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STEAM DISTILLATION AND SUPERCRITICAL CO_2 EXTRACTION OF OREGANO ESSENTIAL OIL FROM COLOMBIAN BIODIVERSITY: A COMPARATIVE STUDY ON YIELD, QUALITY, AND BIOACTIVITY

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Colombia, a megadiverse country, presents unique opportunities for the development of natural, biobased products. This study investigated *Origanum vulgare* cultivated in Tenerife, Valle del Cauca, Colombia, to obtain and characterize its essential oil using two extraction methods: steam distillation (SD) and supercritical CO_2 extraction (SFE). We applied a 2^{4-1} fractional factorial design to optimize SFE conditions and maximize mass yield. The resulting extracts were characterized by GC-MS to compare volatile profiles between the two techniques. Additionally, a comprehensive quality and safety assessment was performed, including analyses for pesticide residues, heavy metals, and mycotoxins.

Bioactivity was assessed through antioxidant capacity (ORAC-L assay), total polyphenol content, and viability and cytotoxicity in HeLa cells. A prototype formulation incorporating the extracts was developed and subjected to a 4-month stability study, assessing physical, chemical, and microbiological parameters.

Results demonstrate that SFE under optimized conditions provided higher mass yields and superior safety profiles with reduced contamination risks, while both techniques yielded oils rich in carvacrol and other bioactive terpenes. The integrated comparative approach highlights the value of combining traditional and modern extraction techniques for developing safe, stable and functional products from Colombian biodiversity. The findings contribute to the manufacturing and quality control of essential oils and extracts, supporting local value chains and advancing the Colombian bioeconomy through science-based innovation. The authors are grateful for the support and funding of the research project with resources from the NATIONAL FUND FOR SCIENCE, TECHNOLOGY AND INNOVATION FRANCISCO JOSÉ DE CALDAS. Contract 112721-249-2024 / Project 109097.

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