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Physicochemical and Sensory Characteristics of Coco - Embryo Jam

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Abstract

Objectives: Exploring the integration of coco-embryo into jam recipes presents a promising yet underexplored frontier. Traditionally regarded as a byproduct in the coconut industry, coco-embryo represents an untapped source of nutritional richness. In this study, Coco-Embryo Jam formulations were developed with varying ratios of coconut embryo (70%, 80%, and 90%). **Methods:** The study made use of completely randomized design. **Findings:** The sensory evaluation revealed that the jam with 70% coconut embryo consistently stood out as the most preferred, exhibiting superior taste, aroma, color, and overall acceptability. This formulation was then subjected to nutritional and microbial analyses, unveiling a rich dietary fat content contributing to its texture and flavor, alongside a notable sweetness level (Total sugar as invert: 77.86%) and an energy-dense profile primarily from carbohydrates (Calories from Carbohydrates: 313.76 kcal/100 g; Total Carbohydrates: 78.44%), aligning with typical jam characteristics. Notably, the product maintained a relatively low sodium content, contributing to a favorable health profile. Microbiological assessment demonstrated exceptionally low microbial counts, with Total Plate Count, Coliform count, and yeast and mold count all falling below detectable limits. **Novelty:** This study is the first to investigate the potential of coco-embryo in food innovation, emphasizing its effects on microbial safety, nutritional value, and sensory qualities. Coconut embryo in food production can serve as a new path for future jam formulation that is new in the market. This contributes to the growing demand for sources of functional food products leading to a sustainable future.

Keywords: Jam; Physicochemical Characteristics; Formulation; Coconut; Microbial Analysis

1 Introduction

The world's health problems and the rising consumer demand for more nutritious and functional food products have accelerated the quest for alternative raw materials which can help achieve a better diet [1]. Recent food science research has begun to pay greater attention to the possibility of developing new products based on apparently sustainable and underutilized biological resources [2]. The mature coconut fruit's embryo is a potentially significant ingredient that lacks enough scientific knowledge. Many coconut-processing operations disregard coconut waste as a mere nuisance. This by-product has a very rich nutrient composition which has considerable dietary fiber [3], bioactive lipids, and essential micronutrients [4]. As a result, coconut waste can make functional food ingredients [5].

The coconut embryo has historically not been industrially or scientifically utilized as much as components such as copra, water, and milk from the coconut [6]. In farming communities like Sanchez Mira, Cagayan where coconuts are an abundant crop [7], however, local industries heavily rely on traditional coconut-based ones. Researchers mostly readymade functional products from the most used coconut fractions. These include coconut meat-based items [8], symbiotic beverages made from coconut water [9], cottage cheese analogue from coconut milk [10], and plant-based milk substitutes [11]. Despite the various studies, coconut embryo, which is a promising functional ingredient due to its good composition and easy availability, has not been studied to a major extent by the researchers.

The literature is largely silent on the topic which demonstrates a broader research gap related to resource inefficiencies and missed opportunities for nutritional enhancement in the coconut. Earlier versions of jam formulations were not designed to improve the retention of nutrients from lesser-used parts of coconut. Thus, the coconut embryo has not been examined consistently for its potential to solve sustainability and nutritional issues.

The current research intends to fill this gap by creating and identifying a new jam backed by its primary functional ingredient, which is the coconut embryo. There are no studies about the use of coconut embryo in jam systems and their functionality characterization. There are various scientific and practical advantages of this approach. The first impact is that it will promote the sustainable use of coconut waste and convert a waste product into an ingredient. Furthermore, it enriches a highly consumed food product with the vitamins, minerals and fiber that are inherent to the coconut embryo [12], [13]. Ultimately, this coincides with the rising global interest in health-oriented, environmentally friendly food innovations. Hence, as an underutilized byproduct of the coconut industry, the coco-embryo's inherent nutritional potential serves as a catalyst for the diversification of food offerings, fostering sustainability and contributing to the ever-evolving landscape of modern gastronomy.

2 Methodology

2.1 Research Design

The study made use of Completely Randomized Design (CRD). This was chosen as the study design because the researchers assigned a control treatment and three other treatments as part of the experiment.

2.2 Sampling Procedure

Evaluators were selected for the study using purposive random sampling. This sampling technique was employed to ensure a diverse range of individuals with a suitable degree of knowledge for evaluating the finished product in alignment with the study's set objectives. The evaluators, as mentioned earlier, assessed the product based on its physical and organoleptic characteristics.

2.3 Evaluators of the Study

Fifty evaluators with diverse backgrounds participated, spanning ages from 20 to 60. They included current institution employees, students, and school staff. These participants volunteered to assess the sensory characteristics of the products. Employing a quantitative assessment approach, they gauged preferences for essential sensory features and the overall acceptability of the items.

Prior to commencing the testing, evaluators received detailed instructions on the rating scales and protocols, aiming for a uniform and informed evaluation process. Throughout the assessment, the evaluators' input served as the primary data, meticulously documented on sensory evaluation score sheets tailored for product assessment. The sensory evaluation environment was conducive, well lighted and ventilated.

2.4 Materials of the Study

The materials used in this study include coconut embryo, young coconut milk, honey, and sugar.

2.5 Treatments of the Study

The experimental treatments in this study adhere to a standardized ratio derived from established practices in the production of coconut-based jams. Four distinct treatments have been defined for comparative analysis: Treatment 1 comprises 90% coconut embryo and 10% coconut milk, Treatment 2 involves an 80% coconut embryo and 20% coconut milk ratio, Treatment 3 features a composition of 70% coconut embryo and 30% coconut milk, and Treatment 4 serves as a control comprising 100% coconut milk.

2.6 Data Gathering Procedure

The collection of data involved various processes.

2.7 Standardization of Treatment Formulation

Food formulations were standardized prior to the actual conduct of the study. The said process ensured consistent procedures and viable formulations in each production cycle that reflect the objectives of the study. The processes involved different concentrations of coconut embryo and coconut milk to identify the top food formulations that would be used in the production of final product for sensory evaluation. To make jam, first a pan is heated at 70 °C then the sugar is added and stirred to caramelize. Researchers then add and mix in coconut milk, coconut embryo, and honey. The mixture is stirred continuously until complete dissolution of the sugar, and the water evaporates by about 80%. When cooked, it is removed from heat, cooled for 15 minutes and placed in sterilized containers to seal completely.

2.8 Sensory Characteristics

A 9 – point Hedonic scale made by the researchers were used to rate the quality of the product as to its taste, aroma, color and general acceptability. Furthermore, the evaluators were instructed to rinse their mouth with water in between tasting to remove prior tastes. This mechanism enabled a more robust data gathering as to the sensory profile of the developed food product reducing the risks of possible impartiality.

2.9 Nutrition Facts Analysis

Standard laboratory analysis was conducted at SGS Philippines Laboratory Testing Center to uncover the nutritional content of the best formulation of coconut embryo jam.

Precise determination of ash and moisture content was facilitated using Gravimetric method. Crude protein content was determined using Kjeldahl method. The Lane-Eynon General Volumetric Method and Enzymatic-Gravimetric method were also employed to analyze total sugar as invert and total dietary fiber. These methods offer a comprehensive analysis as to these crucial components. The reliability and completeness of Philippine Food Composition Tables 2019 was employed in the computation of carbohydrates, fats, and proteins, alongside overall calorie content and total carbohydrates. Furthermore, methods such as Dry Ashing, Acid Digestion, and Quantitation by ICP-OES were the employed protocol for the determination of sodium content. Careful assessment of crude fat composition was made using Soxhlet Extraction Method

2.10 Microbial Analysis

SGS Philippines, Inc. Laboratory revealed the microbial content of the product that helped the researchers identify the safety of the product for consumption.

Total aerobic plate count assessed via pour plate method was used to provide a detailed quantity of viable microorganisms in the sample under investigation. Coliform count on the other hand, was also assessed using a different technique known as the MPN (Most Probable Number) method which is widely used for bacteria samples. Total plate count and coliform were determined using pour plate method.

2.11 Statistical Analysis of the Data

The data gathered that were gathered from the experiment was analyzed and interpreted using Analysis of Variance (ANOVA) and Least Significant Difference (LSD).

3 Results and Discussion

3.1 Sensory Characteristics

Varying proportions of coconut embryo and coconut milk in jam production is presented in Table 1. A common observation revealed that an ideal concentration of coconut embryo mixed in the production process yields to an elevated sensory attribute. This suggests the pivotal role of the raw material in shaping the overall sensory quality of the jam.

Treatment 3 containing 70 percent coconut embryo and 30 percent coconut milk outperformed all other treatments as seen in the mean score of 7.93. Treatment 1 which also contains 90% coconut embryo and 10% coconut milk together with treatment 4 with 100 percent coconut milk gained lower mean scores of 7.25 and 7.55, respectively. T2 (80% coconut embryo and 20% coconut milk) came in second with a score of 7.80. Further comparison of the treatment also revealed that T2 and T3 are comparable in terms of taste. Similarly, T1 and T4, T2 and T4 are comparable with the same sensory characteristic. On the contrary, significant variation was observed when T2 and T3 were matched with T1 and T4. This means that the formulation with the greater proportion of coconut embryo resulted in a more favorable taste, suggesting that coconut embryo contributes to a richer or more appealing flavor. There are previous studies that reported the coconut embryo can improve the taste of products that have coconut on them[14]; however, they often have a small scale or secondary usage of the embryo. In contrast, the current research establishes that the coconut embryo is a primary flavor-contributing ingredient in a processed jam, making it a novel functional application for improving consumer acceptability.

As to aroma/ smell, T3 received the highest score of 8.08, greatly surpassing T1 (7.90), T2 (7.38), and T4 (7.58). This indicates that T3 had the most attractive aroma, most likely because of the higher coconut milk and higher coconut embryo concentration. Analysis using LSD revealed that T3 is significantly different from the other treatments, while the remaining treatments (T1, T2 and T4) are technically comparable to each other. Coconut embryo content exhibited stronger and more attractive aromas, likely due to the higher levels of volatile compounds that are released during processing[15]. This study shows that the concentration of coconut embryos significantly affects the intensity of aroma and attractiveness of jam and can be applied as a guideline for formulation in the development of functional food.

T3 had the highest color score (8.28), making it the most visually appealing color. T4 had the lowest color score (7.10), whereas T1 (7.50) and T2 (7.20) had lower but comparable color values. This indicates that T3 had the most ideal color, most likely because it included a larger percentage of coconut embryo, which could have produced a richer or more vivid hue. The formulation of 70% coconut embryo and 30% coconut milk produces the most aesthetically pleasing product, according to the LSD comparison, which reveals that T3 differs substantially from T1, T2, and T4. Coconut embryo is rich in carotenoids and other natural pigments, enhances the visual appeal of coconut-based jams and desserts[16]. Although the presence of pigments in the coconut embryo has been reported in earlier studies, their functional properties in processed products like jam have not been investigated.

With a score of 8.25 for general acceptability, T3 outperformed the other treatments, suggesting that evaluators thought it was most acceptable. T4 (7.18) was the least acceptable, while T2 (7.68) and T1 (7.43) were close to each other. This indicates that the preferred formulation is the one with the highest amount of coconut embryo (T3). Comparison among treatments further uncovered that T3 is significantly different with the remaining treatments. On the contrary, T1 is comparable to T2 and T4. The finding indicates that coconut embryo enhances both the general acceptability of the product and certain sensory attributes (taste, scent, and color). Coconut-based products containing more coconut embryos were more favorably received by consumers, as the embryo contributed to a more balanced and desirable sensory profile[17]. It provides novel evidence that the coconut embryo, when used as the primary ingredient in jam, can simultaneously optimize multiple sensory attributes and elevate overall product acceptability, highlighting a previously underutilized functional role for this agricultural by-product.

Table 1. Sensory characteristics of the formulated coco – embryo jam

Treatment	**Taste/ Flavor**	**Aroma/ Smell**	**Color**	**General Acceptability**
T_1 (90% coconut embryo and 10% coconut milk)	7.25^{c}	7.90^{b}	7.50^{b}	7.43^{bc}
T_2 (80% coconut embryo and 20% coconut milk)	7.80^{ab}	7.38^{b}	7.20^{c}	7.68^{c}
T_3 (70% coconut embryo and 30% coconut milk)	7.93^{a}	8.08^{a}	8.28^{a}	8.25^{a}
T_4 (100% coconut milk)	7.55^{bc}	7.58^{b}	7.10^{c}	7.18^{b}
ANOVA	**	**	**	**
$LSD_{.01}$	0.3713	0.4016	0.3920	0.3970

** significant @ 0.01

3.2 Nutritional Composition

The decision to subject only the best treatment to both nutritional and microbial analyses reflect a strategic approach to obtaining comprehensive insights while optimizing resources.

The nutritional analysis of the Coco – Embryo Jam reveals several key findings. The relatively low ash content of 0.97% suggests a minimal presence of inorganic mineral components, indicative of a predominantly organic composition. The high crude fat content at 11.14% signifies a rich source of dietary fats, potentially contributing to the product's texture and flavor. Additionally, the low crude protein content of 1.40% indicates a limited protein contribution, emphasizing the formulation's focus on fats and carbohydrates.

The moisture content of 8.05% reflects relatively low water content, contributing to the jam's stability and shelf life. The exceptionally high total sugar content of 77.86% indicates a significant sweetness level, a key attribute expected in jams. Notably, the total dietary fiber is negligible (<0.10%), suggesting a limited contribution to dietary fiber intake.

Calorically, the Coco – Embryo Jam is energy-dense, with 419.62 kcal/100 g, primarily deriving calories from carbohydrates (78.44%), followed by fat (100.26 kcal/100 g) and protein (5.60 kcal/100 g). This distribution aligns with typical characteristics of sweet jams. The sodium content is relatively low at 20.66 mg/100 g, contributing to the product's health profile.

Fruit jams and spreads consistently show low ash content, signaling an organic composition with minimal inorganic mineral components[(18)]. The elevated crude fat content aligns with the anticipated richness in dietary fats, enhancing both caloric density and the product's texture and flavor[(19)].

The nutritional profile reflects a jam formulation with a predominant focus on providing energy through carbohydrates and fats, with minimal protein content. The high sugar content aligns with the sweet nature of jams, contributing to flavor and sweetness perception[(20)]. The low sodium content suggests a product that may align with dietary preferences emphasizing lower salt intake.

Table 2. Nutritional composition of the coco – embryo jam

Analysis Name	Result	Methodology
Ash	0.97 %	Gravimetric Method (QLY-LAB-1153 REV1)
Crude Fat	11.14%	Acid Hydrolysis and Gravimetric Method (QLY-LAB-1147 REV2)
Crude Protein	1.40%	Kjeldahl Method (QLY-LAB-1201 REV1)
Moisture	8.05%	Gravimetric Method (QLY-LAB-1202 REV0)
Total Sugar as Invert	77.86%	Lane-Eynon General Volumetric Method (QLY-LAB-1203 REV0)
Total Dietary Fiber	<0.10%	Enzymatic-Gravimetric Method (QLY-LAB-1208 REV0)
Calories from Carbohydrates	313.76 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Calories from Fat	100.26 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Calories from Protein	5.60 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Total Calories	419.62 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Total Carbohydrates	78.44 %	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Sodium (Na)	20.66 mg/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)

3.3 Bacteriological Analysis

The results of microbial analysis for the Coco – Embryo Jam indicate exceptionally low microbial counts, suggesting a high level of microbiological quality and safety. The coconut embryo jam contains very few viable microorganisms as indicated by the total plate count of <10 CFU/g (Colony Forming Units per gram). This signifies clean and safe production process of the finished product. As to the coliform count, <1.8 MPN/g (Most Probable Number per gram) was detected which further explains the absence or minimal presence of coliform bacteria. Yeast and mold count of <10 CFU/g reveals minimal or no contamination with reference to these microorganisms. Overall, the test parameters results met the strict standards of FDA (Food and Drug Administration) in the Philippines making it a food product safe for consumption. Coco-embryo jam exhibited a good microbiological quality. Microbial counts reported in other coconut-based jams ranged from 50-200 CFU/g also revealed the presence of coliforms. The present study revealed the absence of the coliforms which may be due to processing parameters and hygiene. This indicates the unique contribution of our method to producing a safer and more microbiologically stable coconut jam.

The identified findings resonate with the need for stringent microbial criteria in food products to protect consumers from possible harm. The microbial analysis results resonate with established literature emphasizing stringent microbial criteria in food products[21]. The low Coliform count agrees with FDA standards[22], which emphasizes the significance of bacterial control in food products. This study provides new evidence regarding microbiological control in coconut jam, showing that Coco–Embryo Jam can consistently maintain microbial counts that are well below critical limits. Previous reports highlighted the occasional presence of coliforms and molds in similar products made from coconut. Future research and industries can use this as a standard to enhance the future safety of coconut-based foods.

Table 3. Bacteriological analysis of the coco – embryo jam

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	<10 CFU/g	Pour Plate Method (FDA BAM Ch. 18, April 2001)

4 Conclusion

The sensory profile of the coconut embryo jam developed by the researchers is influenced by the mixture of varying concentrations of coconut embryo and coconut milk. The treatment with 70% coconut embryo and 30% coconut milk concentrations received superior results in terms of taste, aroma, color, and general acceptability. The finished product also exhibited levels of dietary fat content and carbohydrate that complemented its sweetness and energy dense profile. This result aligns with the common jam characteristics as one of the sources of energy. Low sodium content is a favorable health profile to those individuals that cut sodium in their diet. The finished product exhibits exceptionally low microbial counts, with Total Plate Count, Coliform count, and yeast and mold count all below detectable limits, meeting FDA standards and reflecting stringent microbial control measures during production.

Therefore, future research undertakings are recommended to study the potential of scaling up production while assuring quality and safety, and the inclusion of natural preservatives or functional ingredients to enhance shelf-life and nutritional properties further. Moreover, the coconut embryo jam can be promoted as a health-friendly and energy-rich alternative to normal jams that offer scope for commercial production and community-based entrepreneurial initiatives. The study sets a reference on the sensory quality and microbiological safety of coconut-based jams. It offers practical advice for the future development of new functional food products.

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