Journal of Recent Trends in Agriculture and Natural Science
Volume 2, Issue 1, Pages 8-15, 2026 (January-March)
ISSN (online): 3139-1494
DOI: https://doi.org/10.47001/JRTANS/2026.201002
Available Online at https://jrtans.com

Nutritional Evaluation of Yogurt Produced from Soy-Cow Milk Blends Sweetened with Pineapple

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Abstract: The increasing global demand for functional foods, coupled with the rising cost and limited supply of animal milk in developing regions, has necessitated the exploration of alternative protein sources for yogurt production. This review synthesizes current scientific evidence on the formulation and evaluation of yogurt produced from composite blends of soymilk and cow milk, using pineapple (Ananascomosus) as a natural sweetener and flavorant. Research demonstrates that soy-cow milk yogurt blends, particularly formulations with 50% cow milk and 50% soymilk supplemented with 10% pineapple, exhibit acceptable physicochemical properties with pH values ranging from 4.15 to 4.39 and titratable acidity between 0.087 and 0.095%. Proximate analysis reveals that combining cow milk with soymilk increases protein content, with the 50% soy + 50% cow milk blend achieving protein levels of 13.23%. Sensory evaluation indicates that pineapple addition significantly enhances color, taste, and overall acceptability, with the 50% cow milk, 50% soymilk, and 10% pineapple formulation scoring highest in taste (8.22). The total plate count for 100% cow milk yogurt sweetened with 10% pineapple was 1.951×10^5 CFU/ml, while the inclusion of soymilk and pineapple reduced both moisture and fat content. This review identifies that soymilk can be substituted up to 50% in cow milk yogurt preparation without significantly affecting physicochemical and sensory properties, thereby offering a cost-effective, nutritious alternative to conventional dairy yogurt. Furthermore, pineapple fruit juice incorporation at concentrations of 9-15% has been shown to increase lactic acid bacteria counts up to 9.56 log CFU/ml, with vitamin C content increasing while pH decreases. These findings support the commercial potential of soy-cow milk pineapple-sweetened yogurt as a sustainable, affordable, and health-promoting functional food product.

Keywords: Yogurt, soymilk, cow milk, pineapple, natural sweetener, functional food, proximate composition, sensory evaluation.

1. Introduction

Yogurt is a traditional fermented milk product that has been consumed for centuries, originating from the nomadic herdsmen of Asia and Southern and Eastern Europe. It is produced by adding a starter culture of acid-forming bacteria—typically Lactobacillus delbrueckii subsp. bulgaricus and Streptococcus thermophilus—to milk that has been pasteurized and homogenized. During fermentation, lactic acid bacteria break down milk sugars into lactic acid, causing a drop in pH and the formation of the characteristic curd. The acid environment restricts the growth of pathogenic bacteria while contributing to the unique taste and health-promoting properties of yogurt. Research has indicated that regular consumption of fermented dairy products may contribute to longevity and overall health, as observed in populations where such foods are dietary staples.

In recent years, interest in functional foods has surged among consumers due to greater health consciousness and increasing scientific evidence of their effectiveness in disease prevention and management. However, the high cost and inadequate supply of animal milk, particularly in developing nations like Nigeria, have prompted research into alternative protein sources for yogurt production. Soymilk, an aqueous extract of soybeans (Glycine max), has emerged as a promising candidate due to its nutritional profile. It contains all essential amino acids, is rich in protein, and offers health benefits through isoflavone content, though it is characterized by a beany or grassy flavor that can be improved by lactic acid fermentation.

Pineapple (Ananascomosus) is a tropical fruit rich in vitamin C, carbohydrates, and antioxidants such as flavonoids and phenolic acids. Its use as a natural sweetener and flavorant in yogurt production enhances sensory qualities while adding nutritional value and exploring the potential of local agricultural resources. The Food and Agriculture Organization (FAO) and World Health

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Organization (WHO) recommend fruit concentrations of 5-15% in yogurt production to increase added value.

This review synthesizes current scientific evidence on the formulation, production, and evaluation of yogurt made from composite blends of cow milk and soymilk using pineapple as a natural sweetener. It examines proximate composition, physicochemical properties, microbial quality, and sensory attributes of such products, drawing on research conducted in Nigeria and other regions.

2. Nutritional Composition and Quality of Soy-Cow Milk Yogurt Blends

2.1 Proximate Composition

The proximate composition of yogurt is a critical determinant of its nutritional quality and consumer acceptance. Research on soy-cow milk yogurt blends sweetened with pineapple has revealed significant variations in moisture, ash, fat, protein, and carbohydrate content depending on the formulation.

Moisture and Ash Content: The moisture content of yogurt samples ranges from 65.44% to 85.32% depending on the ratio of cow milk to soymilk and the inclusion of pineapple. Samples with 50% soymilk and 50% cow milk had a moisture content of 65.44%, while those with 100% soymilk sweetened with pineapple had higher moisture content of 85.32%. This indicates that soymilk and pineapple contribute to higher moisture levels. Ash content, representing mineral composition, ranged from 0.40% in 100% soymilk to 1.59% in the 50:50 cow-soy blend, suggesting that combining cow milk and soymilk enhances mineral content. Research by Okafor and Eze similarly observed that the addition of soymilk and pineapple reduced moisture and fat content while varying ash content.

Figure 1: Yogurt from soy milk and pineapple

Fat Content: The fat content of yogurt samples shows a decreasing trend upon introduction of pineapple sweetener. The 50% soy + 50% cow milk blend without pineapple had 6.11% fat, which decreased to 4.50% when pineapple was added. Similarly, 100% cow milk yogurt with pineapple had lower fat (2.89%) compared to cow milk yogurt without pineapple (4.77%). This reduction in fat content is nutritionally advantageous, as it contributes to a lower caloric density while maintaining creamy texture.

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Protein Content: Protein content is a key nutritional parameter, and research consistently demonstrates that combining cow milk with soymilk increases protein levels. The sample with 50% soymilk and 50% cow milk achieved the highest protein content at 13.23%, significantly exceeding that of 100% cow milk yogurt (8.56%) and 100% soymilk yogurt (11.21%). This synergistic effect arises from the complementary amino acid profiles of cow milk and soymilk. The addition of pineapple was associated with slight reductions in protein content in some formulations, likely due to dilution effects. Proximate analysis reported in other studies indicated crude protein ranging from 3.09 to 3.96%, reflecting variations in formulation and analytical methods.

Carbohydrate Content: Carbohydrate content, calculated by difference, ranged from 1.40% in 100% soymilk with pineapple to 15.49% in 100% cow milk with pineapple. The higher carbohydrate content in cow milk-based formulations reflects the natural lactose content, while soymilk-based samples have lower available carbohydrates due to the presence of oligosaccharides such as stachyose and raffinose.

2.2 Physicochemical Properties

The pH and titratable acidity (TA) of yogurt are critical quality parameters that reflect fermentation progress, lactic acid production, and product stability. Research on pineapple-sweetened soy-cow milk yogurt demonstrates pH values ranging from 4.15 to 4.39, with corresponding titratable acidity variations between 0.087% and 0.095%.

A study by Nasution et al. investigating yogurt made from skim milk, whole milk, and soybean juice powder with varying pineapple juice concentrations (9%, 12%, and 15%) reported significant effects of both milk type and pineapple concentration on pH and acidity. The addition of pineapple juice was associated with a decrease in pH, with the highest pineapple concentration (15%) yielding the lowest pH (4.06) in skim milk yogurt. This pH value meets Indonesian National Standards (SNI) for yogurt. However, the acidity value increased to 2.90%, exceeding SNI standards, indicating that pineapple juice contributes organic acids that lower pH while increasing total titratable acidity.

The lactic acid bacteria count in these samples ranged up to 9.56 log CFU/ml, with pineapple juice addition significantly increasing total LAB counts. This suggests that pineapple provides additional fermentable sugars that support probiotic bacteria growth, potentially enhancing the functional properties of the yogurt.

2.3 Amino Acid Profile and Nutritional Enhancement

Soymilk serves as an excellent alternative to cow milk due to its nutritional composition, containing all essential amino acids, though some are present in lower concentrations. Research has identified that combination of cow milk and soymilk can improve the overall amino acid profile through complementation, increasing protein quality. The protein content enhancement observed in the 50:50 cow-soy blend (13.23%) compared to pure cow milk (8.56%) confirms the nutritional advantage of composite formulations.

Recent research has also examined the vitamin C content of pineapple-supplemented yogurt. The addition of 15% pineapple juice to soyghurt achieved the highest vitamin C content, with concentrations increasing proportionally to the amount of pineapple added. This represents a significant nutritional enhancement, as vitamin C is a labile vitamin often lost during milk processing.

3. Sensory and Microbial Evaluation of Pineapple-Sweetened Soy-Cow Yogurt

3.1 Sensory Attributes and Consumer Acceptability

Sensory evaluation is essential for determining consumer acceptance of novel food products. Research using 7-point and 9-point hedonic scales has assessed various sensory attributes of pineapple-sweetened soy-cow milk yogurt, including color, taste, texture, flavor, and overall acceptability.

Color: Color ratings ranged from 2.59 to 6.44, representing "dislike moderately" to "like very much." The 100% cow milk (control) sample received the highest color rating, while 100% soymilk with pineapple recorded the lowest score. The lower color

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acceptability of soymilk-containing samples was attributed to the non-bright, dull appearance of soybean, suggesting that natural pigments from pineapple may not fully compensate for the less appealing color of soy-based products.

Taste: Taste is a primary determinant of acceptability, and research indicates that pineapple addition significantly enhances taste perception. The sample containing 50% cow milk, 50% soymilk, and 10% pineapple scored highest in taste with 8.22 on a 9-point hedonic scale, outperforming 100% cow milk yogurt (the control). This finding underscores the synergy between the mild flavor of the 50:50 cow-soy blend and the natural sweetness of pineapple. In contrast, 100% soymilk samples, particularly those with pineapple, received lower taste scores, reflecting residual beany flavor.

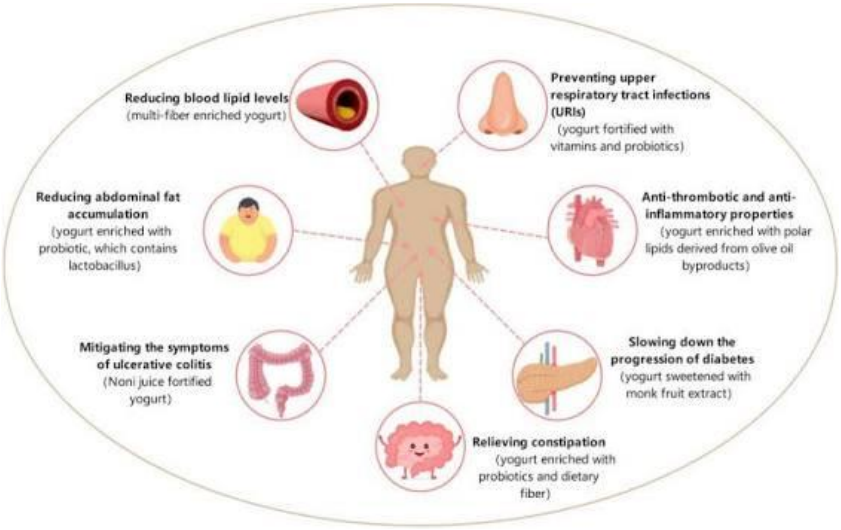

Figure 2: Advances in yogurt development for human

Texture: Texture mean scores ranged from 1.10 to 6.82, indicating "dislike very much" to "like extremely." The control (100% cow milk) was the most preferred, followed by the 50% cow milk + 50% soymilk blend. Texture is influenced by protein content and gel network formation, with higher protein levels generally yielding firmer, more viscous products.

Flavor: Flavor ratings ranged from 1.10 to 5.76, with the control sample being the most accepted and 100% soymilk with pineapple being least accepted. The lower flavor acceptability of soymilk-containing products is attributed to the unpalatable beany flavor associated with soybean, which can persist even after fermentation.

Overall Acceptability: The sample of 100% cow milk with 10% pineapple was most preferred overall at 8.05, while the composite sample of 50% cow milk, 50% soy milk, and 10% pineapple was the preferred blend. Statistical analysis indicated significant differences ($p > 0.05$) in taste, texture, and overall acceptability between the pure cow milk control and composite soy-yogurt samples, except for the 50% cow milk + 50% soymilk blend without pineapple, which was not significantly different from the control ($p < 0.05$).

3.2 Microbial Quality and Safety

Microbiological analysis is crucial for ensuring the safety and quality of fermented dairy products. Research has reported microbial loads ranging from 1.951×10^5 CFU/ml in 100% cow milk yogurt sweetened with 10% pineapple to lower counts in soy-containing formulations. Total plate count (TPC) provides insight into the overall microbial quality, while lactic acid bacteria (LAB) enumeration confirms the presence of active probiotic cultures. Higher microbial loads in cow milk yogurts reflect the more favorable growth environment of dairy substrates, as soy-based products contain oligosaccharides that are not as readily fermented.

Research on fruit-flavored yogurts has shown that natural fruit additions, including pineapple, maintain acceptable microbial

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loads, supporting the use of natural fruits as alternatives to synthetic flavorings. Studies indicate that natural fruit-fortified yogurt should not be stored beyond seven days as there would be a tendency for increased microbial load, although initial microbial counts remain within acceptable limits.

3.3 Probiotic Enhancement through Pineapple Addition

A significant finding is that pineapple addition may enhance probiotic quality. Research on yogurt from skim milk, whole milk, and soybean juice powder demonstrated that pineapple juice concentration of 9-15% significantly increased total lactic acid bacteria counts. The highest LAB count (9.56 log CFU/ml) was observed in skim milk yogurt with 15% pineapple juice. This effect is attributed to pineapple providing additional fermentable sugars and bioactive components that support LAB growth. For soy-based yogurts, pineapple addition similarly enhanced LAB counts, although fermentation of soy's oligosaccharide carbohydrates remains a challenge compared to dairy substrates.

4. Production Technology and Formulation Optimization

4.1 Production Process

The production of pineapple-sweetened soy-cow milk yogurt follows a standardized process based on established dairy fermentation principles. The process can be described in the following steps:

Milk Blend Preparation: Cow milk (fresh or reconstituted from powder) and soymilk (extracted from soybeans or prepared from powder) are combined in varying proportions. Research has investigated ratios including 100% cow milk, 50:50 cow-soy, 100% soymilk, and these formulations with added pineapple.

Pasteurization: The milk blend is pasteurized at 85°C for 5 minutes to eliminate pathogenic microorganisms and inactivate enzymes that might interfere with fermentation. Pasteurization also denatures whey proteins, improving the texture of the final product.

Cooling and Homogenization: The pasteurized mixture is cooled to approximately 40-45°C, the optimal temperature for starter culture activity. Homogenization is performed to ensure uniform distribution of milk solids and pineapple pulp, preventing separation and sedimentation.

Pineapple Preparation: Fresh pineapple is selected, peeled, washed, cut, and blended to produce a puree or juice. The pulp is filtered to remove fibrous material and heated at 80°C for 5 minutes to inactivate endogenous enzymes such as bromelain, which could otherwise hydrolyze milk proteins and affect yogurt texture. The prepared pineapple is cooled to about 40°C before addition.

Inoculation: A starter culture containing Lactobacillus delbrueckii subsp. bulgaricus and Streptococcus thermophilus is added at 0.1-0.5% of the milk volume. For soy-based yogurts, additional probiotic cultures such as Lactobacillus acidophilus or bifidobacteria have been investigated to improve fermentation and reduce beany flavor.

Fermentation: The inoculated mixture is incubated at 40-45°C for 24 hours until the desired pH (typically 4.15-4.39) is achieved. The fermentation time depends on the milk blend composition, pineapple juice concentration, and starter culture activity.

Cooling and Storage: After fermentation, the yogurt is cooled to 4°C to stop further acidification and stored under refrigeration. Studies indicate that fruit-fortified yogurt should ideally be consumed within 7 days to maintain microbial quality and minimize the growth of spoilage organisms.

4.2 Formulation Optimization

Optimization of yogurt formulation involves balancing ingredient proportions to achieve desired nutritional, sensory, and

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functional properties. Research findings support specific recommendations:

Cow Milk to Soymilk Ratio: Substitution of cow milk with soymilk up to 50% produces acceptable sensory and physicochemical properties. The 50% cow milk + 50% soymilk blend achieved protein content of 13.23%, which was higher than either milk alone, and did not show significant sensory differences from 100% cow milk.

Pineapple Concentration: The addition of 10% pineapple pulp has been identified as optimal for sensory acceptability, particularly in taste and overall preference. Research on fruit concentration variations of 9-15% demonstrated that higher pineapple concentrations (15%) can increase lactic acid bacteria counts and vitamin C content but may also increase acidity to levels exceeding standard specifications.

Starter Culture Selection: The combination of Lactobacillus bulgaricus and Streptococcus thermophilus produces the characteristic yogurt flavor and texture in both cow and soy milk formulations. Research has also examined probiotic organisms including Bifidobacteria and various Lactobacillus species for soy-based substrates to improve fermentation of oligosaccharides and reduce beany flavor.

4.3 Quality Standards and Compliance

Quality standards for yogurt vary by country, but generally specify minimum requirements for lactic acid bacteria count, pH, acidity, and microbiological safety. Research from Indonesia reported that yogurt made from skim milk with 15% pineapple juice achieved a pH of 4.06, meeting Indonesian National Standards (SNI) requirements for pH (4.0-4.8). However, the acidity of 2.90% exceeded the SNI standard, suggesting that pineapple concentration may need to be adjusted to balance acidity and sensory acceptability.

Microbiological quality standards require that yogurt contains adequate viable LAB (at least 10^7 CFU/ml) and is free from pathogenic contaminants. Research reported total LAB counts up to 9.56 log CFU/ml in pineapple-supplemented yogurts, significantly exceeding minimum requirements. The presence of pineapple enhanced LAB counts, indicating improved probiotic content.

5. Conclusion

This review has examined the production, nutritional quality, sensory attributes, and microbial characteristics of yogurt produced from composite blends of soymilk and cow milk using pineapple as a natural sweetener. The findings demonstrate that soymilk can be substituted up to 50% in cow milk yogurt preparation without significantly compromising physicochemical and sensory properties, while offering the advantages of lower cost, improved protein content (13.23% in 50:50 cow-soy blend compared to 8.56% in pure cow milk yogurt), and enhanced nutritional value. The addition of 10% pineapple pulp has been shown to significantly enhance sensory qualities, with the 50% cow milk, 50% soymilk, and 10% pineapple formulation scoring highest in taste (8.22) and the 100% cow milk with 10% pineapple receiving the highest overall acceptability score (8.05). Research indicates that pineapple addition increases total lactic acid bacteria counts up to 9.56 log CFU/ml, supporting probiotic activity, while also improving vitamin C content and reducing both moisture and fat content. Physicochemical parameters, including pH (4.15-4.39) and titratable acidity (0.087-0.095%), fall within acceptable ranges for commercial yogurt products. Challenges remain, including the beany flavor of soymilk that can affect taste and color acceptability, and the need to manage acidity levels when higher concentrations of pineapple are used. Nevertheless, soy-cow milk yogurt sweetened with pineapple represents a promising functional food product with commercial potential, particularly in regions where animal milk is expensive or in limited supply. This product offers a sustainable, affordable, and health-promoting alternative to conventional dairy yogurt, supporting food security and nutrition in developing countries. Future research should focus on optimizing fermentation conditions, exploring additional fruit varieties, and investigating the long-term probiotic viability and health benefits of these composite yogurts.

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Citation of this Article:

Oluwatoyin Okoro. (2026). Nutritional Evaluation of Yogurt Produced from Soy-Cow Milk Blends Sweetened with Pineapple. *Journal of Recent Trends in Agriculture and Natural Sciences.* 2(1), 8-15. Article DOI: https://doi.org/10.47001/JRTANS/2026.201002

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