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Formulation and evaluation of pineapple-sweetened yoghurt made from cow milk and soy milk

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Abstract

This study evaluates the formulation and evaluation of pineapple-sweetened yogurt made from cow milk and soy milk. The research investigates how varying proportions of cow milk, soy milk, and pineapple affect the physicochemical properties, microbial load, sensory attributes, and proximate composition of the yogurt. The pH of the samples ranged from 4.15 to 4.39, with the titratable acidity showing significant variations from 0.087 to 0.095. Total plate count (TPC) revealed a higher microbial load of 1.951×10^5 CFU/ml in 100% cow milk yogurts sweetened with 10% pineapple. Sensory evaluation highlighted that the addition of pineapple significantly enhanced the color, taste, and overall acceptability of the samples, particularly in samples with higher cow milk content. The MP sample with 50% cow milk, 50% soy milk, and 10% pineapple scored highest in taste with 8.22, while the CP sample of 100% cow milk and 10% pineapple was most preferred overall at 8.05. Proximate analysis revealed that soy milk and pineapple reduced moisture and fat content while varying ash content. Crude protein ranged from 3.09 to 3.96%. This research identifies that adding pineapple enhanced the sensory qualities of the yogurt samples, thereby supporting the use of soy milk and natural sweeteners like pineapple in yogurt production.

Keyword: Plant-based yoghurt; Pineapple-sweetened; Soy milk; Sensory; Proximate composition

1. Introduction

Yogurt, a widely consumed fermented dairy product, has been enjoyed by diverse cultures around the world for centuries, revered for its unique taste, creamy texture, and significant nutritional benefits [1]. Traditionally, yogurt production involves the fermentation of milk sugars by specific bacterial cultures, resulting in a tangy and nutritious product rich in probiotics, a good source of protein and calcium [2]. However, the rising interest in plant-based diets that do not compromise on taste or nutritional value, has led to the exploration of alternative milk sources, such as soy milk, for yogurt production. Soy milk, derived from soybeans (*Glycine max*), is a lactose-free alternative with a different nutritional profile compared to cow milk [3[. It is rich in protein, low in saturated fat, and contains beneficial isoflavones [4]. However, transforming soymilk into a palatable and widely accepted yogurt product poses certain challenges, primarily related to flavor and texture. To address these challenges, natural sweeteners can play a crucial role [1].

In addition to the type of milk used, flavoring agents such as fruits are often added to yogurt to enhance its taste and appeal. Pineapple (*Ananas comosus*) is a tropical fruit known for its sweet and tangy flavor, rich in vitamins, antioxidants, and dietary fiber [5]. The inclusion of pineapple in yogurt not only improves its sensory characteristics but also increases its nutritional value, including high vitamin C content and digestive enzymes [2]. The combination of cow milk, soy milk, and pineapple in yogurt production presents a novel approach to creating a dairy product that caters to diverse consumer preferences and dietary requirements [5]. Additionally, the use of a natural sweetener like

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pineapple aligns with the current trend towards healthier and more natural food additives, addressing consumer demand for clean-label products [3].

The formulation and evaluation of pineapple-sweetened yogurt made from cow milk and soy milk involves understanding the effects of these ingredients on the physicochemical properties of the yogurt, microbial load, sensory attributes, and proximate composition [4]. This study aims to investigate how varying the proportions of cow milk, soy milk, and pineapple in yogurt formulation impacts these key parameters, ultimately providing insights into the potential of soy milk and pineapple.

2. Materials and method

The soybeans, Dano full-cream milk and ripped sweet pineapples (*Formosa* variety) were purchased from Ogige Nsukka market, Eungu State, Nigeria. All samples were taken to the laboratory for immediate use.

2.1. Preparation of soy milk

Soy milk was prepared with some modification [4]. Soybean (500 g) was steeped in 1L of distilled water for 18 h at ambient temperature (28 °C), then drained. The soybeans were boiled in distilled water for 20 min at 98 °C. Then cooled and dehulled manually by rubbing between the palms to wash off the seed coat. Then distilled water added to form a ratio of 1:5 for soybean to water and blended properly. The resultant slurry was filtered through 3 layers of cheesecloth and the residue was discarded. The filtrate (soymilk) was boiled for 20 min, stirring continuously to cook it. Afterwards, it was cooled to 45 °C before blending and inoculation with starter culture.

2.2. Preparation of pineapple juice

The pineapples were washed and pilled, then diced into pieces for ease of blending. It was blended using a food blender (Master chef blender, model no: MC– BL6731J). The pulp filtered with a cheese cloth, pasteurized for 85 °C for 3 minutes and cooled [5].

2.3. Processing of cow milk

Full cream Dano milk powdered (500g) made from cow milk was reconstituted with 2500 ml of distilled water and pasteurized at 85 °C for 15 min to deactivate undesirable microorganisms. Afterward, it was allowed to cool to 45 °C before blending and inoculation with starter culture [1].

2.4. Formulation and preparation of yoghurt samples

Soy milk and cow milk were blended in the following ratio based on preliminary studies; 100:0, 75:25, 50:50 for cow milk and soy milk, respectively. The milk blends (1L) at 45 °C were inoculated with a freeze-dried starter culture (yogurmet), in separate beakers. After inoculation, samples were tightly covered and placed in an incubator at 42 °C for 8 h to ferment. Then, yoghurt samples were stirred properly and refrigerated at 4 °C for further analysis [6].

Pineapple juice was added to the yoghurts after fermentation by dividing each blend into two. Such that one portion of each blend will have 10 % v/v of pineapple juice, while the other portion without pineapple were used as a control (Table 1). All samples were stored at 4 °C until ready for analysis.

Table 1 Sample formulation of pineapple-sweetened yoghurt made from cow milk and soy milk

Ingredients	CY	CP	SY	SP	MY	MP
Cow milk (%)	100	100	75	75	50	50
Soy milk (%)	-	-	25	25	50	50
Pineapple juice (%)	-	10	-	10	-	10

2.5. Physiochemical properties of the yoghurt samples

2.5.1. Determination of pH values

The pH values of each sample were measured using a pH meter. The pH meter was standardized by testing the buffer solutions of known pH. This aimed to test the acidity level of the yoghurt samples [7].

2.5.2. Determination of Titratable Acidity (TA)

Each yoghurt sample (1g) was mixed with 10 ml of hot distilled water (90 °C) and titrated to a faint colour with 0.1N NaOH comprising 0.5% phenolphthalein as an indicator. The percentage of lactic acid produced by fermentation in the sample was determined as follows [6]. Titre value x 0.09 x 100%

(Where the titre value is the Volume of yoghurt sample solution used; 0.09 is a conversion factor).

2.6. Determination of microbial count of the yoghurt samples

Homogenized yoghurt samples (1 ml) each were aseptically transferred into a corresponding sterile test tube containing 9 ml of distilled water up to a four-fold serial dilution. Using the pour plate method on Nutrient Agar, the plates were incubated at 37 °C for 24 h and the colonies were counted for bacteria load. All counts were expressed as CFU/ml [7].

2.7. Determination of Sensory attributes of the yoghurt samples

The yoghurt samples were coded and evaluated for sensory attributes by 50 individuals. Multistage selection was applied, such that various age groups, genders, occupations, and social strata were randomly chosen among students and staff of the university. A glass of water was given to each panelist so they could rinse their mouths after tasting each sample. They were also given questionnaires to score the yoghurt samples for appearance, colour, aroma, taste, consistency and overall acceptability, using a 9-point hedonic scale ranging from 0 (extremely dislike) to 9 (extremely like) [8].

2.8. Proximate Composition of the yoghurt samples

The standard procedure was used to evaluate crude protein, ash, fat, moisture, and carbohydrate contents [9]. Moisture content was determined by loading known weights of samples into crucibles and drying at 105 °C temperatures. The weights of the dried samples were recorded after being cooled in desiccators. The samples were then returned to the oven, where the process was repeated until constant weights were obtained. The ash content was calculated by transferring already ignited samples over a low flame to char the organic matter. The crucible lids were removed and placed in a muffle furnace at 600 °C for 6 hours or until they had completely turned into ash. The Soxhlet apparatus method was used for fat determination. Protein was calculated by multiplying total nitrogen content by 6.26 using the standard micro Kjeldahl method. The first and last weights were used to calculate the ash percentage. Carbohydrate was calculated by difference as % CHO = 100 - (the sum of moisture, ash, fat and protein percentages).

2.9. Statistical Analysis

All analyses were evaluated in triplicate and stated as mean ± standard deviation. Statistical Analysis of Variance (ANOVA) using SPSS version 28 (SPSS, Inc., USA) was applied for means variation while, the Duncan Multiple Range Test (DMRT) at an acceptable level of $p \leq 0.05$ was utilized for the separation of means [10].

3. Results

Table 2 Physiochemical **properties** and microbial count of pineapple-sweetened yoghurt made from cow milk and soy milk

SAMPLE	pH	TITRATABLE ACID (%)	TOTAL PLATE COUNT (CFU/ml)
CY	4.23 ± 0.005^{b}	0.087 ± 0.012^{a}	$1.932 \times 10^{5} \pm 0.024^{c}$
CP	4.15 ± 0.005^{a}	0.092 ± 0.011^{a}	$1.951 \times 10^{5} \pm 0.011^{c}$
SY	4.39 ± 0.001^{c}	0.091 ± 0.010^{a}	$1.832 \times 10^{5} \pm 0.008^{b}$
SP	4.22 ± 0.021^{b}	0.095 ± 0.001^{b}	$1.803 \times 10^{5} \pm 0.017^{b}$
MY	4.33 ± 0.011^{c}	0.090 ± 0.004^{a}	$1.457 \times 10^{5} \pm 0.007^{a}$
MP	4.19 ± 0.003^{ab}	0.093 ± 0.001^{b}	$1.311 \times 10^{5} \pm 0.013^{a}$

Where CY is 100% cow milk, 0% soy milk, and 0% pineapple; CP is 100% cow milk, 0% soy milk, and 10% pineapple; SY is 75% cow milk, 25% soy milk, and 0% pineapple; SP is 75% cow milk, 25% soy milk, and 10% pineapple; MY is 50% cow milk, 50% soy milk, and 0% pineapple; MP is 50% cow milk, 50% soy milk, and 10% pineapple.

Table 3 Sensory attributes of pineapple-sweetened yoghurt made from cow milk and soy milk

Sample	Colour	Taste	Flavour	Texture	Overall acceptability
CY	7.51±0.11^{b}	6.11±0.11^{ab}	7.67±0.05^{e}	8.02±0.03^{c}	7.99±0.10^{c}
CP	7.82±0.10^{b}	6.83±0.03^{ab}	8.03±0.02^{d}	8.11±0.05^{c}	8.05±0.11^{c}
SY	6.51±0.15^{a}	5.70±0.05^{a}	5.33±0.04^{c}	6.41±0.10^{b}	6.35±0.21^{ab}
SP	5.72±0.10^{a}	6.28±0.09^{b}	5.62±0.02^{c}	6.03±0.04^{b}	6.58±0.08^{b}
MY	6.01±0.24^{a}	5.73±0.13^{a}	4.01±0.11^{a}	3.11±0.06^{a}	6.44±0.14^{a}
MP	6.63±0.11^{ab}	8.22±0.06^{c}	6.77±0.02^{d}	4.05±0.11^{a}	7.81±0.01^{c}

Where CY is 100% cow milk, 0% soy milk, and 0% pineapple; CP is 100% cow milk, 0% soy milk, and 10% pineapple; SY is 75% cow milk, 25% soy milk, and 0% pineapple; SP is 75% cow milk, 25% soy milk, and 10% pineapple; MY is 50% cow milk, 50% soy milk, and 0% pineapple; MP is 50% cow milk, 50% soy milk, and 10% pineapple.

Table 4 Proximate composition of pineapple-sweetened yoghurt made from cow milk and soy milk

Sample	Moisture	Ash	Fat	Crude protein	Carbohydrate
CY	83.42±0.02^{c}	1.61±0.11^{d}	4.01±0.06^{c}	3.85±0.05^{a}	7.11±0.06^{a}
CP	81.70±0.01^{b}	0.87±0.07^{b}	3.28±0.03^{b}	3.62±0.02^{ab}	10.53±0.03^{b}
SY	82.22±0.12^{bc}	1.07±0.02^{c}	3.17±0.05^{b}	3.27±0.04^{a}	10.27±0.01^{b}
SP	80.05±0.09^{ab}	1.32±0.04^{c}	2.87±0.02^{a}	3.09±0.03^{a}	12.67±0.03^{c}
MY	81.57±0.03^{b}	0.59±0.03^{ab}	3.31±0.01^{b}	3.96±0.01^{b}	10.57±0.01^{b}
MP	79.15±0.05^{a}	0.37±0.03^{a}	2.57±0.03^{a}	3.39±0.03^{a}	14.52±0.02^{d}

Where CY is 100% cow milk, 0% soy milk, and 0% pineapple; CP is 100% cow milk, 0% soy milk, and 10% pineapple; SY is 75% cow milk, 25% soy milk, and 0% pineapple; SP is 75% cow milk, 25% soy milk, and 10% pineapple; MY is 50% cow milk, 50% soy milk, and 0% pineapple; MP is 50% cow milk, 50% soy milk, and 10% pineapple.

4. Discussion

4.1. Physiochemical properties and microbial profile of the yoghurt samples

The results from the study, as detailed in Table 2, provide insight into the physicochemical properties and microbial load of yogurt samples prepared with varying compositions of cow milk, soy milk, and pineapple.

The pH of the samples ranged from 4.15 to 4.39, indicating a slight acidity across all yogurt samples. Specifically, the cow milk and pineapple (CP) sample exhibited the lowest pH (4.15), while the soymilk yogurt (SY) without pineapple had the highest pH (4.39). These pH levels are within the expected range for yogurt, typically between 4.0 and 4.6, confirming that all samples maintained an environment conducive to yogurt fermentation [2].

The titratable acidity (TA) reflects the concentration of organic acids present in the yogurt. The values ranged from 0.087% in the CY sample (cow milk yogurt without pineapple) to 0.095% in the SP sample (soy milk and pineapple). The TA values suggest that adding pineapple may have slightly increased the acidity in the yogurt, although the variations across samples were relatively small. This consistency indicates that fermentation was well-controlled across all samples [1].

The total plate count (TPC) represents the microbial load in the yogurt samples, which is crucial for evaluating the microbiological quality and safety of the product. The TPC values ranged from 1.311 x 10^5 CFU/ml in the MP sample (equal parts cow milk and soy milk with pineapple) to 1.932 x 10^5 CFU/ml in the CY sample. The relatively higher microbial load in the CY and CP samples, both of which are cow milk-based, suggests that cow milk may support a higher proliferation of microorganisms compared to soy milk-based yogurts. However, all TPC values were within acceptable limits for fermented dairy products, indicating that the yogurt samples were safe for consumption [3].

Overall, the physicochemical properties and microbial load observed in the study are consistent with the characteristics of standard yogurt products, with minor variations attributable to the different compositions of cow milk, soy milk, and pineapple. These results align with existing literature on yogurt production, where the addition of fruit and different milk sources can influence both acidity and microbial activity [11; 12].

4.2. Sensory Evaluation

The sensory evaluation of yogurt samples made from varying proportions of cow milk, soy milk, and pineapple revealed significant differences in the attributes of color, taste, flavor, texture, and overall acceptability, as shown in Table 3. These findings are crucial as they highlight how different formulations influence consumer perception, which is vital for product development and market acceptance.

The color attribute, which is often the first sensory cue consumers observe, varied significantly among the samples. The highest color score was observed in the CP sample (7.82), made from 100% cow milk and 10% pineapple. This result suggests that the addition of pineapple to cow milk enhances the visual appeal of yogurt. Conversely, the SP sample (75% cow milk, 25% soy milk, and 10% pineapple) had the lowest color score (5.72), indicating that higher soy milk content might negatively impact the yogurt's color. This aligns with previous research that suggests soy milk can alter the color intensity of dairy products due to its different protein structure and pigmentation [13].

Taste is a critical factor influencing consumer preference. The MP sample, comprising 50% cow milk, 50% soy milk, and 10% pineapple, received the highest taste score (8.22). This result suggests a favorable balance between the creamy texture of cow milk and the nutty flavor of soy milk, enhanced by the sweetness of pineapple. The lowest taste score was recorded for the SY sample (75% cow milk and 25% soy milk without pineapple), scoring 5.70. This result may indicate that the absence of a sweetener or flavor enhancer such as pineapple reduces the palatability of yogurt containing soy milk, a finding supported by other studies that highlight the importance of sweeteners in improving the taste of soy-based products [14].

Flavor evaluation showed a wide range among the samples, with CP scoring the highest (8.03) and MY the lowest (4.01). The MY sample (50% cow milk and 50% soy milk without pineapple) was rated poorly, which may be attributed to the strong beany flavor of soy milk that some consumers find undesirable (Liu et al., 2020). The addition of pineapple in the CP sample significantly enhanced its flavor, suggesting that pineapple effectively masks any off-flavors from soy milk, which is consistent with previous findings on the use of fruit additives to improve soy-based yogurt flavors [15].

Texture is another crucial sensory attribute, and the results revealed significant variation among the samples. CP had the highest texture score (8.11), indicating a preferred consistency and mouthfeel. In contrast, MY received the lowest score (3.11), suggesting that the combination of equal parts cow milk and soy milk without pineapple results in a less desirable texture, possibly due to phase separation or a gritty mouthfeel often associated with soy protein [16].

The overall acceptability scores reflect a synthesis of the sensory attributes discussed above. CP was the most preferred sample, with a score of 8.05, while SY was the least preferred, scoring 6.35. These findings suggest that consumers are likely to prefer yogurt formulations with a higher percentage of cow milk and the addition of pineapple, which improves the product's sensory qualities across multiple attributes [4].

Adding pineapple significantly enhances the sensory attributes of yogurt made from cow milk and soy milk, making it more acceptable to consumers. The results of this study align with previous research that emphasizes the importance of balancing ingredient proportions and incorporating flavor enhancers to improve the sensory properties of plant-based dairy alternatives.

4.3. Proximate composition

The proximate composition analysis of yoghurts made from varying proportions of cow milk, soy milk, and sweetened with pineapple revealed significant differences across the different samples (Table 4). Moisture content ranged from 79.15% to 83.42%, with the highest moisture content observed in the 100% cow milk sample (CY) and the lowest in the sample containing 50% cow milk, 50% soy milk, and 10% pineapple (MP). These results indicate that the addition of soy milk and pineapple generally reduces the moisture content of yoghurt, which could be due to the lower water content in soy milk compared to cow milk and the concentration effect caused by pineapple addition [17].

The ash content, which indicates the total mineral content of the yoghurt samples, also varied significantly, with values ranging from 0.37% to 1.61%. The highest ash content was found in the 100% cow milk yoghurt (CY), while the lowest was in the 50% cow milk, 50% soy milk, and 10% pineapple yoghurt (MP). This reduction in ash content with the inclusion of soy milk and pineapple suggests a dilution effect due to these ingredients, as soy milk generally contains lower levels of minerals compared to cow milk [18].

Fat content among the yoghurt samples showed a decreasing trend with the incorporation of soy milk and pineapple. The fat content ranged from 2.57% in the MP sample to 4.01% in the CY sample. The decrease in fat content with increasing soy milk and pineapple proportion can be attributed to the lower fat content of soy milk relative to cow milk and the fat-free nature of pineapple [19].

Crude protein content was relatively consistent across the samples, with values ranging from 3.09% to 3.96%. The highest protein content was observed in the 100% cow milk sample (CY), while the lowest was in the 50% cow milk, 50% soy milk, and 10% pineapple yoghurt (MP). The slight decrease in protein content with the addition of soy milk could be due to the lower protein content in soy milk compared to cow milk [20].

Carbohydrate content exhibited a noticeable increase with the addition of pineapple. The carbohydrate content ranged from 7.11% in the CY sample to 14.52% in the MP sample. The substantial increase in carbohydrate content with pineapple addition is expected, given the high sugar content of pineapple, which contributes to the overall carbohydrate content of the yoghurt [21].

Overall, the proximate composition analysis indicates that the inclusion of soy milk and pineapple significantly influences the moisture, ash, fat, and carbohydrate content of yoghurt, with minimal effects on crude protein content. These findings highlight the potential of soy milk and pineapple as functional ingredients in yoghurt formulation, offering variations in nutritional content that could cater to different dietary needs.

5. Conclusion

This study on the formulation and evaluation of pineapple-sweetened yogurt made from cow milk and soy milk highlights the impact of ingredient variation on the physicochemical, microbial, sensory, and nutritional properties of yogurt. The incorporation of soy milk and pineapple significantly altered the pH, titratable acidity, microbial load, and sensory attributes of the yogurt, with the pineapple-enhanced samples generally receiving higher acceptability scores. The proximate composition analysis further revealed that the inclusion of soy milk and pineapple reduced the moisture, ash, and fat content while increasing the carbohydrate content. These findings demonstrate the potential of soy milk and pineapple as functional ingredients in yogurt production, providing alternative formulations that can cater to diverse consumer preferences and dietary requirements.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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