



Thermogravimetric analysis of irradiated sapodilla (*Manilkara zapota*) peel and seed flour

Bianca Guimarães Negrão¹, Luz Merida Rondan-Flores¹, Daili de dos Santos¹, Anna Lucia Casañas Haasis Villavicencio¹

¹*biancagn@usp.br, Avenida Professor Lineu Prestes, 2242, Cidade Universitária, São Paulo – SP, CEP 05508-000*

1. Introduction

Sapodilla (*Manilkara zapota L.*) is a tropical fruit native to Central America, Mexico, and the Caribbean. Belonging to the Sapotaceae family, it is cultivated in various regions worldwide due to its sweet flavor and nutritional value. The fruit is commonly consumed fresh or used in the preparation of juices, desserts, and jams owing to its rich flavor and aroma.

In recent years, there has been growing interest in studying the potential health benefits of sapodilla, particularly its peel and seeds. Research has indicated that these by-products of sapodilla processing contain valuable bioactive compounds with antioxidant, antimicrobial, and anti-inflammatory properties. These findings have sparked interest in exploring novel applications for sapodilla peel and seeds in the food and pharmaceutical industries [1] [2] [3].

Despite the growing interest in sapodilla peel and seeds, there is limited research on the effect of irradiation on the thermal behavior of these by-products. Irradiation is a common technique used to preserve food products by reducing microbial contamination and extending shelf life. Understanding the thermal behavior of irradiated sapodilla peel and seeds is crucial for assessing their stability and suitability for various applications in the food industry.

Therefore, this study aims to investigate the thermal behavior of sapodilla peel and seeds before and after irradiation using thermogravimetric analysis (TGA). By analyzing the changes in mass as a function of temperature, we aim to elucidate the thermal degradation characteristics of sapodilla peel and seeds and evaluate the effect of irradiation on their composition.

2. Methodology

The flours from sapodilla peel and seeds were irradiated using a ⁶⁰Co source at the Multipurpose Irradiator of the CTR at IPEN/CNEN-SP. Doses of 1 kGy, 3.5 kGy, and 7 kGy were applied (dose rate: 3.51 kGy/h). Then, The TGA (model SDT 600) analysis was conducted under inert gas (nitrogen) atmosphere to prevent oxidation or other chemical reactions during the heating process. The temperature range for analysis was set from ambient temperature to 600°C with a heating rate of 10°C/min and the samples were prepared by accurately weighing approximately 10 mg. During the analysis, the weight of the sample was continuously monitored as a function of temperature using the TGA software.

The resulting thermogravimetric curve provided information on the mass loss of the sample as it underwent thermal decomposition or other physicochemical changes. The thermogravimetric data obtained from the analysis were analyzed to determine key parameters such as onset temperature, peak temperature, and weight loss percentages corresponding to different decomposition or reaction events. This information was used to interpret the thermal stability and decomposition behavior of the sample.

3. Results and Discussion

Studies have underscored the presence of hemicellulose and cellulose in sapodilla peels and seeds, accentuating their potential as dietary fiber sources. Also, Thermogravimetric analysis (TGA) investigations have revealed distinct decomposition temperature ranges for hemicellulose, cellulose, and lignin. Typically, hemicellulose decomposes at lower temperatures, ranging from 220 to 315 °C, whereas cellulose decomposes at higher temperatures, ranging from 300 to 400 °C. In contrast, lignin exhibits decomposition over a wide temperature range, spanning from 150 to 900 °C [4][5].

The DSC curves (Figure 1) of sapodilla peel flour at varying radiation doses (0 kGy, 1 kGy, 3.5 kGy, and 7 kGy) exhibit six exothermic peaks across all doses, spanning temperatures from 31.26°C to 464.36°C.

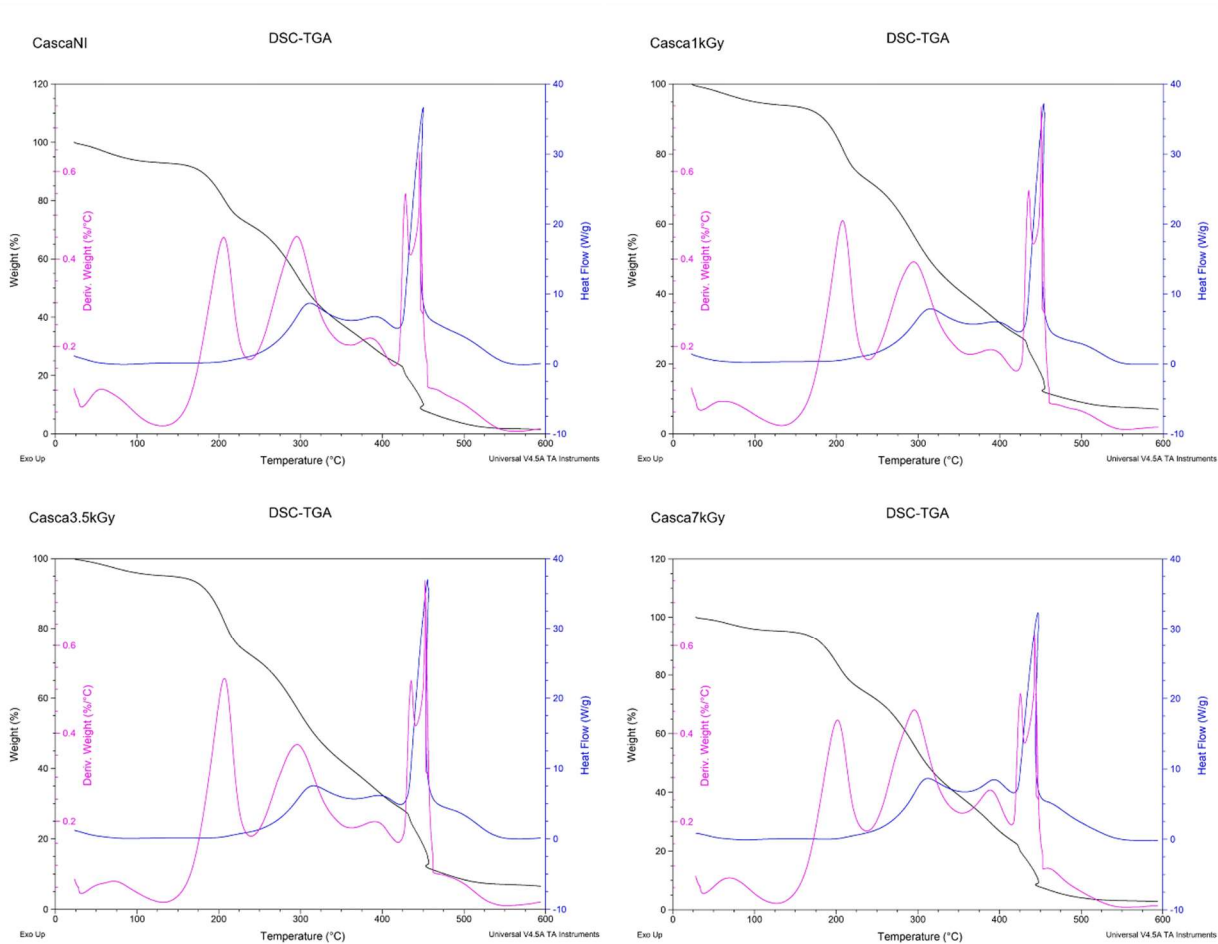


Figure 1: TGA analysis of sapodilla peel flour at different radiation doses (0 kGy, 1 kGy, 3.5 kGy, and 7 kGy).

The temperature and decomposition profiles of hemicellulose and cellulose, alongside other constituents inherent in fruit seeds and peels, may demonstrate variability contingent upon the specific sample composition and experimental conditions. As expected, hemicellulose decomposed at lower temperatures relative to cellulose in this study due to its comparatively less organized structure and the presence of functional groups prone to thermal degradation. Within this spectrum, the cleavage of glycosidic bonds and the subsequent liberation of gases, such as carbon dioxide and water, are discernible [5] [6].

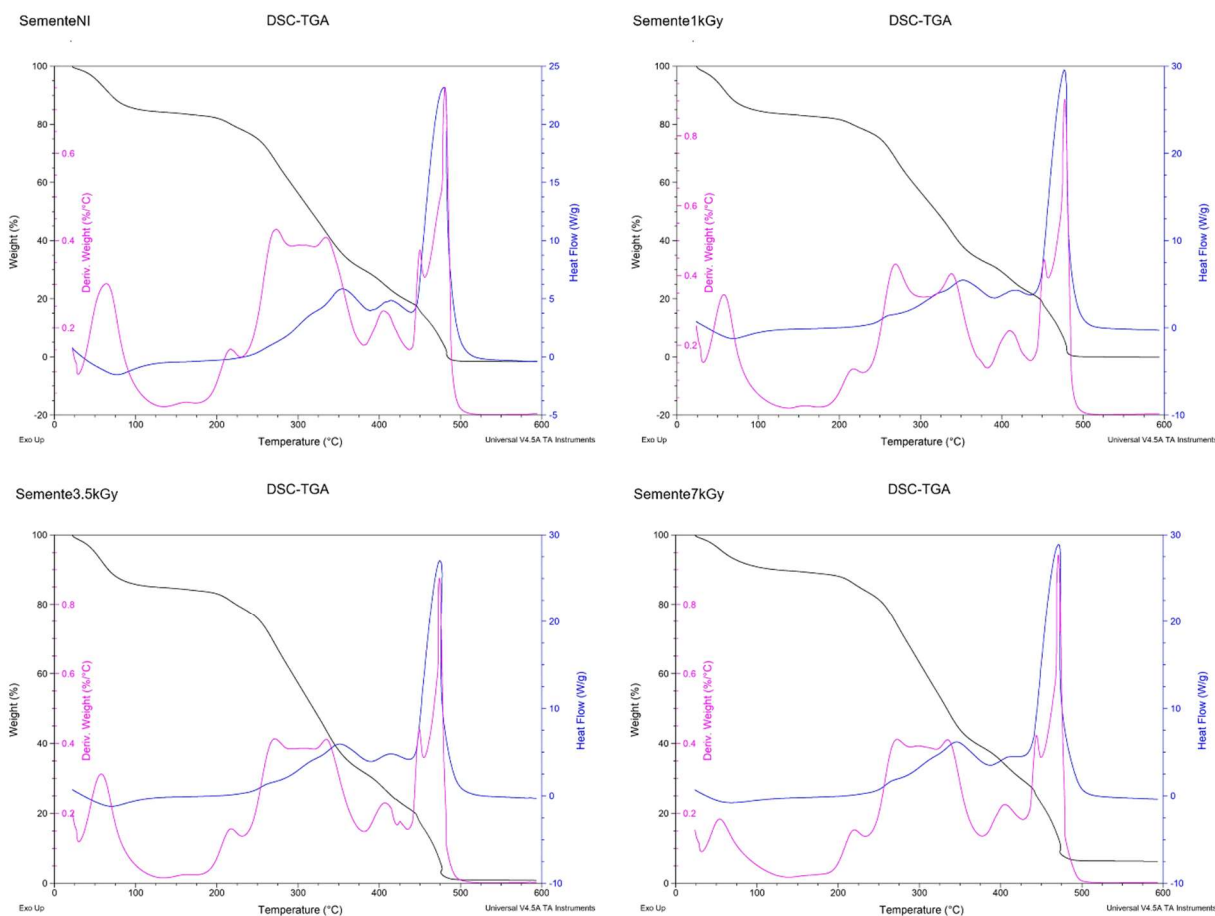


Figure 2: TGA-DSC of sapodilla seed flour at different radiation doses

Conversely, the TGA analysis of sapodilla seed flour (Figure 2) underscored the noted disparities in the behaviors of hemicellulose and cellulose at the onset peaks, indicating that composition wielded more influence than dose. Beyond hemicellulose and cellulose, fruit seeds and peels may harbor a diverse array of constituents, encompassing lignin, pectin, proteins, lipids, minerals, and phenolic compounds.

Each constituent may confer distinct attributes to the thermal degradation profiles observable in TGA analyses, manifesting differential temperature thresholds and decomposition kinetics. Notably, lignin, a constituent present in sapodilla cells, is renowned for its thermal resilience owing to its intricate cross-linkages. Its presence in fruit seeds can significantly impact the observed decomposition patterns in thermogravimetric analyses, thereby influencing decomposition temperatures and kinetics. For instance, lignin may undergo decomposition at elevated temperatures due to its complex and resilient structure [7][8].

4. Conclusions

In conclusion, the disparities regarding the presence of hemicellulose, cellulose, and lignin were more pronounced and relevant than those related to radiation dose in the flour samples. It is evident that the flour and seed samples of the peel exhibit distinct components in their cellular structure, as emphasized by the initial exothermic peaks in the temperature ranges of 175 to 325 for the peel and 200 to 375 for the seed. Therefore, no dose-dependent relationship was observed concerning the temperature range in the 1 to 7 kGy radiation doses in the thermogravimetric analyses studied.

Acknowledgements

The authors express their gratitude to IPEN/CNEN-SP for the scholarship and support provided.

References

- [1] S. Bashir, "Pharmacological importance of Manilkara zapota and its bioactive constituents," *Journal of Medicinal Plants Research*, vol. 18, no. 4, pp. 347-358, 2019.
- [2] M. F. Rivas-Gastelum et al., "Manilkara zapota 'chicozapote' as a fruit source of health-beneficial bioactive compounds and its effects on chronic degenerative and infectious diseases, a review," *Frontiers in Nutrition*, vol. 10, pp. 1-17, 2023.
- [3] L. S. Oliveira, "Changes in postharvest quality and antioxidant metabolism during development and ripening of sapodilla (*Manilkara zapota* L.)," *International Food Research Journal*, vol. 24, pp. 2427-2434, 2017.
- [4] T. Aziz et al., "A Review on the Modification of Cellulose and Its Applications," *Polymers*, vol. 14, p. 3206, 2022.
- [5] H. Yang, R. Yan, H. Chen, D. H. Lee, and C. Zheng, "Characteristics of hemicellulose, cellulose and lignin pyrolysis," *Fuel*, vol. 86, no. 12-13, pp. 1781-1788, 2007.
- [6] P. J. Brown and J. A. Gallagher, "Handbook of Thermal Analysis and Calorimetry," 2nd ed., vol. 6, 2018.
- [7] M. Brebu and C. Vasile, "Thermal degradation of lignin – A review," *Cellulose Chemistry and Technology*, vol. 44, pp. 353-363, 2010.
- [8] E. Kaihal et al., "Thermal and thermomechanical analyses of lignin," *Sustainable Chemistry and Pharmacy*, vol. 9, 2018.