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PROXIMATE COMPOSITION AND ENERGY CONTENT OF FIBROUS BY-PRODUCTS FROM RAW AND TOASTED CACHICHÍN (*Oecopetalum mexicanum*) SEEDS

Alejandro Esli Hernández-Mora[1], José Andrés Herrera-Corredor[1], María Magdalena Crosby-Galván[2], Libia Iris Trejo-Téllez[3], Fernando Carlos Gómez-Merino[1].

Sustainable Agri-food Innovation; Colegio de Postgraduados, Campus Córdoba, Amatlán de los Reyes, Veracruz, Mexico. C. P. 94953. [1]
Genetic Resources and Productivity - Livestock, Colegio de Postgraduados Campus Montecillo, Texcoco, State of Mexico, Mexico. C.P. 56264. [2]
Edaphology, Colegio de Postgraduados Campus Montecillo, Texcoco, State of Mexico, Mexico. C. P. 56264. [3]

INTRODUCTION & AIM

Figure 1. Food processing waste

Globally, fruit processing generates significant volumes of by-products (approximately 25–30% of the total volume), such as peels, pulp, seeds, and fibers. However, food science has identified that these materials, traditionally considered waste, are a valuable source of bioactive compounds (proteins, carbohydrates, fatty acids, and antioxidants) with high nutritional and functional potential [**1**]. The tree species *Oecopetalum mexicanum* (cachichín), an underutilized fruit tree endemic to Mexico and Central Central America, has a seed that is traditionally consumed by inhabitants of the Misantla, Veracruz region as a nutritious snack, either raw, boiled, or toasted. Previous research has evaluated its bioactive composition and the impact of thermal processing on its properties, subjecting the seed to various thermal treatments, including a controlled toasting (25 min at 134 °C) [**2**]. Nevertheless, information regarding the fibrous fraction obtained after oil extraction, a key component for the integral valorization of this resource, is limited. Therefore, the objective of this study is to characterize the proximate and energy composition of these fibrous co-products to lay the groundwork for their integral utilization in the formulation of food and nutraceutical products, thus contributing to a circular bioeconomy.

Figure 2. Cachichín tree

METHOD

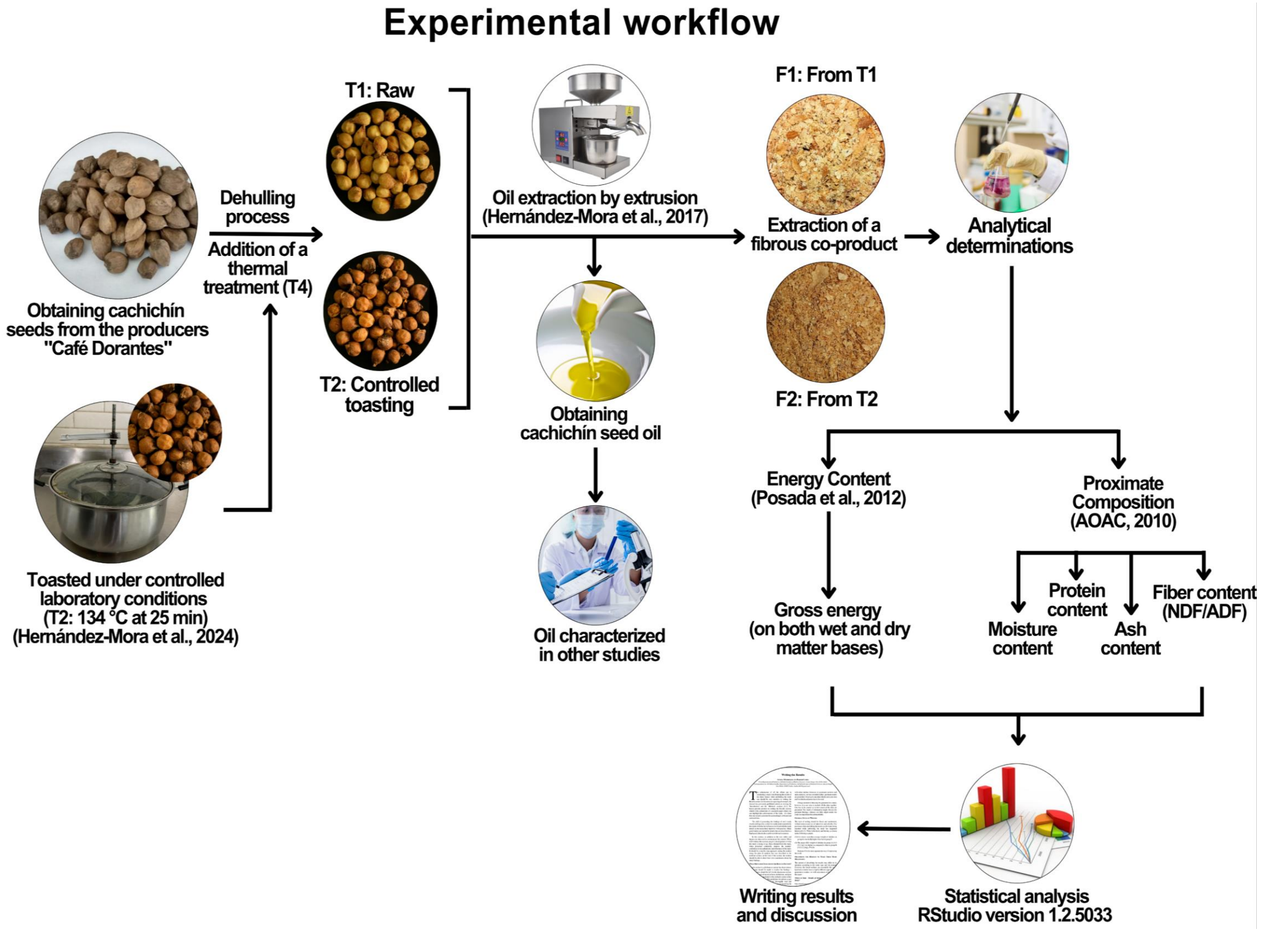

Figure 3. Illustrative diagram depicting the methodology used in the present study

RESULTS & DISCUSSION

Proximate analysis results showed that both thermal treatment and oil extraction significantly affected the composition of the cachichín seed and its fibrous coproducts (**Table 1**). Regarding moisture content, a decrease was observed in the toasted seed (T2) compared to the raw one (T1), as expected. However, the fibrous coproducts (F1 and F2) presented higher moisture, with significantly greater values. The apparent contradiction is explained by the water-holding capacity of the defatted flour. When hydrophobic lipids (oil) are extracted, the hydrophilic components (proteins and fiber) of the seed are exposed. These components have functional groups that attract and retain water molecules, thus increasing the absorption capacity and moisture of the fibrous coproducts [**3**]. Additionally, a higher ash content was found in the fibrous coproducts, with the F2 treatment showing a significant increase compared to the whole seeds T1 and T2; this indicates a concentration of minerals after oil extraction. Furthermore, the formation of polycyclic aromatic hydrocarbons and other volatile compounds during toasting also contributes to this result, as it indicates the conversion of organic matter into ash-forming residues. Notably, the fibrous coproducts (F1 and F2) showed an increase in protein concentration compared to the original seeds. During the defatting process (mechanical or solvent-based), the fatty content of the seed is selectively removed. Therefore, F1 and F2, being derivatives of oil extraction, concentrate proteins due to the elimination of lipids, similar to sesame press cake. Their fibrous profile suggests the retention of a structural matrix rich in proteins associated with cell walls.

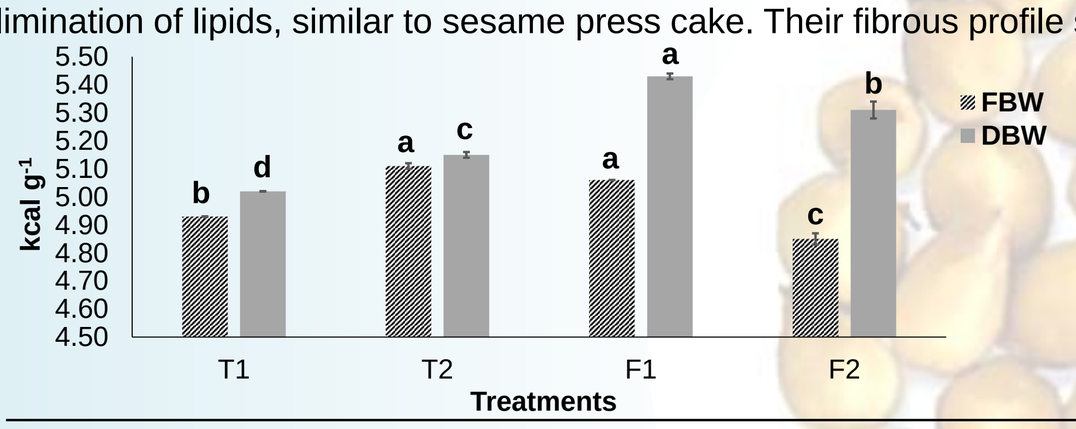

Figure 4. Gross energy expressed on wet basis (kcal g^{-1} FBW) and dry basis (kcal g^{-1} FBW) in raw and control-toasted (134°C, 25 min) cachichín seeds (*Oecopetalum mexicanum*), and their respective byproducts (fibrous fraction). **Note:** Raw cachichín seed (T1); control-toasted cachichín seed (25 min at 134 °C) (T2); raw cachichín seed fiber (F1); control-toasted cachichín seed fiber (F2).

Table 1. Proximal analysis of raw and controlled toasted (25 min at 134 °C) cachichín seeds (*Oecopetalum mexicanum*), as well as their byproducts (fibrous fraction) obtained following oil extraction via extrusion.

Treatment	Moisture	Ash	NDF	ADF	Protein
			%		
T1	1.73 ± 0.05 ab	2.42 ± 0.02 b	0.09 ± 0.00 c	0.02 ± 0.00 c	9.55 ± 0.12 bc
T2	0.88 ± 0.03 b	2.59 ± 0.13 ab	0.19 ± 0.01 b	0.03 ± 0.00 c	9.17 ± 0.09 c
F1	6.68 ± 0.27 ab	3.65 ± 0.02 ab	0.24 ± 0.01 ab	0.07 ± 0.00 b	10.52 ± 0.16 ab
F2	8.98 ± 1.02 a	3.84 ± 0.02 a	0.29 ± 0.02 a	0.12 ± 0.01 a	11.16 ± 0.55 a

Mean ± SE with different letters in each variable indicate significant statistical differences between treatments. **Note**: Raw cachichín seed (T1); control-toasted cachichín seed (25 min at 134 °C) (T2); raw cachichín seed fiber (F1); control-toasted cachichín seed fiber (F2); neutral detergent fiber (NDF); acid detergent fiber (ADF).

On the other hand, fiber content (NDF and ADF) was significantly higher in the coproducts (F1 and F2) than in the whole seeds (T1 and T2), with F2 showing the highest values. During the defatting process, lipids and non-structural compounds (starches and sugars) are selectively removed. This proportionally increases the fibrous fraction (cellulose, hemicellulose, and lignin) in the residual mass (F1 and F2), thereby elevating the NDF and ADF values. These compositional changes highlight the potential of the fibrous fraction for its revalorization in the food industry. Gross energy (**Figure 4**) analysis showed that the toasted seed (T2: 5.11 kcal g^{-1}) and raw seed coproduct (F1: 5.06 kcal g^{-1}) had the highest energy values on a wet basis. This is attributed to carbohydrate release during toasting and extraction. On a dry basis, the fibrous coproducts (F1: 5.43 kcal g^{-1} and F2: 5.31 kcal g^{-1}). This demonstrates that, by eliminating the water content in the fibrous fraction of the cachichín seed, a better availability of carbohydrates is obtained, which translates into a high energy density.

CONCLUSION / FUTURE WORK

These fibrous coproducts represent a promising source of dietary fiber and high-value protein for the agri-food industry. Their potential application includes the development of functional food ingredients (e.g., bakery, cereals, nutritional bars), the enrichment of animal feed, or as a base for nutraceuticals, directly contributing to waste reduction and the promotion of a circular bioeconomy. It is crucial to consider that, for human food use, future studies must validate the absence of relevant antinutrients or contaminants in these fibrous fractions.

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