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## Evaluation of carob tree (*Ceratonia siliqua* L.) pods, through three different drying techniques, and ultrasonic assisted extraction, for presence of bioactives

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## ABSTRACT

The Mediterranean evergreen carob tree (*Ceratonia siliqua* L.) produces pods, that may be edible and even therapeutic. The purpose of this study was to determine how ethanolic extracts of carob pods from Morocco, prepared with ultrasonic assistance were affected by microwave (525 °C for 2.5 min), hot air (65 °C for 16 h), and spray drying (input and output air temperatures 180 and 90 °C, respectively, feed flow rate 2.5 mL/min and 5 bars, respectively), in terms of their physicochemical composition and biological activity. Colorimetric techniques were utilized to ascertain the phytochemical contents of pod extracts, whereas standardized *in vitro* methodologies were employed to quantify the antioxidant and antimicrobial activities. Physicochemical analysis showed that microwaved powders of carob pods presented significantly high ( $p < 0.05$ ) values of  $L^*$  ( $62.15 \pm 0.06$ ) and  $b^*$  ( $21.32 \pm 0.06$ ), and lower values of  $a^*$  ( $4.16 \pm 0.03$ ), as compared to spray dried and hot air-dried powders. Significantly high ( $p < 0.05$ ) amounts of ash ( $3.92 \pm 0.05$  %), fat ( $1.48 \pm 0.02$  %), fiber ( $7.45 \pm 0.12$  %) and protein ( $2.65 \pm 0.06$  %) were found in microwave dried powders, followed by spray dried and hot air dried. Significant difference in macro and micro minerals among three powders was also observed, as microwave dried powders were found to be significantly high ( $p < 0.05$ ) in Mg, K, Ca, Fe, Zn and Mn, followed by spray dried powders, whereas hot air-dried powders presented lowest values. Similarly, spectrophotometric analysis of phytochemicals revealed that ultrasonic assisted ethanolic extracts of microwave dried powders were found to be highest in total phenolics, flavonoids and carotenoids, with values  $69.18 \pm 0.15$  mg GAE/g,  $34.88 \pm 0.08$  mg QE/g and  $24.05 \pm 0.15$  mg g<sup>-1</sup>, respectively. *In vitro* antioxidant and antimicrobial analysis also showed a similar trend as, extracts of microwave dried powders exhibited significantly high ( $p < 0.05$ ) antioxidant and antimicrobial activities, followed by spray dried and hot air-dried. As compared to hot air and spray drying, the microwave drying and ultrasonic assisted extraction using 70 % ethanol as solvent could be employed on carob pods, to obtain powders and extracts, respectively, with minimum degradation of physicochemical characteristics, and maximum retention of nutritional, bioactive and antioxidant contents.

**Practical applications:** In recent years, Morocco has become more and more dependent on the use of carob fruit and its powders. Nonetheless, very rare is known about the composition and carob pod quality of those grown in Mediterranean nations. The current study presents a comparison of the effects of three distinct commercial drying methods on the composition and physical characteristics of flour made from carob pods. The study's findings can also be used to evaluate how well information is composed, processed, and preserved for use in future research and commercial applications.

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