promising strategy is to develop fermented egg-based products, where the fermentation process can enhance the economic value and shelf life of eggs (Boukid et al., 2023).

Eggs are often referred to as a "complete food" due to their rich composition of essential nutrients. Fresh whole eggs contain approximately 12.6% high-quality protein, 9.5% fat, and 0.7% carbohydrates, along with various vitamins and minerals (Sophie et al., 2019). Their complete essential amino acid profile makes eggs an excellent candidate for functional food development. A novel concept in this field is the production of Egghurt that is a fermented egg-based product analogous to yogurt. Egghurt is a fermented product made from a mixture of liquid whole egg and UHT milk that undergoes acid-induced coagulation during lactic fermentation. The combination of egg proteins and milk solids forms a semi-solid gel structure similar to set yogurt, resulting in a thick and spoonable consistency rather than the liquid or curd like texture typically produced by heat treatment of eggs. In this process, coagulation is driven entirely by lactic acid bacteria rather than thermal denaturation, giving the final product a mild, creamy, and yogurt-like sensory profile. Previous studies have demonstrated that lactic fermentation of egg white can reduce blood cholesterol in human subjects (Matsuoka, 2022), suggesting potential health-promoting effects of fermented egg products. Therefore, transforming eggs into Egghurt offers not only a means to minimize waste during price declines but also an opportunity to produce novel functional foods beneficial to consumers.

Given the potential of eggs as a substrate for fermentation, understanding the broader role of fermentation in food systems becomes essential. Fermentation is not only applicable to dairy products but also offers significant advantages when applied to alternative protein sources such as eggs. Food fermentation plays an essential role in enhancing nutritional value and extending the shelf life of perishable materials. Through microbial metabolism, fermentation increases nutritional quality by synthesizing bioactive compounds such as vitamins and organic acids and by degrading antinutritional factors (Kårlund et al., 2020). As a result, the digestibility and bioavailability of nutrients improve significantly. For example, fermentation of protein- rich substrates such as dairy and legumes as well as soybean increases vitamin B_{12} levels and antioxidant activity, while cereal fermentation reduces phytic acid, thereby enhancing mineral absorption, demonstrating how microbial proteolysis can improve functional properties of high protein foods that are also applicable to fermented egg based products (Sawant et al., 2025). Additionally, lactic fermentation lowers product pH and generates natural antimicrobial compounds that inhibit spoilage microorganisms, effectively prolonging storage stability (Aziz et al., 2023; Homayouni et al., 2018). Historically, fermentation has served as a natural preservation method for perishable foods such as milk and meat through the production of lactic acid and aroma-active compounds (T, 2018; Widyastuti et al., 2021). In the context of eggs, fermentation is expected to enhance nutritional functionality such as the formation of bioactive peptides from protein hydrolysis while simultaneously improving preservation through the accumulation of organic acids with natural preservative properties.

Despite its promise, the development of Egghurt faces several scientific and technological challenges. Unlike milk, eggs contain negligible amounts of fermentable sugars, with only about 0.7% total carbohydrates and virtually no lactose (Rafed et al., 2024). Lactic acid bacteria such as *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* require fermentable carbohydrates as energy sources for acid production. In the absence of these sugars, fermentation proceeds slowly and inefficiently, leading to limited bacterial growth and weak gel formation (Dan et al., 2019). The unbalanced C/N ratio of eggs can further trigger the production of undesirable metabolites such as ammonia instead of lactic acid (García et al., 2017; Han et al., 2024). Moreover, the textural quality of Egghurt differs from that of yogurt because the dominant egg proteins (ovalbumin and ovotransferrin) behave differently from milk caseins during acid-induced coagulation. Previous studies have shown that fermented egg white tends to form weak curds with high syneresis compared to milk yogurt (Herring, 2021; M. Yang et al., 2025). Therefore, achieving a desirable Egghurt texture requires optimization of both substrate composition and microbial growth conditions.

Fortifying the egg substrate with skim milk powder is an effective strategy, as skim milk provides lactose and additional solids that improve fermentation performance and gel formation. Previous studies show that skim milk enhances lactic acid bacteria growth, acidification, and texture in fermented dairy and mixed-protein products (Gilbert et al., 2020). The addition of skim milk introduces lactose as a fermentable carbohydrate source for LAB and contributes milk solids (mainly casein and lactose) that enhance gel strength and mouthfeel. Skim milk is preferred for its high protein and lactose content without increasing product fat levels, thereby promoting efficient acid production and improving texture (Costa et al., 2022; France et al., 2021). In yogurt production, increasing non-fat milk solids is a common technique to raise viscosity and minimize whey separation (Hashim et al., 2021). Similarly, incorporating Egghurt with skim milk is expected to yield a creamier and thicker texture, mask the characteristic eggy flavor, and support optimal LAB growth, resulting in higher probiotic viability and balanced acidity.

A literature reveals that research on egg-based fermentation remains limited and underexplored. These findings suggest potential for egg utilization in fermented food systems; however, the complexity of the formulations indicates that optimization is still necessary. Nonetheless, comprehensive investigations on how skim milk incorporation directly influences the microbiological profile and hedonic attributes of Egghurt remain scarce. Therefore, this study aims to evaluate the effect of varying skim milk concentrations on the microbiological and sensory characteristics of egg-based Egghurt. The findings are expected to contribute to the scientific understanding of fermented egg products and support the development of high-value, nutritious, and consumer-acceptable egg-based foods that enhance local food utilization.

Materials and Methods

This study was carried out at the Food Chemistry and Nutrition Laboratory and the Food and Agricultural Product Engineering Laboratory, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang, Indonesia.

Materials

Fresh whole chicken eggs were obtained from a local supermarket (Superindo, Semarang). The starter culture used was *Yogourmet* (Canada), containing *Streptococcus thermophilus*, *Lactobacillus bulgaricus*, and *Lactobacillus acidophilus*. Other materials included UHT milk (Greenfield, Indonesia), skim milk powder (Indoprima, Indonesia), sucrose (Gulaku, Indonesia), and analytical reagents such as de Man Rogosa Sharpe Agar (MRSA) and Plate Count Agar (PCA) (Merck, Germany). NaCl solution 0.85% (Merck, Germany) and pH buffer standards (pH 4.0 and 7.0) were used for analytical calibration.

The laboratory equipment comprised an incubator, magnetic stirrer with hot plate (IKA, Malaysia), laminar air flow cabinet (Airtech, China), water bath (Memmert, Germany), pH meter (Hanna Instruments, Indonesia), water activity meter (Novasina, Switzerland), and an analytical balance.

Preparation of Egghurt Starter

The starter was prepared according to the Yogourmet manufacturer's protocol with slight adjustments to incubation temperature and duration. Briefly, 250 mL of UHT milk was heated to 42–44°C, and 1.25 g of the starter powder was dissolved in a small volume of the warm milk before mixing with the

Table 1. Water Activity and pH Values of Egghurt Fermentation with Skim Milk Addition

Skim Milk Concentration (%)	Water Activity Value	pH
0	0.954±0.001[d]	5.46±0.02[a]
5	0.946±0.003[c]	5.68±0.01[c]
10	0.940±0.006[b]	5.68±0.02[c]
15	0.937±0.006[ab]	5.64±0.02[b]
20	0.934±0.002[a]	5.62±0.03[b]

Different superscript letters in the same column indicate significant differences ($p < 0.05$).

remainder. The inoculated milk was then incubated at 35°C for 24 hours until it developed a thick, yogurt-like texture. The fermented milk culture was stored at 4°C for later use.

Preparation of Liquid Whole Egg

Eggs were cracked, homogenized using a magnetic stirrer, and filtered to remove the chalaza and shell residues. The resulting liquid whole egg (LWE) was pasteurized at 64°C for 2.5 minutes in a water bath to ensure microbial safety while maintaining its functional properties, as described by (Bermudez-aguirre & Niemira, 2023)

Production of Egghurt with Skim Milk Addition

Egghurt was produced by blending pasteurized LWE with 8% (w/w) sucrose and skim milk powder at concentrations of 0%, 5%, 10%, 15%, and 20% (w/w). Each formulation was inoculated with 10% (w/w) of the previously prepared Yogourmet starter culture. The mixtures were incubated in sealed glass jars at 45°C for 18 hours until coagulation was achieved.

Microbiological and Physicochemical Analyses

Determination of Water Activity (a_w)

The water activity (a_w) of egghurt samples was measured using a Novasina a_w-meter (Switzerland). Each sample was placed in the measuring chamber and readings were recorded after the system reached equilibrium .

Measurement of pH

The pH values of the samples were analyzed using a calibrated pH meter (Hanna Instruments, Indonesia). Calibration was carried out with standard buffer solutions (pH 4.0 and 7.0) prior to measurement (Aziz et al., 2023).

Enumeration of Lactic Acid Bacteria (LAB)

The viable count of lactic acid bacteria was determined using the pour plate technique on de Man Rogosa Sharpe Agar (MRSA). Serial dilutions of each sample (10^{-1}–10^{-7}) were prepared using 0.85% NaCl solution, and aliquots were plated in duplicate. The plates were incubated at 37°C for 48 hours, after which colonies were counted. Results were expressed as colony-forming units per milliliter (CFU/mL) for plates containing 30–300 colonies (Lebdoyono et al., 2024).

Total Aerobic Microbial Count

The total microbial load was determined using Plate Count Agar (PCA) following the pour plate method. Diluted samples were incubated at 37°C for 48 hours, and microbial counts were reported as CFU/mL. (Karimi et al., 2011)

Sensory Evaluation

The sensory properties of egghurt samples containing 0% and 20% skim milk were evaluated by 25 semi-trained panelists. Panelists were categorized as semi-trained because they received a short orientation prior to testing. Participants assessed color, aroma, texture, taste, and overall acceptability using a 4-point hedonic scale, where 1 = dislike very much and 5 = like very much (Karageorgou et al., 2023).

Statistical Analysis

Data on water activity, pH, LAB count, and total microbial count were subjected to one-way analysis of variance (ANOVA). When significant differences were detected, Duncan's Multiple Range Test (DMRT) was applied at a 95% confidence level ($\alpha = 0.05$). Sensory scores were analyzed using the Kruskal–Wallis and Mann–Whitney U-tests for non-parametric comparisons. All analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA).

Result and Discussion

Water Activity (a_w) of Egghurt Fortified with Skim Milk

The water activity (a_w) of egghurt exhibited a gradual decline with increasing levels of skim milk addition (Table 1). The control sample (0% skim milk) showed an a_w value of approximately 0.954, which significant decreased ($p<0.05$) to 0.934 when 20% skim milk was incorporated. This reduction reflects a decrease in the proportion of unbound or free water within the product. The inclusion of skim milk contributed additional solids primarily proteins and lactose that possess water-binding capacity, thereby converting more water molecules into a bound state unavailable for microbial or chemical reactions (Wang et al., 2016).

Similar observations have been reported in fortified yogurt formulations, where the enrichment of milk solids to roughly 14% total solids effectively reduced syneresis (whey separation) and enhanced gel strength, as milk proteins can retain water within the gel matrix (Baranowska et al., 2025). Consequently, the lower a_w values observed from 0.954 (0% skim milk) to 0.934 (20% skim milk) in the current egghurt formulations likely stem from increased solid content derived from skim milk addition, which limits the fraction of freely available moisture.

The obtained a_w values (0.93–0.95) were slightly lower than those typically found in conventional cow's milk yogurt, which generally ranges from 0.97 to 0.99 due to its high moisture content (Lucatto et al., 2010). The reduced a_w of egghurt may be attributed to the presence of suspended solids and hydrophilic components such as egg and milk proteins, which effectively bind water (Moghadam et al., 2013). A lower a_w has important implications for microbial stability; spoilage and pathogenic microorganisms have difficulty proliferating

Table 2. Total Lactic Acid Bacteria and Total Microbial Counts of *Egghurt* Fermentation with Skim Milk Addition

Skim Milk Concentration (%)	Total Lactic Acid Bacteria (Log CFU/mL)	Total Microbes (Log CFU/mL)
0	5.92±0.07^{a}	8.81±0.08^{a}
5	6.20±0.83^{a}	8.96±0.20^{a}
10	6.87±0.82^{ab}	9.10±0.24^{ab}
15	7.27±0.57^{b}	9.10±0.24^{ab}
20	7.70±0.44^{b}	9.40±0.43^{b}

Different superscript letters in the same column indicate significant differences ($p < 0.05$).

under reduced water availability (Sanchez et al., 2018). Studies indicate that microbial growth is significantly inhibited at a_w values near 0.73, especially when combined with acidic conditions resulting from lactic fermentation(Othman et al., 2017).

Thus, the decline in a_w following skim milk incorporation n aligns with the formulation objective to produce a thick, cohesive egghurt with a semi-solid texture and water retained within the protein–polysaccharide network, comparable to that of high-quality set yogurt. The increased solids from skim milk promote tighter protein interactions, enhancing water binding capacity.

pH Value of Egghurt Fortified with Skim Milk

The pH of egghurt displayed a slightly increasing trend with higher skim milk concentrations (Table1). The pH increased significantly with skim milk addition, from 5.46^{a} (0%) to 5.68^{c} at 5–10%, then significantly decreased to 5.64^{b} and 5.62^{b} at 15–20%. Statistical analysis ($p < 0.05$) confirmed that all skim-milk treatments had significantly higher pH than the control. The control (0% skim milk) had a pH of 5.46, which rose modestly to 5.64–5.68 at 5–10% addition, before slightly decreasing to 5.62 at 20% addition. Overall, samples containing skim milk exhibited higher final pH values 5.6 than the control 5.4. This trend, although counterintuitive given the expected increase in lactic acid bacteria (LAB) activity, can be attributed to the enhanced buffering capacity introduced by the skim milk solids.

Skim milk contains casein and whey proteins, as well as phosphate-based minerals, which increase the system's resistance to pH reduction during fermentation (Murphy et al., 2024). As a result, even though LAB actively produce lactic acid, the additional milk solids neutralize part of the acidity, slowing the decline in pH (Kim et al., 2018). Kim et al. (2018) demonstrated that elevating the buffering capacity in yogurt substrates delays the time required for cultures to reach a specific pHfor instance, extending the time to achieve pH 4.5 from 8 to 12 hours. A comparable phenomenon likely occurred in the current egghurt formulations, where skim milk supplementation moderated acidification, yielding slightly higher final pH values.

Notably, the final pH of egghurt 5.4–5.6 remains higher than that of conventional cow's milk yogurt, which typically reaches pH 4.2–4.5 to achieve its characteristic tangy flavor and microbial stability(Ilić et al., 2024; Kim et al., 2018). The relatively mild acidity in egghurt is likely desirable to preserve the sensory and structural quality of the egg proteins. Eggs possess a high protein content with intrinsic buffering properties, causing the fermentation process to stabilize at a more moderate pH. Similarly reported that egg-based fermented products tend to exhibit weaker acidity but improved texture stability, with minimal whey separation (Zang, 2023). Despite this higher pH, studies indicate that fermented egg-based and high-protein matrices can remain microbiologically stable when supported by high LAB populations, organic acid production, and reduced water activity (Widyastuti et al., 2021)(Homayouni et al., 2018). Such conditions inhibit spoilage and pathogenic microorganisms, suggesting that egghurt can maintain microbial stability even at a moderately higher pH.

Total Lactic Acid Bacteria (LAB) Count in Egghurt

The population of lactic acid bacteria (LAB) in egghurt increased markedly as the concentration of skim milk powder (Table 2). In the control sample (0% skim milk), the LAB count was 5.92 log CFU/mL, a level below the minimum standard for yogurt established, which requires at least 10^{6}-10^{7} viable LAB per milliliter for fermented milk products (Agrawal, 2007). The LAB population increased with higher skim milk concentrations, rising from 5.92^{a} log CFU/mL in the control to 6.20^{a}, 6.87^{ab}, 7.27^{b}, and 7.70^{b} log CFU/mL at 5%, 10%, 15%, and 20% skim milk, respectively. Statistical analysis ($p < 0.05$) showed that the 15% and 20% treatments had significantly higher LAB counts than the control and 5% treatments. . Thus, at 15–20% skim milk, egghurt achieved LAB levels exceeding 10^{7} CFU/mL fulfilling the benchmark typically applied to commercial yogurts (Mayssoun & Nadine, 2010; Zang, 2023).

This substantial growth in LAB populations can be logically attributed to the nutritional enrichment provided by the skim milk addition. The yogurt starter cultures (*Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*) rely primarily on lactose as their carbon source. Since eggs contain only trace amounts of carbohydrates, LAB proliferation is limited in formulations lacking skim milk. The introduction of skim milk supplies additional lactose, which is readily fermented into lactic acid, thereby stimulating bacterial growth. Supplementing yogurt with pineapple juice a natural source of fermentable sugars significantly increased LAB counts in parallel with greater pH reduction. Their study found that adding 15% pineapple juice to skim milk yogurt yielded 9.56 log CFU/mL LAB with a final pH of 4.06, confirming that carbohydrate availability plays a crucial role in supporting LAB proliferation (Nasution & Rahmadi, 2025).

Besides lactose, proteins and micronutrients from skim milk may further enhance bacterial viability. Co-fortification of yogurt with whey protein and honey improved the survival of *S. thermophilus* and *L. bulgaricus* during refrigerated storage. Whey proteins supply peptides and amino acids that serve as nitrogen

Table 3 Sensory Evaluation of *Egghurt* Fermented Beverages

Sensory Attribute	Skim Milk Concentration	
	0%	20%
Color	3.24	3.08
Aroma	2.16	2.28
Flavor	2.72	2.76
Texture	2.24	3.24
Overall	2.72	2.88

Scoring scale: 1 = dislike very much, 2 = dislike, 3 = neutral, 4 = like, 5 = like very much.

sources, while honey contributes readily fermentable sugars, together sustaining bacterial metabolism (Baranowska et al., 2025). In the context of egghurt, skim milk performs a dual function: it provides lactose as an energy substrate and milk proteins as nutritional and structural components that support bacterial activity. These findings suggest that fortifying egg-based fermentation substrates with skim milk can effectively yield functionally enriched egghurt with a robust probiotic profile and desirable microbiological quality.

Moreover, the sucrose added to the formulation also contributes fermentable carbohydrates, as several LAB strains are capable of hydrolyzing sucrose into glucose and fructose via invertase, thereby supplying additional substrates for acid production and growth (Hernández-Riveros et al., 2024). Therefore, the enhanced LAB counts observed in skim-milk-fortified egghurt likely result from the combined availability of lactose and sucrose, together with the nutritional benefits of milk proteins. These factors collectively promote a probiotic profile and desirable microbiological quality in the final product.

Total Microbial Count in Egghurt

The total microbial count of egghurt followed a pattern similar to that of the LAB population but at a higher overall magnitude (Table 2). Total counts, which include all culturable microorganisms present on a non-selective medium, mainly represent LAB starter cultures with minor contributions from other background microbes. Total microbial counts increased from 8.81^{a} log CFU/mL in the control to 8.96^{a}, 9.10^{ab}, 9.10^{ab}, and 9.40^{b} log CFU/mL at 5%, 10%, 15%, and 20% skim milk, respectively. Statistical analysis ($p < 0.05$) showed that only the 20% skim milk treatment had a significantly higher total microbial count than the control, indicating that the rise in total microbes was mainly driven by enhanced LAB growth rather than contamination .. In essence, providing more lactose through skim milk promoted faster starter culture multiplication, leading to a higher total viable count.

Interestingly, in the formulation without skim milk, total microbial counts (8.81 log CFU/mL) were about three log units higher than the detected LAB counts (5.92 log CFU/mL). This discrepancy likely results from differences in growth media and selectivity. For instance, *Streptococcus thermophilus*, one of the yogurt starter strains, may grows more efficiently on Plate Count Agar (PCA) than on de Man Rogosa Sharpe (MRS) Agar (Huys et al., 2002). At 20% skim milk, total microbial counts (9.40^{b} log CFU/mL) and LAB counts (7.70^{b} log CFU/mL) both increased significantly compared to the control ($p < 0.05$). These results indicate that skim milk incorporation enhances overall microbial growth, particularly LAB, but no statistical evidence supports a conclusion about the uniformity of growth between different starter species

Egghurt with higher skim milk addition achieved total microbial loads, indicating a highly active and stable fermentation process. This level is consistent with the total bacterial counts typically reported for optimally fermented cow's milk yogurt (10^{8}–10^{9} CFU/mL) (Nasution & Rahmadi, 2025). The similarity in microbial load suggests that the fermentation conditions in egghurt effectively support LAB proliferation comparable to conventional yogurt systems

Hedonic Evaluation of Egghurt Fortified with Skim Milk

Sensory assessment covered appearance (color), aroma, flavor, texture, and overall acceptability. Skim-milk incorporation chiefly influenced texture, while shifts in other attributes were modest (Table 3).

Appearance (color)

Introducing skim milk produced a slight decline in color liking. The 0% skim sample scored 3.24, whereas the 20% skim sample scored 3.08 (5-point scale). Scores around 3 indicate neutrality to mild liking. Color differences are attributable to matrix composition: formulas without skim contain a higher proportion of egg yolk pigments (carotenoids), yielding a deeper yellow hue generally favored by panelists. As skim solids increased, the matrix lightened (whiter/paler) due to dilution of yolk pigments by the white milk solids, leading to a 0.16-point decrease. Although the shift is minor, it is consistent with the expectation that higher egg proportions produce a more saturated yellow tone (L. Yang et al., 2024). Future optimization could target a more appealing hue by slightly adjusting egg milk ratios or by incorporating natural colorants (e.g., turmeric curcumin or β-carotene) without compromising nutritional composition.

Aroma

Aroma acceptance rose slightly with skim milk: from 2.16 (control) to 2.28 (20% skim), both still in the lower range of preference. The relatively low scores likely reflect egg-specific sulfur volatiles (e.g., hydrogen sulfide) accentuated by heat treatments (Geveke et al., 2016). In the control, these notes are more pronounced; skim milk appears to soften and balance the aroma profile by adding mild dairy/fermented notes that partially mask sulfur nuances (Ma et al., 2020). The small improvement indicates a favorable direction but also suggests further work is needed. Practical options include vanilla or fruit flavoring, or pre-treatments that reduce egg volatiles e.g hydrogen sulfide . A slightly deeper fermentation may also encourage formation of buttery/diacetyl notes that enhance perceived aroma (Eicher et al., 2024).

Flavor

Flavor scores were stable across treatments: 2.72 (0% skim) vs 2.76 (20% skim), indicating near-neutral acceptability. Similarities likely arise because both versions shared the same added sugar level and had comparable acidity (pH 5.4–5.6), producing a mild sweet-acid balance. Egg contributes gentle savory notes and richness; skim milk adds dairy taste without fat, so no off-flavors were introduced. The slightly neutral profile suggests the product could benefit from flavor fortification (e.g., vanilla, fruit purees) or fine-tuning of sweetness/acid balance to heighten perceived flavor impact while maintaining product identity.

Texture

Texture showed the most pronounced improvement with addition, increasing from 2.24 (disliked to slightly disliked) to 3.24 (slightly liked). The unfortified sample likely presented a weaker gel/looser body with some syneresis at the measured pH, whereas adding skim milk raised total solids and supplied casein/whey proteins that form a stronger acid-induced gel network (Costa et al., 2022; France et al., 2021). Enhanced water-binding and emulsifying properties of milk proteins reduced whey separation and yielded a thicker, smoother, creamier consistency. Industrially, elevating nonfat milk solids to 12–14% is a common route to create firm, syneresis-resistant yogurt (Gilbert et al., 2020); a similar principle appears effective in the egg–milk system here, where skim-milk proteins may act as a structural co-gellant complementing egg proteins. The marked texture gain 1.0 point aligns with the overall acceptance trend and underscores texture as a key driver of consumer liking.

Overall acceptability

The overall score increased slightly from 2.72 (0% skim) to 2.88 (20% skim) (+0.16), representing a 0.16 point increase on the hedonic scale, indicating a small but consistent preference for the fortified product. In consumer judgments, overall liking typically tracks the most salient attributes; here, the clear texture improvement, combined with a modest aroma lift and minimal change in flavor, explains the net positive shift despite the slight color penalty. Although the absolute values (≈2.7–2.9) remain below “like,” these scores reflect a moderate level of acceptance for the two egghurt samples tested. . Targeted sensory engineering—particularly flavor enhancement and fine control of acidity/solids is likely to yield more substantial gains in overall acceptance.

Conclusion

Supplementation of *egghurt* with skim milk powder improved its microbiological and physicochemical quality. Increasing skim milk concentration from 0% to 20% lowered water activity, slightly increased pH, and raised lactic acid bacteria counts from 5.92 to 7.70 log CFU/mL, meeting the yogurt standard of $\geq 10^7$ CFU/mL.Total microbial counts also increased significantly (8.81 to 9.40 log CFU/mL). Sensory evaluation showed no significant differences in color, aroma, or flavor, but texture improved significantly, resulting in higher overall acceptability. Thus, adding up to 20% skim milk effectively enhances the texture and microbial quality of egg-based fermented products without altering other sensory attributes.

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