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Influence of ginger addition on the microbiological shelf life and sensory attributes of soy–cow milk yoghurt blends

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This study evaluated the effect of ginger addition on the sensory microbial shelf-life and attributes of soy–cow milk yoghurt during storage. Yoghurt samples were prepared using three milk formulations (100:0, 75:25 and 50:50 of cow milk to soymilk ratio, respectively), fermented with *Lactobacillus bulgaricus* and *Streptococcus thermophilus* then, varying concentrations of ginger extract (0%, 5%, and 10%) added to each blend and stored at 25°C for 96 h. Microbiological analyses, including total bacterial count, lactic acid bacteria enumeration, and fungal count, were conducted using standard plate count techniques during a 96 h storage period. Sensory evaluation by semi-trained panelists was conducted using a 9-point hedonic scale. Then statistically analyzed using ANOVA. Results showed that bacterial populations in all samples ranged from 1.9×10^8 to 7.9×10^8 CFU/mL initially and increased during storage, indicating continued metabolic activity of lactic acid bacteria. Fungal counts remained within acceptable limits throughout the storage period. The increase in LAB counts suggests ongoing probiotic activity, although the stability of fungal counts indicates no spoilage. Sensory evaluation revealed that sample AQ (100% cow milk with 5% ginger) received the highest overall acceptability score (8.74 ± 0.012), with the highest ratings for sweetness, flavor and thickness. Samples with higher proportions of soy milk received significantly lower overall acceptability scores, with CH (50:50% cow milk with 10% ginger) scoring lowest (1.50 ± 0.002). These findings suggest that moderate ginger addition enhances sensory appeal in dairy-dominant yoghurts, but formulation adjustments may be needed to improve the acceptability of soy-rich variants.

Keywords: Soy-cow milk yoghurt; probiotic viability; functional food; ginger extract; shelf stability.

INTRODUCTION

The global dairy industry has witnessed significant transformations in recent decades, with increased consumer demand for functional foods that offer both nutritional and health benefits beyond basic nutrition (Khosroshahi *et al.,* 2025). Fermented dairy products, particularly yoghurt, have garnered substantial attention due to their probiotic properties and potential health-promoting effects (He *et al.,* 2024). Traditional yoghurt, produced from cow milk, remains a popular choice; however, plant-based alternatives and composite formulations have emerged as significant market segments, catering to diverse consumer preferences, dietary restrictions, and sustainability concerns (Qadir *et al.,* 2025).

Soy milk, derived from soybeans (*Glycine max*), has been recognized as a nutritionally valuable alternative to animal milk, containing high-quality protein, essential fatty acids, and various bioactive compounds (Hsieh *et al.,* 2024). The incorporation of soy milk into dairy products has gained traction, not only as a cost-effective strategy but also as a means to enhance the nutritional profile and functional properties of the resulting products (Shao *et al.,* 2023). Composite yoghurt formulations combining soy milk and cow milk represent an innovative approach to leverage the complementary nutritional attributes of both milk sources while addressing the challenges associated with purely plant-based fermentations (Taormina *et al.,* 2024).

Despite the numerous advantages offered by soy-cow milk composite yoghurt, product stability and shelf-life remain critical concerns for manufacturers and consumers alike. The microbiological quality and sensory attributes of yoghurt typically deteriorate during storage, limiting commercial viability and consumer acceptance (Rahman *et al.,* 2024). Various factors, including post-acidification, proteolysis, and microbial contamination, contribute to the degradation of yoghurt quality parameters over time (Qadir *et al.,* 2025). Consequently, there is growing interest in natural preservatives that can extend shelf-life while maintaining or enhancing sensory characteristics and nutritional value (Malomo *et al.,* 2025).

Ginger (*Zingiber officinale* Roscoe), a rhizomatous herbaceous plant, has been traditionally utilized as both a culinary ingredient and medicinal resource across numerous cultures (Malomo *et al.,* 2025). The bioactive components of ginger, including gingerols, shogaols, and zingerone, have demonstrated significant antimicrobial, antioxidant, and anti-inflammatory properties in various food systems (Mahayothee *et al.,* 2020). Research by Malomo *et al.* (2025) has highlighted the efficacy of ginger extracts against a wide spectrum of food spoilage and pathogenic microorganisms, suggesting potential applications in food preservation. Furthermore, the distinctive aromatic profile of ginger may contribute positively to the sensory attributes of food products, potentially enhancing consumer acceptance (De Oliveira *et al.,* 2024).

The integration of ginger into dairy formulations represents a promising strategy to address stability issues while potentially enhancing functional properties and consumer appeal. Previous studies have explored the incorporation of various plant extracts into yoghurt systems, with promising results regarding microbial stability and sensory characteristics (Diaz-Bustamante *et al.,* 2023). However, comprehensive investigations specifically examining the effects of ginger on soy-cow milk composite yoghurt remain limited in the scientific literature. Moreover, the relationship between antimicrobial efficacy, sensory perception, and overall consumer acceptance of ginger-enhanced yoghurt formulations warrants further investigation for commercial viability (Rahman *et al.,* 2024).

This research aims to bridge this knowledge gap by systematically evaluating the influence of ginger incorporation on the sensory attributes and antimicrobial properties of soy-cow milk composite yoghurt during refrigerated storage. The study addresses the following objectives: to assess the impact of varying concentrations of ginger on the sensory characteristics of soy-cow milk composite yoghurt; to evaluate the microbial activity of ginger against common yoghurt spoilage and pathogenic microorganisms; and to determine the effect of ginger incorporation on the shelf stability of soy-cow milk composite yoghurt under refrigerated conditions, This research aligns with current consumer trends favoring clean label products with minimal artificial additives and enhanced functional properties (He *et al.,* 2024). The outcomes may inform the development of innovative, stable, and organoleptically appealing yoghurt products that meet evolving consumer expectations and market demands. Therefore, the aim of this paper is to evaluate the sensory and microbial activity of ginger on the shelf stability of soy-cow milk composite yoghurt.

MATERIALS AND METHODS

Sample collection

Yellow seeds of *Glycine maxima* (soybeans) were procured from New Market in Enugu State, Nigeria. Additional materials including skimmed powdered milk (Dano), starter culture derived from skimmed milk, distilled water, flavoring agents and sugar, were purchased from a local market in Enugu East. Fresh ginger (*Zingiber officinale*) was obtained from the same local market. All reagents used for microbiological and biochemical analyses were of analytical grade. The experimental analyses were conducted at the Microbiology Laboratory of Godfrey Okoye University, Enugu State, Nigeria. The methodology employed in this study was adapted from previous research with modifications.

Sample preparation

Preparation of soymilk

Soymilk was prepared following the method described by Abagoshu *et al*. (2017) with slight modifications. Four hundred grams (400 g) of soybeans were soaked overnight in 4 L of distilled water at room temperature (25 ± 2°C), maintaining a solid-to-liquid ratio of 1:10 (w/v). After soaking, the hydrated soybeans were drained, rinsed thoroughly with clean water, and ground with distilled water at a water-to-dry bean ratio of 8:1 (w/w). The grinding process was carried out for 3 min at high-speed using a Hamilton Beach blender (Model: 585-1, Peabody, MA, USA). The resulting soy slurry was filtered through a double-layered muslin cloth to separate the insoluble residue from the soymilk. Then, it was poured into a small pot, which was placed in a larger pot containing boiling water (indirect heating method), to minimize scorching. When the soymilk temperature reached 90°C, the small pot was transferred directly to the stove surface and heated to a boil. The soymilk was maintained at boiling temperature with continuous stirring for 20 min to inactivate trypsin inhibitors and improve digestibility. The pot was subsequently transferred to an ice bath and cooled to room temperature. This cooled soymilk was then used for preparing the composite yoghurt formulations.

Preparation of cow milk

Cow milk was prepared using a modified method described by Obi *et al.* (2016). 1500 mL of distilled water was added to 600 g of Dano skimmed powdered milk and stirred continuously using a sterile spatula until a homogeneous solution was formed. The milk was

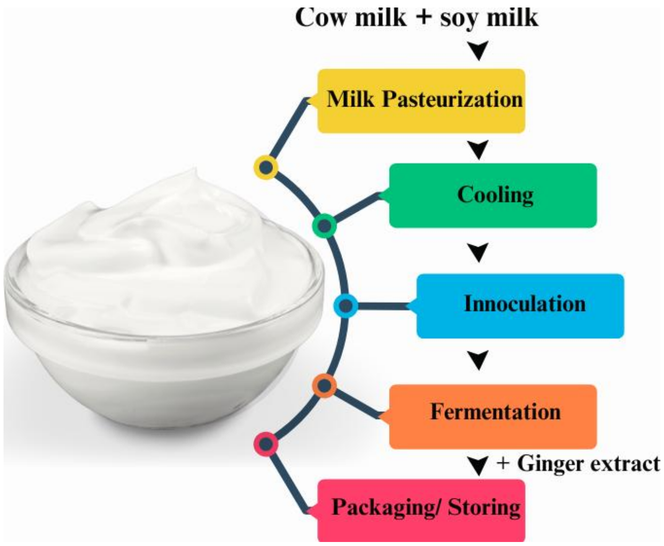

Figure 1. Flow diagram for composite soy-cow milk yoghurt improved with ginger extract fermented at 35°C for 12 h and stored for 98 h.

transferred to glass beakers, covered with aluminum foil, and pasteurized at 85°C for 15 min in a water bath.

Preparation of composite milk blends

Three milk formulations were chosen based on preliminary studies and prepared in duplicates. The formulations were as follows:

- Sample A: 600 mL Dano milk (100:0% cow: soy milk ratio)
- Sample B: 450 mL Dano milk + 150 mL soymilk (75:25% cow: soy milk ratio)
- Sample C: 300 mL Dano milk + 300 mL soymilk (50:50% cow: soy milk ratio)

Each blend was thoroughly mixed and allowed to cool to 35°C before inoculation, as recommended by Chen *et al.* (2024) for optimal starter culture activity.

Inoculation and fermentation

Each milk blend was inoculated with 5 g of a mixed starter culture containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Yogourmet). The inoculated samples were incubated at 35°C for 12 h in a controlled incubator, to facilitate fermentation for optimal yoghurt texture and acidity development (Olabiran *et al.,* 2023).

Incorporation of ginger extract

Fresh ginger preparation followed the methodology described by Wang *et al.* (202). 250 g of fresh ginger rhizomes were peeled, washed thoroughly with potable water, and blended with 500 mL of distilled water until a very smooth consistency was achieved. The ginger was immediately incorporated into the yoghurt samples to preserve bioactive compounds and not interfere with fermentation. After fermentation, each yoghurt formulation (A, B, and C) was stirred thoroughly and divided into three portions of 200 mL each. As shown in Figure 1, which presents the composite yoghurt samples made from cow milk, soymilk and ginger extract. The ginger extract was added to achieve concentrations of 0%, 5%, and 10% (v/v), resulting in nine distinct samples as outlined in Table 1.

Table 1. Formulation of ingredients for yoghurt preparation.

Sample Code	Description	Yoghurt blend (mL)	Ginger (%)
AZ	100% cow milk	200	0
AQ	100% cow milk	200	5
AH	100% cow milk	200	10
BZ	75:25% cow:soy milk	200	0
BQ	75:25% cow:soy milk	200	5
BH	75:25% cow:soy milk	200	10
CZ	50:50% cow:soy milk	200	0
CQ	50:50% cow:soy milk	200	5
CH	50:50% cow:soy milk	200	10

The prepared samples were thoroughly stirred to ensure uniform distribution of the ginger extract and stored at room temperature (25 ± 2°C) for subsequent analyses at 0, 48, and 96 h as indicated by preliminary studies.

Microbiological analyses

Sample preparation for microbial enumeration

Serial dilutions of the yoghurt samples were prepared according to the method described by Ihemeje *et al.* (2015). One milliliter (1 mL) of each homogenized yoghurt sample was aseptically transferred into a corresponding sterile test tube containing 9 mL of sterile distilled water (10^1 dilution). Dilutions were prepared up to 10^4, and 0.1 mL aliquots were plated in triplicate on appropriate agar media to ensure accuracy and reproducibility. All microbiological analyses were conducted under aseptic conditions in a laminar flow hood.

Total colony count (TCC)

Total colony counts were determined using the pour plate method as described by Ihemeje *et al.* (2015). Dilutions 10^2 and 10^4 were plated on Nutrient Agar (Oxoid, UK). The plates were incubated at 37°C for 24 h, after which colonies were counted using a colony counter. The counts were taken from plates with 30–300 colonies, as with standard microbial counting practice. Results were expressed as colony-forming units per milliliter (CFU/mL) of sample.

Lactic acid bacteria (LAB) count

Enumeration of lactic acid bacteria was performed according to the method described by Obi *et al.* (2016). Appropriate dilutions (10^2 and 10^4) were plated on de Man, Rogosa and Sharpe (MRS) agar (Oxoid, UK). The plates were incubated at 37°C for 24 h under microaerophilic conditions. Colonies were counted and expressed as CFU/mL of sample.

Fungal count

Fungal enumeration was conducted using Potato Dextrose Agar (PDA) supplemented with chloramphenicol (0.05 g/L) to inhibit bacterial growth, following the methodology of Aamir *et al.* (2023). The plates were incubated at 25°C for 36 – 60 h in the dark. Results were expressed as CFU/mL of sample.

Table 2. Microbial loads of the yoghurt samples.

Samples	DAY 0 (CFU/mL)	DAY 4 (CFU/mL)	DAY 8 (CFU/mL)
Lactic Acid Bacteria Count			
AZ	$1.9 \times 10^8 \pm 0.120$	$5.3 \times 10^8 \pm 0.005$	$5.9 \times 10^8 \pm 0.020$
AQ	$7.7 \times 10^8 \pm 0.041$	$5.0 \times 10^8 \pm 0.045$	$9.2 \times 10^8 \pm 0.001$
AH	$7.9 \times 10^8 \pm 0.050$	$5.9 \times 10^8 \pm 0.010$	$6.9 \times 10^8 \pm 0.025$
BZ	$2.0 \times 10^8 \pm 0.010$	$6.6 \times 10^8 \pm 0.045$	$8.3 \times 10^8 \pm 0.002$
CZ	$6.8 \times 10^8 \pm 0.015$	$2.7 \times 10^8 \pm 0.0.20$	$5.1 \times 10^8 \pm 0.020$
Total Colony Count (TCC)			
AQ	$5.4 \times 10^8 \pm 0.100$	$7.4 \times 10^8 \pm 0.050$	$8.6 \times 10^8 \pm 0.075$
AH	$7.2 \times 10^8 \pm 0.080$	$5.0 \times 10^8 \pm 0.045$	$9.2 \times 10^8 \pm 0.010$
BQ	$2.4 \times 10^8 \pm 0.050$	$5.3 \times 10^8 \pm 0.075$	$5.9 \times 10^8 \pm 0.025$
BH	$3.0 \times 10^8 \pm 0.020$	$6.4 \times 10^8 \pm 0.010$	$7.4 \times 10^8 \pm 0.045$
CH	$4.3 \times 10^8 \pm 0.110$	$5.3 \times 10^8 \pm 0.050$	$7.9 \times 10^8 \pm 0.020$

Means ± standard deviation in a column with the same letter are not significantly different ($p>0.05$). Means of three replicates. Where AZ – 100% cowmilk, AQ 100% cowmilk 5% ginger; AH - 100% cowmilk 10% ginger, BZ - 75% cowmilk 25% soymilk 0% ginger, BQ - 75% cowmilk 25% soymilk 5% ginger, BH- 75% cowmilk 25% soymilk 10% ginger, CZ - 50% cowmilk 50% soymilk 0% ginger, CH - 50% cowmilk 50% soymilk 10% ginger.

Sensory evaluation

Sensory evaluation was conducted according to the method described by Aamir *et al.* (2023) with slight modifications. Twenty panelists were randomly selected from the university community, aged between 18–45 years, and familiar with yoghurt products, to evaluate the yoghurt samples. The samples were coded with three-digit random numbers and presented in random order. Each panelist was provided with a glass of water to rinse their mouths between sample tastings to prevent carry-over effects. The panelists evaluated the yoghurt samples for color, creaminess, sweetness, flavor, mouthfeel/smoothness, sourness, viscosity, and overall acceptability using a 9-point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like). The evaluation was conducted in a well-lit, odor-free sensory evaluation booth at room temperature (25 ± 2°C).

Statistical analysis

All analyses were performed in triplicate, and results were expressed as mean ± standard deviation. Statistical analysis was conducted using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA).. One-way analysis of variance (ANOVA) was used to determine significant differences among means, while Duncan's Multiple Range Test (DMRT) was applied for mean separation, and a significance difference was conducted at a level of $p \leq 0.05$.

RESULTS AND DISCUSSION

Microbiological Analysis of Yoghurt Samples

Microbial load analysis - total colony forming units (TCFU)

The microbial loads of yoghurt samples as determined by total colony forming units (TCFU) are presented in Table 2. Some samples were discarded owing to their too high or low microbial loads. Analysis of viable counts on MRS agar, which is selective for lactic acid bacteria, showed that bacterial populations in all samples ranged from 1.9×10^8 to 7.9×10^8 CFU/mL on day 0. This range is consistent with the findings of Kılıc *et al.* (2022), who reported that commercially acceptable yoghurt typically contains 10^7 to 10^9 CFU/mL of viable lactic acid bacteria.

Throughout the storage period, the bacterial counts on MRS agar generally increased. Day 4 counts ranged from 2.7×10^8 to 6.6×10^8 CFU/mL, and by day 8, they further increased to 5.1×10^8 to 9.2×10^8 CFU/mL. This pattern indicates continued metabolic activity and growth of lactic acid bacteria during refrigerated storage, which aligns with observations by Kılıc *et al.* (2022), who noted that post-acidification in yoghurt is associated with ongoing bacterial metabolism during storage.

Sample AH exhibited the highest initial count on MRS agar (7.9×10^8 CFU/mL), while sample BZ showed the lowest (1.9×10^8 CFU/mL). The high ginger concentration (10%) in sample AH did not appear to inhibit initial bacterial growth, suggesting that at this concentration, ginger may not exert significant antimicrobial activity against the starter culture organisms. This observation contrasts with the findings by Malomo *et al.* (2025), who reported concentration-dependent antimicrobial effects of ginger against various microorganisms.

The viable counts on nutrient agar (NA), which supports the growth of a broader range of microorganisms, showed similar trends to those observed on MRS agar. Initial counts ranged from 2.4×10^8 to 7.2×10^8 CFU/mL on day 0, increasing to 5.0×10^8 to 7.4×10^8 CFU/mL by day 4, and further to 5.9×10^8 to 9.2×10^8 CFU/mL by day 8. Sample AH demonstrated the highest initial count (7.2×10^8 CFU/mL), while sample BQ had the lowest (2.4×10^8

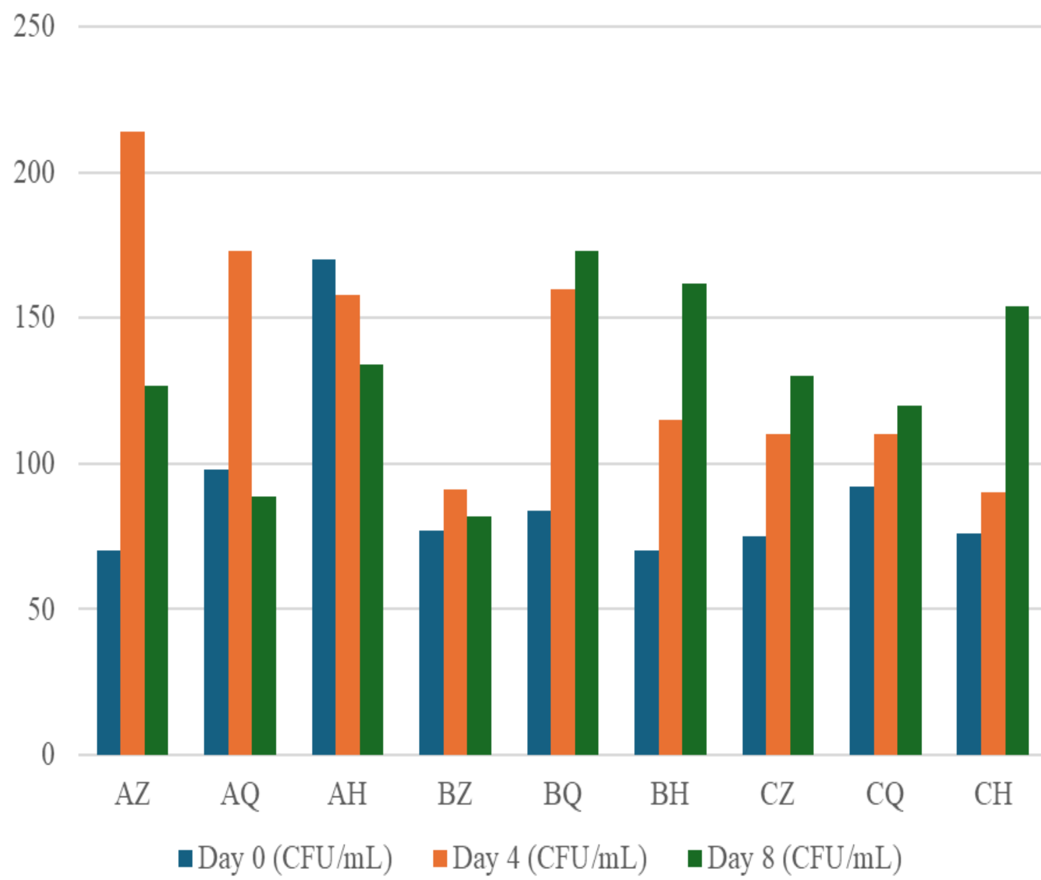

Figure 2. Viable plate count for fungi in the yoghurt samples. Where AZ – 100% cowmilk, AQ 100% cowmilk 5% ginger; AH - 100% cowmilk 10% ginger, BZ - 75% cowmilk 25% soymilk 0% ginger, BQ - 75% cowmilk 25% soymilk 5% ginger, BH- 75% cowmilk 25% soymilk 10% ginger, CZ - 50% cowmilk 50% soymilk 0% ginger, CQ - 50% cowmilk 50% soymilk 5% ginger, CH - 50% cowmilk 50% soymilk 10% ginger.

CFU/mL). Samples containing ginger extract (AQ, AH, BQ, BH and CH) did not consistently show lower microbial counts compared to control samples without ginger (AZ, BZ, CZ), suggesting that at the concentrations tested (5% and 10%), ginger extract did not substantially inhibit the growth of beneficial lactic acid bacteria. This finding is valuable from a product development perspective, as it indicates that ginger can be incorporated into yoghurt formulations without significantly compromising the viability of probiotic cultures, which is essential for maintaining the functional properties of yoghurt.

Fungal Count

Fungal counts in the yoghurt samples over the 8-day storage period are presented in Figure 2. Initial fungal counts on day 0 ranged from 70 to 170 CFU/mL across all samples. Sample AH exhibited the highest initial fungal count (170 CFU/mL), while samples AZ and BH showed the lowest (70 CFU/mL).

A general increase in fungal counts was observed by day 4, with values ranging from 90 to 214 CFU/mL for CH to AZ, respectively. Sample AZ demonstrated the highest fungal proliferation (214 CFU/mL), while sample CH maintained the lowest count (90 CFU/mL). By day 8, fungal counts for most samples decreased or stabilized, ranging from 82 to 173 CFU/mL. Samples BQ and BH showed the highest fungal counts (173 and 162 CFU/mL, respectively), while sample BZ maintained the lowest count (82 CFU/mL).

The fluctuation in fungal counts during storage might be attributed to changes in the yoghurt environment, including pH reduction, accumulation of metabolites, and competition with lactic acid bacteria. According to Darko *et al.* (2025), lactic acid bacteria produce various antimicrobial compounds, including organic acids, hydrogen peroxide, and bacteriocins, which can inhibit the growth of fungi and other spoilage microorganisms. The presence of ginger extract did not consistently correlate with lower fungal counts across all samples and time points, suggesting that at the concentrations tested, ginger may not exert significant antifungal activity in the complex yoghurt matrix. This finding partially contradicts results reported by Malomo *et al.* (2025), who demonstrated

Table 3. Sensory Evaluation of the yoghurt samples

Sample	Colour	Creaminess	Sweetness	Flavour	Smoothness	Sourness	Thickness	Overall acceptability
AZ	7.05±0.112^{c}	8.50±0.100^{d}	4.02±0.111^{b}	4.50±0.011^{c}	8.94±0.011^{g}	5.35±0.051^{bc}	6.05±0.110^{de}	5.33±0.100^{d}
AQ	5.34±0.280^{ab}	7.45±0.002^{c}	5.25±0.052^{b}	6.32±0.100^{d}	8.04±0.210^{f}	6.20±0.045^{bc}	6.75±0.012^{e}	8.74±0.012^{f}
AH	5.22±0.056^{a}	6.05±0.064^{b}	4.10±0.051^{b}	5.05±0.002^{c}	5.21±0.001^{d}	6.08±0.111^{c}	5.55±0.025^{cde}	7.25±0.011^{e}
BZ	7.75±0.178^{c}	4.32±0.160^{a}	1.33±0.025^{a}	1.04±0.004^{a}	4.07±0.003^{bc}	2.32±0.012^{a}	5.01±0.112^{bcd}	3.05±0.102^{b}
BQ	6.00±0.030^{b}	5.12±0.001^{a}	1.75±0.110^{a}	3.33±0.012^{b}	5.25±0.102^{d}	1.73±0.112^{a}	5.03±0.041^{bcd}	4.25±0.002^{c}
BH	5.45±0.005^{a}	4.50±0.022^{a}	1.05±0.051^{a}	2.52±0.025^{a}	4.50±0.023^{cd}	1.56±0.022^{a}	4.05±0.011^{ab}	3.22±0.102^{b}
CZ	5.25±0.100^{a}	5.25±0.015^{a}	4.35±0.101^{b}	4.61±0.102^{c}	3.70±0.002^{ab}	5.02±0.115^{b}	4.51±0.001^{bc}	3.15±0.110^{b}
CQ	5.01±0.056^{a}	4.01±0.045^{a}	2.25±0.022^{a}	2.05±0.025^{a}	3.25±0.003^{a}	1.53±0.015^{a}	5.06±0.002^{bc}	2.33±0.021^{a}
CH	6.53±0.112^{ab}	5.25±0.050^{a}	1.05±0.201^{a}	1.25±0.101^{a}	6.35±0.021^{e}	2.75±0.003^{a}	3.45±0.121^{a}	1.50±0.002^{a}

Means ± standard deviation in a column with the same letter are not significantly different (p>0.05). Means of three replicates. Where AZ – 100% cowmilk, AQ 100% cowmilk 5% ginger; AH - 100% cowmilk 10% ginger, BZ - 75% cowmilk 25% soymilk 0% ginger, BQ - 75% cowmilk 25% soymilk 5% ginger, BH- 75% cowmilk 25% soymilk 10% ginger, CZ - 50% cowmilk 50% soymilk 0% ginger, CQ - 50% cowmilk 50% soymilk 5% ginger, CH - 50% cowmilk 50% soymilk 10% ginger.

significant antifungal properties of ginger extracts in *in vitro* studies. The discrepancy may be attributed to food matrix effects, where components such as proteins and fats can bind to or otherwise interfere with bioactive compounds, reducing their antimicrobial efficacy. Despite the presence of fungi in all samples, the counts remained within acceptable limits for dairy products throughout the storage period, as established by various regulatory standards (Assen and Abegaz, 2024). Furthermore, no visible mold growth or signs of spoilage were observed in any of the yoghurt samples during the 8-day storage period, suggesting that the combination of intrinsic preservative factors (low pH, metabolites from lactic acid bacteria) and potentially the bioactive compounds in ginger were sufficient to prevent overt fungal spoilage.

Sensory evaluation of soy-cow milk composite yoghurt incorporated with ginger

The sensory attributes of a food product significantly influence consumer acceptance and marketability. Table 3 presents the sensory evaluation results of the yoghurt samples as assessed by the panelists on a 9-point hedonic scale. The sensory attributes evaluated included color, creaminess, sweetness, flavor, smoothness, sourness, thickness, and overall acceptability.

The color of yoghurt samples varied significantly ($p \leq 0.05$) among different formulations. Sample BZ (75:25% cow: soy milk ratio with no ginger) exhibited the highest color score (7.75 ± 0.178), which was not significantly different from sample AZ (100% cow milk with no ginger, 7.05 ± 0.112). The high scores for these control samples without ginger suggest that the natural white color of cow milk was preferred by panelists, which aligns with consumer expectations for traditional yoghurt. Samples containing ginger extract generally received lower color scores, with sample CQ (50:50% cow: soy milk with moderate ginger) having the lowest (5.01 ± 0.056). This reduction in color preference may be attributed to the yellowish tint imparted by the ginger extract, which deviates from the conventional white appearance of yoghurt. Similar findings were reported by Aamir *et al.* (2023), who observed that incorporation of plant extracts into dairy products altered color perception and affected consumer acceptance.

Creaminess scores showed significant variations among samples, with the highest score observed for sample AZ (8.50 ± 0.100), followed by sample AQ (7.45 ± 0.002). The consistently high creaminess scores for 100% cow milk formulations (AZ, AQ, AH) compared to formulations with higher soy milk content indicate that cow milk contributes positively to the creamy mouthfeel of yoghurt. Additionally, the moderate incorporation of ginger in sample AQ maintained acceptable creaminess while enhancing other sensory attributes.

Sweetness scores ranged from 1.05 ± 0.051 to 5.25 ± 0.052, with sample AQ (100% cow milk with moderate ginger) receiving the highest rating, closely followed by samples CZ, AH, and AZ. Notably, samples with 75:25% cow: soy milk ratio (BZ, BQ, BH) received significantly lower sweetness scores regardless of ginger concentration. This trend suggests that at this specific ratio, the characteristic beany flavor of soymilk might be more pronounced, potentially masking sweetness perception. As suggested by Taormina *et al.* (2024), the off-flavors in soy milk are primarily attributed to lipoxygenase activity, which can generate undesirable flavor compounds

For flavor attribute, sample AQ (100% cow milk with moderate ginger) received the highest score (6.32 ± 0.100), indicating that moderate ginger incorporation (5%) improved flavor perception in cow milk yoghurt. Sample BZ (75:25% cow: soy milk with no ginger) received the lowest flavor score (1.04 ± 0.004), further supporting the observation that this particular ratio may accentuate undesirable flavor notes. These findings correspond with research by Aamir *et al.* (2023), who found that ginger can contribute positively to sensory attributes when used at appropriate concentrations, imparting a distinctive aromatic profile that enhances consumer appeal.

Smoothness scores varied significantly across samples, with the highest score recorded for sample AZ (8.94 ± 0.011), followed by sample AQ (8.04 ± 0.210). A general trend of decreasing smoothness was observed with increasing soy milk proportion, particularly in the 50:50% cow: soy milk formulations (CZ, CQ). This observation aligns with findings by Taormina *et al.* (2024), who reported that increasing soy protein content in dairy formulations affects the protein matrix formation during fermentation, potentially resulting in a coarser texture. Interestingly, sample CH (50:50% cow: soy milk with high ginger) showed a relatively high smoothness score (6.35 ± 0.021) compared to other 50:50% formulations, suggesting that high ginger concentration might improve the perceived texture of high-soy formulations through mechanisms that warrant further investigation.

Thickness scores ranged from 3.45 ± 0.121 to 6.75 ± 0.012, with sample AQ (100% cow milk with moderate ginger) receiving the highest score. The variation in thickness perception across samples may be attributed to differences in protein coagulation patterns between cow and soy milk during fermentation, as well as potential interactions between milk proteins and bioactive compounds in ginger. As noted by Qadir *et al.* (2025), yoghurt viscosity is primarily influenced by protein content, acidity development, and exopolysaccharide production by starter cultures, all of which can be modulated by ingredients that affect fermentation dynamics.

Sourness scores showed significant variations among samples, with highest scores observed in samples AQ (6.20 ± 0.045), AH (6.08 ± 0.111), and AZ (5.35 ± 0.051). Samples containing higher proportions of soy milk generally received lower sourness scores, particularly those in the 75:25% cow: soy milk category (BZ, BQ, BH). This pattern suggests that soy milk may buffer acid development during fermentation, resulting in reduced perceived sourness. Plant proteins, including those from soy, can exhibit buffering capacity, which may influence the rate of pH reduction during fermentation and subsequent acid perception.

Overall acceptability scores varied significantly ($p \leq 0.05$) among yoghurt formulations, ranging from 1.50 ± 0.002 to 8.74 ± 0.012. Sample AQ (100% cow milk with moderate ginger) received the highest overall acceptability score, followed by sample AH (100% cow milk with high ginger). This finding indicates that ginger incorporation at both moderate (5%) and high (10%) concentrations enhanced the overall acceptance of cow milk yoghurt. The positive impact of ginger on consumer acceptance can be attributed to its distinctive flavor profile and potential masking of unfavorable notes in yoghurt (Aamir *et al.,* 2023).

Samples with higher soy milk proportions received significantly lower overall acceptability scores, with sample CH (50:50% cow: soy milk with high ginger) receiving the lowest score (1.50 ± 0.002). This trend indicates that while ginger incorporation improved acceptance of cow milk yoghurt, it did not effectively mitigate the sensory challenges associated with high soy milk formulations. Taormina *et al.* (2024) noted that consumer acceptance of plant-based or composite dairy alternatives is heavily influenced by sensory familiarity, with products that closely resemble conventional dairy being more readily accepted by mainstream consumers.

The substantial difference in overall acceptability between 100% cow milk formulations (AZ, AQ, AH) and formulations with soy milk incorporation (BZ, BQ, BH, CZ, CQ, CH) suggests that sensory optimization of composite yoghurt formulations requires targeted approaches beyond flavor enhancement. Therefore, integrated strategies involving fermentation optimization, masking agents, and consumer education are necessary to improve market acceptance of plant protein-enriched dairy products.

Therefore, moderate ginger incorporation (5%) significantly enhanced the sensory attributes and overall acceptability of cow milk yoghurt, while demonstrating limited effectiveness in improving the sensory profile of high-soy formulations. These findings provide valuable insights for the development of ginger-enhanced yoghurt products with optimal consumer appeal and market potential.

Conclusion

This study found that adding 5% ginger extract to yogurt significantly improved taste, sweetness, and texture while maintaining microbiological safety during 8-day storage, but these benefits were most pronounced in 100% cow milk yogurt rather than soy-cow milk blends. The research demonstrates that moderate ginger incorporation can enhance both sensory appeal and shelf stability of yogurt products, providing practical guidance for developing functional dairy products with improved consumer acceptance, though higher ginger concentrations and soymilk ratios showed diminished effectiveness. These results support the commercial viability of moderate ginger incorporation in dairy-based yoghurt, offering a natural strategy to enhance flavor and functional stability without compromising microbial safety. Further research is recommended to explore encapsulation, enzymatic treatment, or flavor masking techniques to improve the sensory appeal of soy-enriched yoghurt formulations.

REFERENCES

Aamir, M., Arshad, A., Afzaal, M., Rakha, A., Oda, N. J. M., Nadeem, M., ... and Shah, M. A. (2023). Physicochemical and sensory profile of spiced yogurt as affected by ginger supplementation. *International Journal of Food Properties,* ***26*****(2):** 2732–2741. https://doi.org/10.1080/10942912.2023.2254021

Abagoshu, N. A., Ibrahim, A. M., Teka, T. A., and Mekonnen, T. B. (2017). Effect of soybean varieties and processing methods on nutritional and sensory properties of soymilk. *Journal of Food Processing and Preservation*. https://doi.org/10.1111/jfpp.13014

Assen, K. A., and Abegaz, M. A. (2024). Review on quality attributes of milk and commonly produced dairy products in Ethiopia. *Heliyon,* ***10*****(21):** e40089. https://doi.org/10.1016/j.heliyon.2024.e40089

Darko, N. K. O., and Mills-Robertson, F. C. (2025). Probiotic potential and antimicrobial effects of lactic acid bacteria isolated from palm wine against foodborne pathogens in Ghana. *Food Chemistry Advances,* **7:** 101002. https://doi.org/10.1016/j.focha.2025.101002

De Oliveira, L. I. G. de., Costa, W. K. A. da., Oliveira, F. de C. de., Bezerril, F. F., Eireli, L. P. A. M., Lima, M. dos S., Noronha, M. F., Cabral, L., Wagner, R., Pimentel, T. C., and Magnani, M. (2024). Ginger beer derived from back-slopping: Volatile compounds, microbial communities on activation and fermentation, metabolites and sensory characteristics. *Food Chemistry,* ***435*****:** 137640. https://doi.org/10.1016/j.foodchem.2023.137640

Diaz-Bustamante, M. L., Keppler, J. K., Reyes, L. H., and Alvarez Solano, O. A. (2023). Trends and prospects in dairy protein replacement in yogurt and cheese. *Heliyon,* **9(6):** e16974. https://doi.org/10.1016/j.heliyon.2023.e16974

He, K., Cheng, H., McClements, D. J., Xu, Z., Meng, M., Zou, Y., Chen, G., and Chen, L. (2024). Utilization of diverse probiotics to create human health promoting fatty acids: A review. *Food Chemistry,* ***458*****:** 140180. https://doi.org/10.1016/j.foodchem.2024.140180

Hsieh, K.-C., Liao, W.-H., Lin, K.-Y., Cheng, K.-C., and Ting, Y. (2024). Reducing of lipoxygenase and trypsin inhibitor in soy milk for improving nutritional quality through atmospheric cold plasma pretreated soybeans. *Food and Bioproducts Processing,* ***148*****:** 538–546. https://doi.org/10.1016/j.fbp.2024.10.006

Ihemeje, A., Nwachukwu, C. N., and Ekwe, C. C. (2015). Production and quality evaluation of flavoured yoghurts using carrot, pineapple, and spiced yoghurts using ginger and pepper fruit. *African Journal of Food Science,* **9(3):** 163–169. https://doi.org/10.5897/AJFS2014.1244

Khosroshahi, E. D., Razavi, S. H., Salami, M., and Ubeyitogullari, A. (2025). Recent advances in bioprocessing of medicinal plants through fermentation: A promising approach to maximize nutritional/functional value, bioactive potential, and health benefits. *Food Bioscience,* ***70*****:** 107045. https://doi.org/10.1016/j.fbio.2025.107045

Kılıç, E. E., Kılıç, İ. H., and Koç, B. (2022). Yoghurt production potential of lactic acid bacteria isolated from leguminous seeds and effects of encapsulated lactic acid bacteria on bacterial viability and physicochemical and sensory properties of yoghurt. *Journal of Chemistry,* p2683126. https://doi.org/10.1155/2022/2683126

Mahayothee, B., Thamsala, T., Khuwijitjaru, P., and Janjai, S. (2020). Effect of drying temperature and drying method on drying rate and bioactive compounds in cassumunar ginger (*Zingiber montanum*). *Journal of Applied Research on Medicinal and Aromatic Plants,* ***18*****:** 100262. https://doi.org/10.1016/j.jarmap.2020.100262.

Malomo, A. A., Obayomi, O. V., Akala, J. M., Olaniran, A. F., Adeniran, H. A., and Abiose, S. H. (2025). Influence of bio and chemical preservative on microbiological, sensory properties and antioxidant activity of ginger-flavored plantain wine for food waste prevention strategy. *Journal of Agriculture and Food Research,* ***21*****:** 101902. https://doi.org/10.1016/j.jafr.2025.101902

Obi, C. N., Olugbue, V. U., and Mpamugo, C. P. (2016). Yoghurt production from powdered milk using mixed lactic acid bacteria starter cultures. *Saudi Journal of Pathology and Microbiology,* ***1*****(2):** 42–49. https://saudijournals.com/media/articles/SJPM-1242-49.pdf

Olabiran, T. E., Awolu, O. O., and Ayo-Omogie, H. N. (2023). Quality characterization of functional soy-based yoghurt incorporated with scent leaf (*Ocimum gratissimum*) essential oil microcapsules. *Food Chemistry Advances,* **3:** 100336. https://doi.org/10.1016/j.focha.2023.100336

Qadir, R., Nasir, W. N. A. W. M., Azmi, A. B., Fatima, S., Mehmood, N., and Hussin, A. S. M. (2025). An insight into plant-based yogurts: Physicochemical, organoleptic properties and functional food aspects. *Journal of Food Composition and Analysis,* ***143*****:** 107578. https://doi.org/10.1016/j.jfca.2025.107578

Shao, T., Ma, X., Zhang, Y., Wu, R., Wang, X., Gu, R., and Chen, X. (2023). Physical and nutritional properties of Chinese steamed bun (mantou) made with fermented soy milk. *LWT,* ***183*****:** 114849. https://doi.org/10.1016/j.lwt.2023.114849

Taormina, V. M., Kelly, S., and Kraft, J. (2024). Plant-based yogurt alternatives: Suitable substitutes for cow's milk yogurts? *Current Developments in Nutrition,* ***8*****(Suppl. 2):** 102896. https://doi.org/10.1016/j.cdnut.2024.102896

Wang, X., Zhang, D., Jiang, H., Zhang, S., Pang, X., Gao, S., Zhang, H., Zhang, S., Xiao, Q., Chen, L., Wang, S., Qi, D., and Li, Y. (2020). Gut microbiota variation with short-term intake of ginger juice on human health. *Frontiers in Microbiology,* ***11*****:** 576061. https://doi.org/10.3389/fmicb.2020.576061