Drying solid residues remained after essential oil distillation of rosemary with three different methods: An optimization study

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The essential oil distillation process of aromatic plants generates a huge amount of solid plant residues (SPR) that are considered a rich source of phenolics-antioxidants compounds. Valorization of these unutilized SPR to obtain phenolic extracts (PE) could address the sustainable development goals in the agro-industry sector. Proper drying of SPR represents a key to obtaining an extract rich in antioxidants. The current research focuses on the optimization of the rosemary SPR drying conditions of three heating processes: oven-drying heating (DH), microwave heating (MW) and infrared radiation (IR).
The response surface methodology (RSM) consisting of a two-level full factorial central composite design (CCD) (?=1,414, 5 center points, total 13 runs) was used to optimize drying time (X1, 30–120 min), drying temperature (X2, 40–60 °C) for DH process; drying time (X1, 20–60 min), drying temperature (X2, 40–60 °C), for IR process; drying time (X1, 1–4 min), drying power (X2, 400–1600 W), for MW process. The responses for each drying method were moisture content (%), total phenolic (TPC) and flavonoid content (TFC), DPPH (2,2-diphenyl-1-picrylhydrazyl), and ABTS (2'-azino-bis-3-ethylbenzthiazoline-6-sulphonic acid) values. The minimization of moisture content and maximization of the values of the other parameters was set as the goal of optimization. Moreover, the moisture content was constrained to be less than 10% in order to keep the solid residue safe from microbial/fungal contamination.
The equations for each response obtained from the analysis of the response surface design showed values higher than 75% for R2 and higher than 0.70 for R2(adj). The optimized conditions for drying rosemary SPR were 96min at 33°C for DH, 28min at 36°C for IR and 1.7min at 400W for the MW process. These optimized conditions gave very high overall desirability: 0.78, 0.91 and 0.83 for DH, IR and MW, respectively. Among the three processes used, the MW decreased the moisture content to less than 10% in the shortest time. The results obtained revealed that if optimization is used there are advantages not only in terms of assuring safe storage of the rosemary solid by-product but also in preserving phenolic content and reducing energy consumption.