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Quality Evaluation of Yogurt Produced from Chili Pepper-Derived Starter Culture

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Abstract
The study investigated the production of yogurt using starter cultures developed from chili pepper and evaluated its effect on some quality parameters of the resultant yogurt. The quality parameters investigated were: nutritional content and sensory attributes. Statistical analysis, (ANOVA) and Duncan's multiple range test were applied to assess significant differences. The results revealed that the addition of chili pepper have significant effects ($p<0.05$) on yogurt quality parameters. Moisture content ranged from 83.46±0.15% to 89.50±0.20%, crude protein from 3.15±0.55% to 6.01±0.11%, crude fat from 2.86±0.15% to 5.89±0.09%, and ash content from 0.50±0.01% to 0.69±0.025%. Vitamin A levels ranged from 0.07% to 0.20%, indicating that chili pepper enhanced the Vitamin A content compared to the control (0.06%). Calcium content varied between 284 mg/100g and 342 mg/100g, while potassium content ranged from 92.32 mg/100g to 172.11 mg/100g. Sensory attributes varied significantly with the taste quality range from 3.00±0.50 to 5.00±0.50, texture from 4.00±0.50 to 5.00±0.50, aroma from 2.00±0.50 to 4.00±0.50, appearance from 2.17±0.29 to 5.00±0.50, and general acceptability from 3.00±1.00 to 5.00±0.50. In conclusion, chili pepper shows promising results for use in starter culture for yogurt production, because it can positively influence the nutritional and sensory properties of the yogurt, compared to the control.

Keywords: *Chili pepper, yogurt, starter culture, proximate composition, sensory evaluation.*

1.0 Introduction

Most regulatory agencies worldwide classify yogurt, also spelled as "yoghurt" or "yoghourt," as a fermented milk product. It contains digested lactose and specific live bacterial strains, usually *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. Yogurt is rich in essential nutrients like protein, calcium, potassium, phosphorus, Vitamins B2, and B12, and often used as a medium for fortification [1]. It is believed that milk products became part of the human diet approximately between 10,000 and 5000 BC, coinciding with the domestication of milk-producing animals such as cows, sheep, goats, yaks, horses, buffalo, and camels [2].

Yogurt stands as a widely favored fermented milk product globally, renowned for its perceived health benefits. It offers a rich array of nutrients relative to its calorie and fat content, rendering it a nutrient-rich option. Notably, yogurt serves as a bioavailable source of calcium. Additionally, its consumption is linked to various health advantages, including enhanced lactose tolerance, potential contribution to weight management, and the positive impacts associated with probiotic bacteria [3].

A starter culture is a microbial preparation containing one or more microorganisms that produce different enzymes, such as lactase, proteases, peptidase, and lipases, to facilitate the rate of chemical reactions and are mixed with the fermenting compound in order to speed up and control the fermentation process [4].

Starter cultures play a crucial role in cheese production, evolving significantly over time. Initially, starters comprised of undefined mixtures of species, now replaced by well-defined strains, often custom-designed. Mainly composed of lactic acid bacteria (LAB) like *Lactococcuslactis* and *Streptococcus thermophilus*, these starters not only acidify but also influences flavor and aroma. [4]. Chili pepper, scientifically known as *Capsicum annuum*, belongs to the domesticated species within the plant genus Capsicum, which falls under the family Solanaceae [5].

Varieties and cultivars of *Capsicum annuum* are categorized according to their fruit shapes, which develop from the gynoecium post-fertilization. These fruits undergo significant morphological and structural changes in the carpels. The Capsicum genus, comprising sweet and hot peppers, exhibits diversity in fruit type, color, shape, taste, and biochemical composition both within and between species [6]. Chili serves as a crucial spice, integral to a diverse range of cuisines globally. Its role extends beyond mere flavoring, as it adds color, tanginess, and depth to dishes. Capsicum species are utilized whole or ground, either alone or in conjunction with other flavorings, particularly in pickles, stews, or barbecues [7].

The utilization of unconventional sources like chili pepper in the production of starter cultures for yogurt making presents an intriguing avenue for exploration. However, the compatibility of this fruit with traditional

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yogurt fermentation processes remains unclear. Investigating its efficacy as a potential substrate for starter culture development is crucial to understanding its impact on yogurt quality and flavor. This study aims at addressing this gap in knowledge and providing insights into novel approaches for enhancing yogurt production using unconventional ingredients.

2.0 Materials and Methods

2.1 Materials

Samples of powdered milk and chili pepper were purchased from Kure Market in Minna, Niger State, Nigeria.

2.2 Methods

2.2.1 Experimental Design

The Design Expert 13 software of 2021 was used to prepare the experimental design for this study. Table 1 shows the experimental designs for the chili pepper samples.

Table 1: Experimental Design for Chili Pepper Samples

Number of Runs	Thickness (cm)	Number of Chili
1	1.5	2
2	1.45	4
3	1.2	2
4	1.2	4

Temperature was kept constant at 65°C

where:

B5= Two chili pepper with a diameter of 1.5 cm
B6 = Four chili peppers with a diameter of 1.45 cm
B7= Two chili peppers with a diameter of 1.2 cm
B8= Four chili peppers with a diameter of 1.2 cm
Control = Commercially produced yogurt

2.2.2 Development of Starter Culture

The processing methods employed included the selection of fresh chili peppers as a source of naturally occurring lactic acid bacteria, such as *Lactiplantibacillus plantarum*, and incubation under controlled conditions.

Figure 1: Chili Pepper Samples

Fifty grams (50g) of milk was measured into a container labeled B5, and 250 mL of water was added and mixed thoroughly to ensure homogeneity. The mixture was pasteurized at 85 °C for 30 minutes, which also denatured the milk proteins and improved the texture of the final yogurt.

After pasteurization, the milk was cooled to 40 °C. Chili peppers were sorted according to size using a vernier caliper. Two chili peppers with an average diameter of 1.5 cm were selected and added to the milk sample for inoculation. The selected number and size of chili peppers were used to standardize the inoculation process and to evaluate the effect of chili pepper size and quantity on the quality of yogurt produced using the respective starter cultures. After 36 hours of incubation, the developed starter culture was removed and prepared for yogurt production.

This procedure was repeated for three additional samples in containers labeled B6, B7, and B8. In all treatments, 50 g of milk and 250 mL of water were used under the same pasteurization and incubation

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conditions. The treatments differed only in the number and size of the chili peppers used for inoculation, as follows:
B6: Four chili peppers with an average diameter of 1.45 cm.
B7: Two chili peppers with an average diameter of 1.20 cm.
B8: Four chili peppers with an average diameter of 1.20 cm.

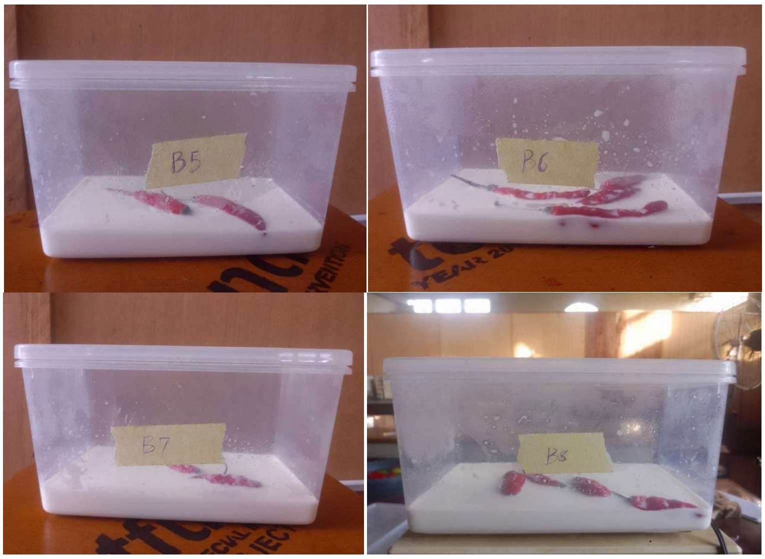

Figure 2: Milk and Chili pepper mixture before Incubation

2.2.3 Production of Yoghurt

After 36 hours, the starter cultures were removed from the incubator to stop the fermentation process. One hundred grams (100g) of milk was dissolved in 500ml of water to make the sample, which was then pasteurized at 90°C. The milk sample was cooled to 45°C and inoculated with the starter culture produced from chili with a diameter of 1.5cm in sample B5. It was then incubated at 65°C for 12 hours. After fermentation, the milk was agitated to produce a drinkable yogurt (Figure 3). This process was repeated for samples B5 through B8. The samples were then prepared for sensory evaluation and laboratory analysis and the remaining samples were stored in a refrigerator at 4°C.


Figure 3: Produced Yogurt from Chili Pepper Starter Culture

2.2.4 Sensory Evaluation

Sensory evaluation was conducted following the method of [8], with a panel of 10 individuals from the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Niger State. Using a 9-point hedonic scale, panelists evaluated yogurt samples for taste, texture, aroma, appearance, and overall acceptability. Samples were presented randomly in small cups. Panelists rinsed their mouths with water between samples and observed a 60-second resting interval before evaluating the next sample to clear residual flavor and minimize carryover bias. Completed evaluation forms were collected for analysis.

2.2.5 Nutritional Content Analysis

The proximate composition, including moisture content, crude ash, crude fat, crude fibre, and protein, was analyzed using established methods as outlined by the [9].

Moisture content was determined by oven-drying 5 g of yogurt at 100°C until constant weight was achieved. Crude ash content was measured by incinerating 5 g of the sample in a muffle furnace at 550°C for 5 hours. To determine crude fibre, 2 g of defatted yogurt was boiled in 0.25M H_2SO_4, filtered, then boiled again

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in 0.25M NaOH, with the residue ashed at 550°C for 2 hours. Crude fat was extracted using petroleum ether in a Soxhlet apparatus over an 8-hour period.

Protein content was determined via the Kjeldahl method, where 2 g of the sample was digested with sulfuric acid and catalysts, and nitrogen was distilled and titrated with HCl. Carbohydrate content was calculated by subtracting the total percentages of ash, protein, fat, and fibre from 100%.

For Vitamin A analysis, 2g of the sample was homogenized with 10ml of 85% acetone, filtered, and the filtrate was analyzed using a spectrophotometer at four wavelengths: 425.5 nM, 633 nM, 644 nM, and 663 nM . For calcium and potassium analysis, samples were ashed at 500°C, vortexed with aqua regia, centrifuged, and analyzed using an Atomic Absorption Spectrophotometer (Buck Scientific Model 211).

2.2.6 Statistical Analysis

All data in this study were collected in triplicates. For each set, the mean and standard error were computed. SPSS version 26 statistical software was used for data analysis. Statistical parameters were estimated using analysis of variance (ANOVA). Differences between means were assessed with the help of Duncan multiple range test, and significance level at p=0.05.

3.0 Results and Discussion

3.1 Results

The results are presented in Tables below:

Table 2: Proximate composition of the various yogurt samples

Parameter	MC (%)	Ash (%)	Fibre (%)	Fat (%)	Protein (%)	Carbohydrate (%)
Control	85.00 ±1.0^{d}	1.23 ±0.25^{e}	0.23 ±0.05^{c}	3.60 ±0.055^{b}	5.17 ± 0.28^{f}	4.83 ± 0.28^{c}
B5	87.50± 0.20^{f}	0.69± 0.025^{cd}	0.04 ±0.005^{a}	4.35 ± 0.15^{c}	3.15± 0.55^{a}	4.25 ±0.60^{c}
B6	89.50 ± 0.20^{g}	0.55± 0.152^{abc}	0.34 ±0.025^{d}	3.04 ± 0.04^{a}	6.01± 0.11^{g}	0.53 ±0.76^{a}
B7	83.46 ± 0.15^{c}	0.50± 0.01^{ab}	0.24 ±0.02^{c}	5.89 ± 0.09^{e}	5.02± 0.06^{f}	4.86 ±0.36^{c}
B8	85.46 ± 0.15^{d}	0.67± 0.06^{bc}	0.09 ±0.01^{b}	2.86 ± 0.15^{a}	4.49± 0.16^{e}	6.40 ±0.76^{d}

The data was presented as the mean± Standard Deviation, significant difference (P<0.05) were indicated for values with distinct alphabets in superscripts in each column.

B5=Two chili pepper with a diameter of 1.5 cm
B6 =Four chili peppers with a diameter of 1.45 cm
B7= Two chili peppers with a diameter of 1.2 cm
B8= Four chili peppers with a diameter of 1.2 cm
Control = Commercially produced yogurt

Table 3: Vitamin A and Minerals (Calcium and Potassium)

Parameters	Vitamin A	Calcium	Potassium
Control	0.06 ±0.007^{a}	350.00±5.00^{g}	350±5.00^{f}
B5	0.19 ±0.010^{d}	284.00±1.00^{b}	92.32±0.84^{a}
B6	0.17 ±0.004^{c}	291.00±1.00^{c}	137.15±1.03^{d}
B7	0.07 ±0.003^{a}	342.00±1.00^{f}	172.11±1.02^{e}
B8	0.20±0.004^{e}	306.00±1.00^{e}	119.43±0.51^{c}

The data was presented as the mean± Standard Deviation, significant difference (P<0.05) were indicated for values with distinct alphabets in superscripts in each column.

Table 4: Sensory Evaluation of yogurt samples

Parameters	Taste	Texture	Aroma	Appearance	General Acceptability
Control	5.17±0.76^{b}	3.50±5.0^{ab}	2.00±0.50^{a}	2.17±0.29^{a}	3.00±1.0^{a}
B5	3.00±0.50^{a}	4.00±0.50^{b}	3.00±0.50^{b}	4.00±0.50^{b}	3.33±0.28^{a}
B6	5.00±0.50^{b}	5.00±0.50^{c}	4.00±0.50^{c}	5.00±0.50^{c}	4.00±0.50^{ab}
B7	5.00±0.50^{b}	5.00±0.50^{c}	4.00±0.29^{c}	5.00±0.50^{c}	5.00±0.50^{b}
B8	3.00±0.50^{a}	4.00±0.50^{b}	3.00±0.19^{b}	4.00±0.50^{b}	4.00±0.50^{ab}

The data was presented as the mean± Standard Deviation, significant difference (P<0.05) were indicated for values with distinct alphabets in superscripts in each column.

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3.2 Discussion

3.2.1 Nutritional Composition of Yogurt

The moisture content in the chili pepper yogurt samples varied between 83.46% (B7) and 89.50% (B6). These values are higher than the 70.64% reported by [10], suggesting that the chili pepper yogurt samples retained substantial moisture. The control yogurt has 85.00% moisture content, which is comparable to B8 but lower than B6. The higher moisture in B5 and B6 could enhance the creaminess, as indicated by [11].

Crude ash content, indicating mineral content, ranged from 0.50% (B7) to 0.69% (B5), while the control had a significantly higher value of 1.23%. This low ash content might reduce the mineral availability in the chili pepper yogurt compared to the control. [12] reported a crude ash value of 0.89% for soymilk yogurt, indicating that the chili pepper yogurt samples have lower mineral content than the control. The crude fibre content ranged from 0.04% (B5) to 0.34% (B6). B6's fibre content was higher than the control (0.23%) and also exceeded many literature values, indicating that chili pepper may enhance fibre content, contributing to texture and health benefits, as noted by [11].

Fat content varied across the samples, from 2.86% in B8 to 5.89% in B7. All chili pepper yogurt samples meet the USDA guideline (minimum 3.25%) for yogurt, with B7 showing the highest fat content [13]. The control yogurt had 3.60% fat, which is comparable to B6 and B8. These results suggest that fat content may affect creaminess and flavor, as noted by [14]. Protein content was highest in B6 (6.01%) and lowest in B5 (3.15%). B6's protein level surpassed the control (5.17%), reflecting the potential for enhanced nutritional benefits. This trend aligns with [15], who reported high protein levels in yogurt drink from Buffalo milk.

Carbohydrate content ranged from 0.53% (B6) to 6.40% (B8), with the control at 4.83%. The low carbohydrate content in B6, below the 11.63% reported by [10] for probiotic yogurt like fermented milk, suggests it may provide fewer energy resources. The chili pepper yogurt samples showed Vitamin A levels from 0.07% (B7) to 0.20% (B8), higher than the control (0.06%). This indicates that chili peppers may enhance the Vitamin A content of yogurt, offering additional health benefits, particularly for vision and immune function.

Calcium levels ranged from 284 mg/100g in B5 to 342 mg/100g in B7. All chili pepper samples have lower calcium content than the control (350 mg/100g), but they still provide a reasonable source of calcium. These results are in line with [16], who reported 240.81 mg/100g calcium, for yogurt with 1% mulberry leaves powder. Potassium content ranged from 92.32 mg/100g (B5) to 172.11 mg/100g (B7), significantly lower than the control (350 mg/100g). This suggests that the chili pepper yogurts may not meet the potassium levels seen in other yogurts, such as those reported by [17], at 228mg/100g for low fat yogurt. The lower potassium levels may be due to the specific processing methods or ingredients used.

3.2.2 Sensory Evaluation

Taste varied significantly, with B5 and B8 rated 3.00 (moderately sweet) and B6 and B7 rated 5.00 (neither sweet nor sour). The control scored 5.17, showing a lower acceptance rate than the chili pepper yogurt samples. These results are consistent with [18], who reported a moderate sweetness rating of 3.10 for yogurt samples.

For texture, the control was rated 3.50 (moderately thick), which was more favorable than the produced samples, with values between 4.00 to 5.00. The findings show a reasonable acceptable level of texture, reflecting [12] who reported texture ratings between 2.10 and 4.90 for commercial and cow yogurt.

Aroma rating ranged from 3.00 (moderately pleasant) to 4.00 (slightly pleasant) for B5 through B8. The control has a lower aroma score of 2.00, indicating that the control was more acceptable than the produced yogurt samples. Aroma profile for the chili pepper yogurts, in line with [19] who reported similar aroma results in Jersey cow yogurt (2.35-3.33).

Appearance scores were 4.00 (slightly creamy) for B5 and B8, and B8 5.00 (neither creamy nor watery) for B6 and B7, compared to the control's 2.17 (very creamy). Suggesting that the chili pepper yogurt samples have a lower appearance acceptability than the control. General acceptability scores ranged from 3.33 in B5 (moderately liked) to 5.00 in B7 (slightly liked), with the control scoring 3.00 (moderately liked). This suggests that B5 was the most preferred chili pepper yogurt, while B7 was less favorable, reflecting varying levels of acceptance.

4.0 Conclusion

The study revealed that chili pepper yogurt samples exhibited higher moisture content and protein levels than the control, with B6 showing the most enhanced nutritional profile. However, the control yogurt has higher ash, calcium, and potassium content, reflecting its superior mineral availability. Sensory evaluation indicates that B7 had the highest general acceptability, while B5 was less favored. Overall, chili pepper yogurt samples show potential for enhanced nutritional benefits, particularly in Vitamin A and protein content, but adjustments in fat, fibre, and mineral content are necessary to improve their sensory appeal and overall acceptability compared to commercial yogurt.

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