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ORIGINAL ARTICLE

Physicochemical and Organoleptic Characteristics of Yogurt from Coconut Milk

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Abstract

Objectives: Yogurt made from coconut milk presents an appealing alternative to traditional dairy yogurts, ideal for those with lactose intolerance or seeking plant-based options. This research gives a systematic comparison of yogurt from pre-mature, mature and over-mature coconut fruits as to its sensory, nutritional and microbiological characteristics. **Methods:** The study made use of completely randomized design. **Findings:** The sensory evaluation indicated that yogurt made from mature coconut fruit (T2) had the highest scores for taste/flavor (7.88), aroma/smell (7.68), color (7.90), and general acceptability (7.80) based on the 9 – point Hedonic scale, which was significantly superior and had better scores than yogurt from pre-mature (6.18–6.25) and over-mature fruits (6.73–6.93) ($p < 0.01$). Nutritional analysis highlighted its richness in essential minerals (ash content: 0.25%), moderate protein (1.23%), balanced carbohydrate profile (Calories from Carbohydrates: 70.88 kcal/100 g, Total Calories: 93.44 kcal/100 g, Total Carbohydrates: 17.72%), and low sodium content (34.51 mg/100 g), making it suitable for various dietary needs. Bacteriological analysis confirmed compliance with stringent quality standards (total plate count <10 CFU/g, coliforms <1.8 MPN/g, and yeast/mold <2.1 CFU/g), with total plate counts, coliform counts, and yeast and mold counts all below detectable limits, indicating hygienic production practices. **Novelty:** This study provides a new scientific finding that yogurt from mature coconut fruit has much better sensory qualities and improved nutritious values than those from young coconut or on any other plant-based substrate which has been focused on earlier studies. This study successfully demonstrates the functional advantages of mature coconut as a yogurt base. In addition, findings highlighted the importance of further studies on processing enhancement and flavoring agent addition for further improvement on product diversity and acceptability.

Keywords: Coconut milk; Yogurt; Physicochemical analysis; Organoleptic characteristics; Plant - based

1 Introduction

Due to health, ethical and environmental consciousness, the dietary patterns of the world are changing [1]. Since conventional dairy is associated with lactose intolerance, milk-protein allergies, and exposure to hormones and/or antibiotics, it is increasingly under fire [2]. At the same time, the ecological footprint of big dairy production greenhouse gas emissions, land use, and animal welfare issues has caused lots of consumers to look for plant-based options. As a result, non-dairy milk options such as soy, almond, oat and coconut are becoming popular as sustainable, lactose-free alternatives with less saturated fat and lower environmental impact [3].

Coconut milk is emerging as a promising substrate for yogurt making owing to its creamy nature, presence of medium-chain triglycerides, and its attractiveness to consumers in tropical regions. There are many researchers interested in coconut milk yogurt, but the research is sparse and not comprehensive [4]. Earlier investigations usually measured one or a few parameters in isolation like probiotic viability, basic nutritional content, or single sensory parameters. No earlier study integrated all physicochemical, sensory, and microbiological parameters essential for a complete product [5]. Moreover, little is known in existing studies about coconut maturity stage, although coconut developmental physiology is understood to regulate fat composition, volatile compounds and sensory attributes [6]. The most acceptable and nutritionally favorable coconut yogurt is still unknown with respect to different stages of maturity. This situation created a practical and scientific gap on the optimization of coconut ferments.

Most studies do not compare coconut yogurt with anything commercially available, nor do they measure if plant-based products can achieve the same quality parameters as dairy yogurt [7]. The existing studies have some limitations. For example, no standardized sensory evaluation method was used. In addition, the nutritional analysis was not characterized quantitatively [8]. Similarly, a microbial safety assessment was not done. Finally, the comparative study did not take place across coconut maturity stages. Together, these gaps block science and the use of findings in the food industry.

The present study offers the first integrated assessment of coconut milk yogurt formulated from pre-mature, mature and over-mature coconuts to address the inadequacies. The challenge was met through standardized analyses of sensory quality, proximate composition, microbiological safety and others. This work establishes measurable benchmarks for product optimization by comparing direct formulations to commercial yogurt, hence, this study.

2 Methodology

2.1 Research Design

Complete Randomized Design was used in the investigation. This study design was selected because, as part of the investigation, the researchers assigned three alternative treatments in addition to the control.

2.2 Sampling Procedure

Purposive sampling was utilized in the selection of evaluators for the research. To guarantee a varied group of people with an appropriate level of expertise for assessing the result in accordance with the study's predetermined objectives, this sampling strategy was used. As previously stated, the product was evaluated by the evaluators based on its physical and organoleptic features.

2.3 Evaluators of the Study

Fifty evaluators between the ages of 20 and 60 and are usual consumers of yogurt participated, representing a range of backgrounds. Students, faculty, and staff from the existing institution were among them. These people offered their time to rate the products' sensory qualities. They measured preferences for important sensory aspects and the general acceptability of the products using a quantitative evaluation methodology.

Evaluators were provided with comprehensive information on the rating scales and methods prior to the testing to ensure a consistent and well-informed evaluation process. Throughout the evaluation, the primary data were the evaluators' comments, which were carefully recorded on sensory evaluation score sheets specifically designed for product evaluation.

2.4 Materials of the Study

The materials used in this study include Coconut Milk, Skimmed Milk, Powdered Milk, Honey, Yogurt yeast starter culture, and Water.

2.5 Treatments of the Study

The treatments of this study were based on the standardized ratio in the production of yogurt. Maturity of coconut fruit varies accordingly[9]. The treatments of the study are as follows: Treatment 1: Premature coconut fruit, Treatment 2: Mature coconut fruit, Treatment 3: Over – mature coconut fruit, and Treatment 4: Commercialized yogurt.

2.6 Data Gathering Procedure

The collection of data involved various processes.

2.7 Standardization of Treatment Formulation

To create uniform protocols and product specifications for every stage of the food item's manufacture, a standardization process was put in place[10]. Disparities in the concentrations of the raw materials used were measured to determine the possible effect on coconut yogurt. To guarantee consistent quality in each batch, the formulations that were made were carefully evaluated and selected prior to its inclusion to the set which will be used in the experiment stage of the study.

2.8 Sensory Characteristics

Taste, aroma, color and general acceptability as set sensory profiles were all evaluated by the group of evaluators using a standard 9 – point Hedonic scale. Objective evaluation was made since the evaluators were instructed to rinse their mouths in between tasting to eliminate possible discrepancies and biases on the taste of the finished products.

2.9 Nutrition Facts Analysis

Protocol for the comprehensive microbiological and nutritional analyses of the coconut yogurt was conducted at SGS Philippines Laboratory Testing Center. Determination of ash and moisture content, crude protein, total sugar as invert and total dietary fiber used gravimetric method, Kjeldahl method, Enzymatic-Gravimetric approach and the Lane-Eynon General Volumetric, respectively.

Calculations on the distribution composition of macromolecules such as carbohydrates, lipids, and proteins including total calorie content and carbohydrates were all referred to the 2019 Table of the Philippine Food Composition. This is one of the most recognized reference tables used to recognize composition for the identified nutritive values in the country. In addition, the use of dry ashing, acid digestion and quantification by the ICP – OES were used in relation to the sodium levels. Finally, the Soxhlet Extraction Method employed to determine the volume of crude fat present in the finished product.

2.10 Microbial Analysis

To ensure safety in the consumption of the food product, the SGS Philippines, Inc. performed the necessary microbial analysis of the sample given. Standard pour plate method was used to quantify the living microbes (total aerobic pate count). The pour plate method was also employed in the determination of the total plate count and the identification of coliforms in the sample. Furthermore, the MPN (Most Probable Number) method was employed to evaluate coliform bacteria in samples.

2.11 Statistical Analysis of the Data

With regards to the statistical analysis of data, One way Analysis of Variance (ANOVA) and Least Significant Difference (LSD) were used to analyze and interpret the data collected from the experiment.

3 Results and Discussion

3.1 Sensory Properties

Table 1 presents the sensory characteristics of yogurt made from coconut milk. The taste and flavor scores ranged from 6.25 to 7.88, with T2 (Mature coconut fruit) achieving the highest score and T1 (pre-mature coconut fruit) the lowest. The comparison of treatment means that T2 and T4 are statistically comparable. However, when T2 and T4 were compared to T1 and T3, noticeable variations were observed. Yogurt prepared from mature coconut fruit was found to have the most palatable taste and flavor. This indicates greater fruit maturity enhanced the palatability of coconut milk yogurt. Research has shown that coconut flavor becomes more pronounced as the fruit matures, because of higher concentrations of sugars, fatty acids, and

aroma compounds[11]. Compared to some older studies which mainly looked through the chemical composition of coconut milk, the current study proves that coconut maturity affects yogurt flavor directly. This shows that naturally coconut-flavored coconut yogurt can be developed without adding artificial flavors. Choosing mature coconut fruits can enhance the sensory quality of coconut-based dairy alternatives, as this unique contribution notes.

Aroma/smell scores varied from 6.25 to 8.03, with the highest score observed in T4 (Commercialized yogurt) and the lowest in T1 (pre-mature coconut fruit). The comparison of treatment means showed that T2 and T4 exhibited similar aromas. However, distinct differences in aroma were evident when T2 and T4 were compared to T1 and T3. Based on the results above, the aroma of T2 and T4 would likely be more like each other, as they are statistically comparable. The aroma of yogurt made from old coconut fruit was comparable to commercialized yogurt indicating that fermentation may breed similar flavor notes. Commercial yogurt had a very strong smell. It likely contained an aroma to enhance its smell or flavoring agents. As the coconut ripens, the number of lactones present increases and that results in aroma which makes it more aromatic. The previous finding helps to confirm studies that report lactone content is what gives coconut scent[12]. This study shows that mature coconut naturally can generate an aroma like commercial products in yogurt unlike most commercial products. It can be a substitute for flavored commercial products.

Color scores ranged from 6.18 to 7.95, with T2 (Mature coconut fruit) having the highest score and T1 (pre-mature coconut fruit) the lowest. The comparison of treatment means showed that T2 and T4 had similar colors, but significant variations in color were observed when these treatments were compared to T1 and T3. The analysis revealed that T2 and T4 exhibited similar colors, indicating a close match in their visual characteristics. However, when T1 and T3 were compared to T2 and T4, notable differences in color were observed, suggesting that the stage of coconut maturity and the processed yogurt affect the color significantly. The yogurt made from mature coconut fruit was the most colorful when compared to the yogurt from premature and over-mature coconuts. This is probably caused by the synthesis of carotenoids or other pigments during fruit ripening. Based on existing research, natural pigments have been shown to affect the visual appeal of yogurt. Past studies have reported that color is one of the sensory attributes, however, not many have linked it to coconut maturity level for yogurt production[13]. The present work shows that color increases significantly in coconut yogurts when made from optimally mature coconuts. The improvement in sensory attractiveness enhances consumer acceptability while offering industrial applicability of coconut dairy products.

General acceptability scores ranged from 6.18 to 7.80, with the highest score observed in T2 (Mature coconut fruit) and the lowest in T1 (pre-mature coconut fruit). Careful analysis of the treatment means, it was found that T2 and T4 had comparable general acceptability. In contrast, T1 and T3 displayed distinct differences when compared to T2 and T4. This suggests that while the color of T2 and T4 may have been similar, the overall preference or acceptance by participants (considering factors like taste, and texture) varied considerably when compared to T1 and T3. This suggests that taste and texture as well as smell are jointly responsible for overall acceptability, not just appearance alone. Similar findings have been reported on coconut yogurt. Best maturity is rated higher in sensory and other quality scores[14]. The study's contribution is to confirm quantitatively that selecting coconuts at the optimal maturity stage improves individual sensory attributes and overall consumer satisfaction. This finding has a practical application in small-scale and commercial yogurt production.

Table 1. Sensory characteristics of the formulated yogurt from coconut milk

Treatment	Taste/Flavor	Aroma/Smell	Color	General Acceptability
T1: Premature coconut fruit	6.25^{c}	6.25^{c}	6.18^{c}	6.18^{c}
T2: Mature coconut fruit	7.88^{a}	7.68^{a}	7.90^{a}	7.80^{a}
T3: Over – mature coconut fruit	6.93^{b}	6.78^{b}	6.73^{b}	6.88^{b}
T4: Commercialized yogurt	7.68^{a}	8.03^{a}	7.95^{a}	7.78^{a}
ANOVA	**	**	**	**
$LSD_{.01}$	0.3562	0.3586	0.3582	0. .3548

** significant @ 0.01

3.2 Nutritional Composition

3.2.1. Ash

Indicative of test results revealed that 0.25% of trace minerals were seen after the complete combustion. The value indicates the presence of essential inorganic nutrients, including calcium, potassium, and magnesium. The finding of this study on ash content which ranged from 0.4–0.5%, is consistent with previous findings for coconut-based dairy substitutes which reported

similar values of 0.2–0.5%[14]. This means coconut yogurt is retained mineral content during yogurt processing. The main contribution of study is that coconut yogurt can provide trace minerals for human nutrition, even with minimum processing, so it can be potentially a mineral-enriched functional food.

3.2.2. Crude Fat

The crude fat content of 1.96% represents the lipid content present in the yogurt derived from coconut milk. This value is lower than the fat content in conventional coconut milk (2–3%) probably due to the dilution of coconut milk to prepare yogurt. Medium chain fatty acids found in coconut yogurt are energizing and boost metabolism, according to earlier research findings[15]. The findings of this study corroborate these findings, and coconut yogurt also does not have too much fat and richness so well-suited to health-conscious consumers.

3.2.3. Crude Protein

The yogurt contains 1.23% crude protein, which comes from coconut milk. The protein concentration obtained was below that of cow's milk yogurt, typically 3–4% protein, but like other plant-based yogurts as they are naturally lower in protein. Unlike earlier studies on coconut yogurt formulations which highlight limiting protein as a barrier, this study shows that while protein may be limited, its presence is not degraded by fermentation and coconut yogurt can still contribute to daily protein intake when consumed with other protein sources in the diet[16].

3.2.4. Moisture

The moisture content of 78.84% indicates the water content present in the yogurt. This is like commercial coconut yogurts with 75–82% moisture. With the help of high moisture content, microbial fermentation is supported and prevents excessive thickening which helps in enhancing the durability of the product. This study adds value in a manner where moisture levels do not need additional stabilizers[17]. This dictates the possibility of gaining coconut yogurt with similar texture.

3.2.5. Sugar as Invert

The high total sugar content of 77.86% indicates that the yogurt is sweetened, likely with added sugars or sweetening agents. Earlier studies regarding plant-based yogurts suggest sugar contents in the range of 60–80% depending on formulation[18]. This work is unique in that it quantifies sugar in coconut yogurt, which is valuable information for labelling or dietary purposes and for formulation purposes for those looking for lower sugar options.

3.2.6. Total Dietary Fiber

While the total dietary fiber content of 0.19% is on the lower side, it still contributes to the overall nutritional value of the yogurt from coconut milk. Coconut yogurt gets its fiber mainly from the solids left behind during milk extraction. This finding is in line with other plant-based yogurts, which typically contain 0.1–0.5% fiber[19]. In this study, it can be observed that even with the low content of fiber within the yogurt, it can still be eaten in a high-fiber diet if it has added fiber.

3.2.7. Calories from Carbohydrates, Fat, and Protein

The yogurt provides most of its calories from carbohydrates (70.88 kcal/100 g), followed by fat (17.64 kcal/100 g) and protein (4.92 kcal/100 g). Similar analysis of plant-based yogurts revealed that they were carbohydrate-dominant because of the added sugar[20]. This yogurt has a better caloric composition than some commercial products of higher fat content. The mature coconut yogurt could be an energy-dense snack having moderate number of calories as it prepared from mature coconut which has balanced sugar and creaminess.

3.2.8. Total Calories

The total calorie content of the yogurt is 93.44 kcal/100 g. When compared to the coconut-based yogurts documented in (85-110 kcal/100 g), this appears to be as expected. This study provides nutritional data of mature coconut yogurt to help plan a diet for health-conscious people and it benefits the field[21].

3.2.9. Total Carbohydrates

Carbohydrates make up 17.72% of the total composition of the yogurt. This agrees with product data on plant-based yogurt which show that sugars dominate the carbohydrate fraction. The study is the first to measure total sugar and carbohydrate in the same formulation[22]. It helps in understanding the sources of energy better. Moreover, it allows better labelling with newer guidelines and easy comparison with market products.

3.2.10. Sodium

With a sodium content of just 34.51 mg per 100 g, this yogurt is relatively low in sodium. Coconut yogurts have been reported previously to contain <50 mg sodium per 100 g[23]. This study shows that coconut yogurt can be developed as a functional food with both sensory and cardiovascular benefits due to its low sodium content. It may provide a healthier alternative to conventional dairy yogurt.

Table 2. Nutritional composition of the yogurt from coconut milk

Analysis Name	Result	Methodology
Ash	0.25%	Gravimetric Method (QLY-LAB-1153 REV1)
Crude Fat	1.96%	Acid Hydrolysis and Gravimetric Method (QLY-LAB-1147 REV2)
Crude Protein	1.23%	Kjeldahl Method (QLY-LAB-1201 REV1)
Moisture	78.84%	Gravimetric Method (QLY-LAB-1202 REV0)
Total Sugar as Invert	77.86%	Lane-Eynon General Volumetric Method (QLY-LAB-1203 REV0)
Total Dietary Fiber	0.19%	Enzymatic-Gravimetric Method (QLY-LAB-1208 REV0)
Calories from Carbohydrates	70.88 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Calories from Fat	17.64 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Calories from Protein	4.92 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Total Calories	93.44 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Total Carbohydrates	17.72 %	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Sodium (Na)	34.51 mg/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)

3.3 Bacteriological Analysis

The total microbial load in the yogurt (which was tested one day after it was produced), including bacteria, yeasts, and molds, is illustrated by the total plate count. The overall plate count for yogurt made from coconut milk is reported as "<10 CFU/g". This indicates that the count of viable microbes in each gram of yogurt falls under the detection limit of 10 colony-forming units (CFU) per gram. This corroborated with findings from other studies on properly fermented plant-based yogurts[24]. Due to controlled fermentation processes, pasteurization and hygienic handling, they often report low microbial counts. This study shows that while commercial yogurt may have more microbes due to the introduction of strain and less stringent processing, coconut yogurt can achieve just as much safety with better quality.

The coliform levels in yogurt are stated as "<1.8 MPN/g," signifying that they are under the detection threshold of 1.8 MPN per gram. The findings are consistent with similar studies on coconut-based fermented products, which show coliform levels below the safety limit when good manufacturing practices are adopted[25]. According to this study, coliform contamination may be prevented on a small scale or during the testing of coconut yogurt production. Moreover, this makes the product safe for consumption.

The report shows a yeast and mold count of "<2.1 CFU/g", indicating that there are fewer than the 2.1 viable yeast and mold cells per gram of yogurt, which is below the detection threshold. Similar literature shows that a low level of water activity and fermentation in coconut yogurt stops the growth of excessive yeast and mold[26]. The other plant-based yogurts have mold contamination especially during storage. However, this study notes that coconut yogurt with help of properly preparing will attain microbiological stability without sensory deviation.

4 Conclusion

Mature coconut fruit yielded yogurt with superior taste/flavor, aroma/smell, color, and overall acceptability compared to premature fruit. Coconut milk yogurt highlights its richness in essential minerals and medium-chain triglycerides, modest protein

Table 3. Bacteriological analysis of yogurt from coconut milk

Analysis Name	Result	Methodology
Total Plate Count	<10 CFU/g	Pour Plate Method (FDA BAM Ch. 3, January 2001)
Coliform	<1.8 MPN/g	MPN Method (FDA BAM Ch. 4, February 2013)
Yeast and Mold Count	<2.1 CFU/g	Pour Plate Method (FDA BAM Ch. 18, April 2001)

Note: "<" means result is less than the method detection limit (there was no growth observed after the incubation period)

content, balanced carbohydrate profile, and low sodium content, making it a suitable option for a number of dietary preferences and health related needs. The sample reveals that it meets stringent quality standards, with total plate counts, coliform counts, and yeast and mold counts all below detectable limits, indicating hygienic production practices.

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