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ORIGINAL ARTICLE

Preliminary characterization of palmiche flour (*Roystonea regia*) for food use

Caracterización preliminar de la harina de palmiche (*Roystonea regia*) para uso alimentario

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Abstract Palmiche is an abundant food in Cuba, promising due to its high oil and protein content, with levels varying between different varieties of its species. This study aimed to characterize palmiche flour for food use preliminarily. Fresh fruits of royal palm (*Roystonea regia*) were used, and their size, weight, and hardness were determined, the latter measured before and after drying using a penetration test with a 30º cone. The obtained flour's optimal temperature and particle size were determined by drying the grains at 150 °C for 6 hours. The dried fruits were ground in a hammer mill, and the process efficiency was evaluated through visual inspection and the homogeneity of the milling. The flour was analyzed for physical-chemical, microbiological, and toxicological parameters. The dimensions of the palmiche fruit were smaller than those reported in the literature. The optimal temperature for obtaining high-quality flour was 150 °C. The high-fat content flour was found to be safe according to the quality indicators and was rated as having good sensory quality. However, the judges rejected it after five days of storage.

Keywords palmiche, flour, chemical composition, sensory quality, drying temperature.

Resumen El palmiche es un alimento abundante en Cuba, prometedor por su alto contenido de aceite y proteínas, cuyos niveles varían entre las diferentes variedades de su especie. Este estudio tuvo como objetivo caracterizar preliminarmente la harina de palmiche para uso alimentario. Se utilizaron frutos frescos de palma real (*Roystonea regia*) y se determinaron su tamaño, peso y dureza, esta última medida antes y después del secado mediante una prueba de penetración con un cono a 30º. Se determinó la temperatura óptima y el tamaño de partícula de la harina obtenida, secando los granos a 150 °C durante 6 horas. Los frutos secos fueron triturados en un molino de martillo, evaluando la eficiencia del proceso por inspección visual y la homogeneidad del molinado. La harina fue analizada en términos físico-químicos, microbiológicos y toxicológicos. Las dimensiones del fruto de palmiche fueron menores a las reportadas en la literatura. La temperatura óptima para obtener harina de calidad en corto tiempo fue de 150 °C. La harina con un alto contenido de grasa resultó inocua según los indicadores de calidad, y fue calificada como de buena calidad sensorial, aunque fue rechazada por los jueces después de cinco días de almacenamiento.

Palabras clave palmiche, harina, composición química, calidad sensorial, temperatura de secado.

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PUBLIS EDITORIAL

Introduction

In Cuba, underutilized foods with potential for human consumption could be used as additives in the production of already established products. Among them stands out the fruit of the Royal Palm (*Roystonea regia*), known as palmiche, which is widely present in Cuban fields. This palm, the main remnant of the semi-deciduous forests predominant on the island, also grows in fertile and humid mountainous areas and is common in secondary vegetation (Arias et al., 2016).

The flowering and fruiting of palmiche extend throughout the year, and each palm can produce 2 to 8 bunches annually, with an average weight of 23 kg, occasionally reaching up to 92 kg (Ly & Grageola, 2016). The fruit, a slightly elongated berry of purplish color, measures approximately 10 mm in length and 9 mm in diameter and contains a single seed. The size of the grain depends on soil and climatic conditions (Ly et al., 2016).

Previous research has explored using palmiche in animal feed production, demonstrating its ability to improve flour-rich foods' productive performance and nutritional value (Martínez-Pérez et al., 2021). However, the literature does not provide references regarding the specific conditions for obtaining palmiche flour for human consumption or its potential use as an ingredient in food products.

Given its abundance in Cuba and its nutritional properties, palmiche has great potential as a new ingredient in food preparations that are attractive, pleasant to taste, and beneficial to health. Therefore, this study aimed to characterize palmiche flour for its potential food use.

Materials and methods

The method for preparing the oregano extract was carried ouPalmiche fruits from 25 randomly selected bunches were used, which were dried in the sun on a 12 m² surface, being turned every two hours during periods of maximum solar radiation. Subsequently, the dried grains were stored under cool and dry conditions for analysis, using 15 kg for flour production. Before processing, fruit quality parameters such as the presence of foreign material (ICAITI 34052 h3, 1978) and damaged grains (Codex Stan 153, 2019) were evaluated, along with dimensions (ISO 13690, 1999), weight (AACC, 1983), and texture, both before and after drying at 150 °C. The texture analysis was performed using a penetration analyzer with a 30° cone, recording data at ambient temperature.

The drying process was evaluated with a 2 kg sample subjected to temperatures of 70, 110, and 150 °C for 3 hours in a hot air dryer. The flour was obtained using two types of mills: one with a fixed pin (1934 rpm, 3 mm mesh) and another with a hammer (1740 rpm, 1 mm mesh), qualitatively evaluating the grinding quality. The obtained flour was assessed for apparent density, particle size using sieves, and chemical composition, including moisture (ISO 712, 1998), proteins (ISO 16634-2, 2016), ash (ISO 2171, 2023), and fat according to AOAC (2019) methodology, following standard methods. Microbiological characterization was also performed by evaluating mesophiles (ISO 4833-1, 2013), total coliforms (ISO 4832, 2006), fecal coliforms (ISO 4831, 2010), fungi and yeasts (ISO 7954, 1987), and aflatoxins by HPLC.

For sensory evaluation, a trained panel rated attributes such as appearance, odor, and texture, with initial sessions held every three days in the first week. An acceptance-rejection scale was used, and the results were statistically analyzed using ANOVA and Duncan's test with a significance level of $p \leq 0.05$.

Results and discussion

The palmiche batch studied showed less than 1% foreign material content, suggesting proper harvesting and storage, with no contamination from plant residues, insect excreta, or other materials. This result is lower than those reported in previous studies (Sasson, 2000). Regarding damaged grains, only 2% showed deterioration, such as dents or perforations, attributable to impact during harvesting or insect, bird, and bat attacks. This value is within the permissible limits for this product. The low proportion of impurities and physical damage to the grains favors the quality of the flour, minimizing off-odors and flavors and improving the uniformity of the final product.

The palmiche fruit had a diameter of 7.30 mm, a length of 8.57 mm, and a weight of 0.24 g. These values were at the lower limit reported in the literature (Ly & Grageola, 2016). The differences could be related to soil characteristics, rainfall regime, plant age, and fruit maturity. Optimal soil and climate conditions promote grain development (Vives, 2020).

The average weight of 1000 palmiche fruits obtained in this study was 238.2 g, with a standard deviation of 0.36, a value close to the range reported by Pilcher et al. (2002), which ranges from 240 to 370 g. This parameter, used as a quality index in commercializing similar products, provides information about the grain size and milling yield. Moreover, it varies according to the moisture content, with weight decreasing as moisture decreases.

Fresh palmiche fruits have an average hardness of 22.51 N, higher than the value reported for coffee (9.5 N), according to Reinosa & Paul (1984), due to the structural characteristics of its endosperm and the high fiber content. When dried at 150 °C, the hardness increases significantly, surpassing that of grains such as roasted peas (56-60 N) and raw coffee (40-50 N). This increase is due to the greater resistance of the shell as it loses moisture, as observed in the typical penetration graph shown in Figure 1.

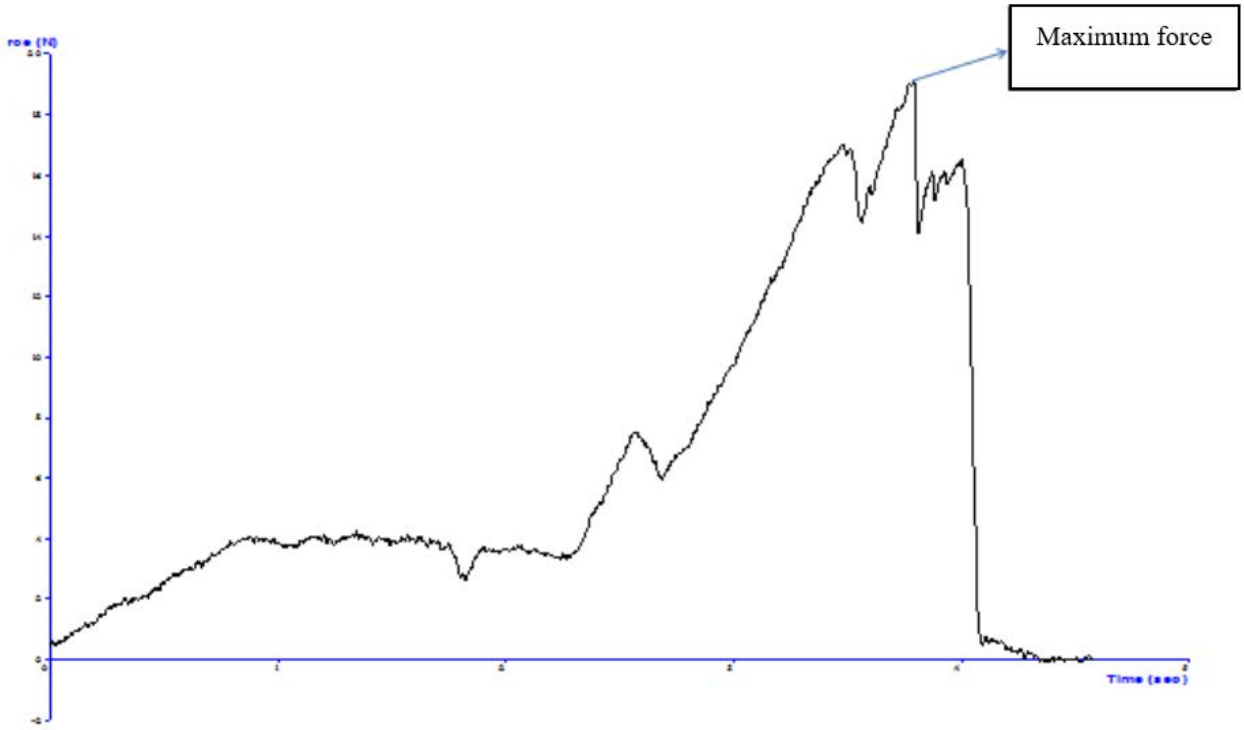

Figure 1. Penetration curve of palmiche fruit using a texture analyzer.

The hardness level of palmiche is essential for selecting the appropriate equipment for milling after roasting at 150 °C. A direct relationship has been demonstrated between the hardness of the whole grain and the sensory characteristics perceived when chewing products made with flour. Harder fruits produce flours with coarser granulation and a sandy texture due to the difficulty of fracturing the endosperm, which the trained judges corroborated.

Figure 2 presents the drying curves obtained at three different temperatures. The curve corresponding to 150 °C shows a steeper slope during the first hours of the process, indicating a higher rate of moisture loss compared to the curves obtained at lower temperatures. The 70 °C curve shows the least slope.

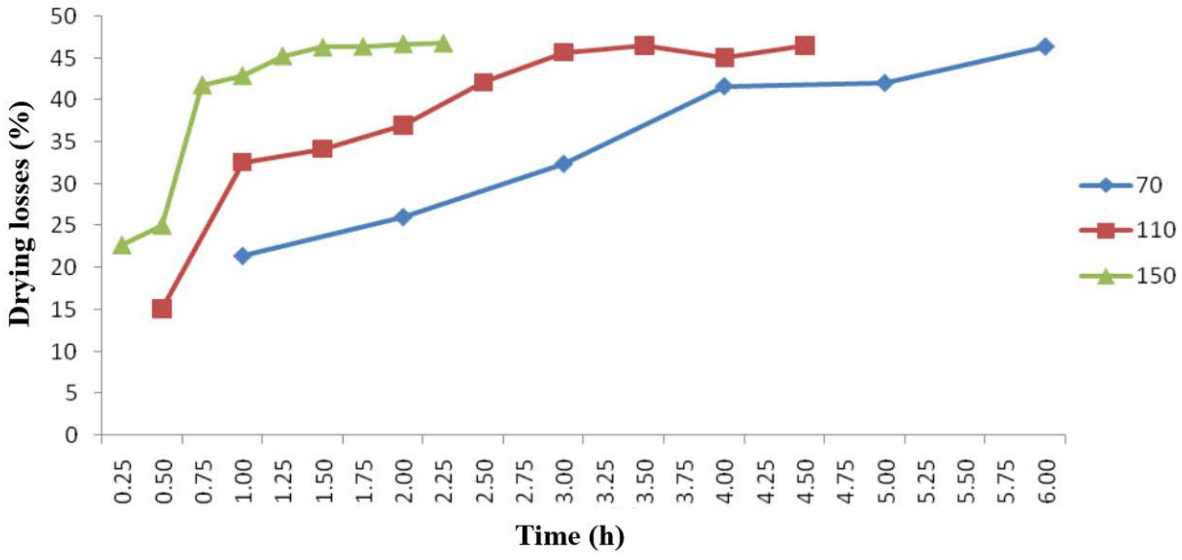

Figure 2. Drying curves of palmiche at three different temperatures (70, 110, and 150 °C).

In the case of the 150 °C temperature, it was observed that the drying curve began to stabilize after one and a half hours, at which point the fruit had already lost a significant amount of water, reaching a minimal loss. From that moment on, the reduction in moisture became slow, allowing the drying process to be completed and avoiding unnecessary energy expenditure and additional costs. After leaving the oven, the grain with the most intense process resulted in more efficient milling, as it passed more easily through the mill screens.

According to Table 1, the losses were not uniform throughout the oven; the trays on the left side experienced more mass loss due to the residual moisture in the grain. The temperature at 150 °C was the most suitable for the study, as it favored a faster drying. However, technological issues related to the dryer diffusers limited this forced convection process.

Table 1. Behavior of losses by location in the dryer

Level	Temperature					
	70 °C		110 °C		150 °C	
	Left	Right	Left	Right	Left	Right
1	46.65	45.85	47.30	45.95	47.01	45.55
2	47.95	45.05	47.00	45.75	48.36	48.01

The average apparent density value was 430 kg/m³. Figure 3 shows the particle size distribution of the flour obtained from milling the palmiche fruit dried at 150 °C.

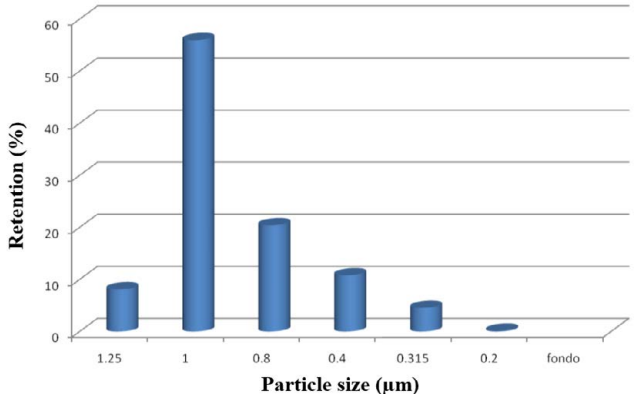

Figure 3. Particle size distribution in the flour.

The highest proportion of retained flour was found between sieves with 1.25 and 0.8 mm openings. This value indicated that the milling process was adequate at this temperature, and visual observations of the milling characteristics showed it was satisfactory, as a homogeneous flour was obtained. For the two lower drying temperatures, obstructions occurred in the mesh holes, making the process less efficient, and the highest percentage of retention was located in the first sieve, resulting in coarse flours that were discarded due to their lack of homogeneity in particle size distribution. Once the flours were obtained, they were subjected to chemical composition determination.

Figure 4 shows the chemical composition of the flour obtained from palmiche fruit roasted at 150 °C. Fat was the major component in palmiche flour, making it a significant energy source due to its high lipid content. Compared to soybean grain, which has 20% fat, the lipid content in palmiche flour was considered high.

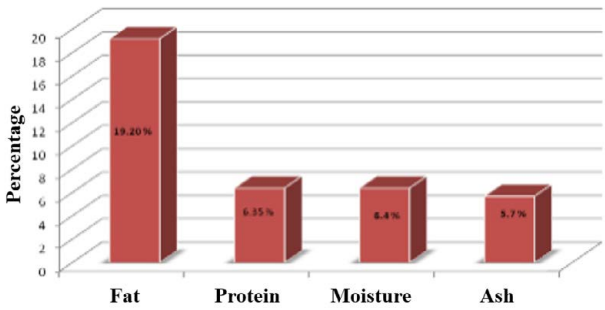

Figure 4. Chemical composition of palmiche flour.

It was observed that, although the protein content was not high, it was acceptable compared to other grains. Palmiche is rich in essential amino acids such as lysine, methionine, and tryptophan. It is relevant when considering its use as a filler in meat or cereal products, complementing potential amino acid deficiencies. Fat content values similar to those of other grains were found, with palmiche standing out for its richness in unsaturated fatty acids beneficial to health (Martínez-Pérez et al., 2021). The moisture content prevented biological agent development, such as fungi and insects. Additionally, the high ash content, compared to other whole grain flours, made this product a good source of minerals, especially phosphorus and calcium, according to the results of Martínez-Pérez et al. (2021).

Table 2 presents the microbiological results of the studied flours, which showed good microbiological quality. The values for the total viable mesophilic count, total coliforms, fecal coliforms, fungi, and yeasts were consistent with those obtained in other studies on palmiche grain (Ly & Grageola, 2016).

Table 2. Microbiological analysis of the flour

Temperature (ºC)	Viable mesophiles (CFU/g)	Total coliforms (CFU/g)	Fecal coliforms (CFU/g)	Fungi (CFU/g)	Yeasts
70	3.95	2.95	0	3	0
110	3.95	1.95	0	1	0
150	3.95	1.95	0	1	0

The counts of coliforms and fungi showed that as the temperature increased, the counts of both microorganisms decreased, with no differences observed between 110 and 150 °C. No reports regarding microbiological analysis values for palmiche flour were found in the literature. The microbiological results suggested its potential use in the production of meat products.

No aflatoxin B1 was found in the palm kernel samples dried at the three temperatures (70, 110, and 150 °C), demonstrating that, from a toxicological standpoint, the flour could be used in food production. The grains' storage conditions prevented the development of toxin-producing fungi.

In the initial sensory evaluation, the judges rated the selected flour as good quality. Table 3 included five descriptors corresponding to the three main organoleptic characteristics of the flours.

Table 3. Initial sensory description of palmiche flour

Attribute	Description	Score
Appearance	Slightly homogeneous (presence of some particles), brown color	4
Smell	Oily, toasted	4
Texture	Sandy	4
Overall quality		4

The sensory quality of the flour immediately after production is shown in Table 3. From the fifth day onward, trained judges noted changes in the product compared to the initial evaluation. From the third day, they detected changes in smell, a tendency toward rancidity, clumping, and a pasty texture, rendering the product unacceptable with rejection ratings by the judges. These results align with the literature regarding the shelf life of this product at room temperature, which maintains sensory quality for 72 hours (Caicedo et al., 2017).

Conclusions

The ripe palmiche fruit showed smaller dimensions than those reported in the literature. The fresh grain weight was 0.24 g, with an average hardness of 22.51 N, while the dried grain had a hardness of 98.67 N. The optimal temperature for producing quality flour was 150 °C, using a hot air dryer and a hammer mill at 1700 rpm. The particle size of the flour ranged between 0.8 and 1.25 mm, and the bulk density was 430 kg/m³. Palmiche flour exhibited a high-fat content, an acceptable protein level, and compliance with safety standards according to the evaluated indicators. It received a good sensory rating during the initial evaluation, but after five days of storage, it was rejected by the analytical judges.

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Conflicts of interest
The authors declare that they have no conflicts of interest.

Author contributions
Conceptualization: Ernys León. **Data curation:** Manuel G. Roca-Argüelles, Juan González. **Formal analysis:** Ernys León, Manuel G. Roca-Argüelles, Juan González. **Research:** Ernys León, Manuel G. Roca-Argüelles, Juan González. **Methodology:** Manuel G. Roca-Argüelles. **Software:** Juan González. **Supervision:** Manuel G. Roca-Argüelles. **Validation:** Manuel G. Roca-Argüelles, Juan González. **Visualization:** Ernys León. **Writing the original draft:** Ernys León, Manuel G. Roca-Argüelles, Juan González. **Writing, review and editing:** Ernys León, Manuel G. Roca-Argüelles, Juan González.

Data availability statement
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Statement on the use of AI
The authors acknowledge the use of generative AI and AI-assisted technologies to improve the readability and clarity of the article.

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