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Improvement of the drying performance of pre-cooked beans (*Phaseolus vulgaris*) through ultrasonic-assisted hulling

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Abstract

Beans are among the most versatile and widely consumed staple foods worldwide. They are highly nutritious and contain high levels of dietary fibers, complex carbohydrates, proteins, essential vitamins, and minerals that are indispensable to human wellbeing. Due to their given importance, the development of processing methods for hard-to-cook beans for the preparation of instant end-products is of great interest, especially in developing countries. Thus, this study focused on investigating the influence of ultrasonic-assisted dehulling on the drying behaviour of pre-cooked beans as a viable alternative to the present drying approaches. Red kidney beans (*Phaseolus vulgaris*), unhulled (UHB) and dehulled via ultrasonication (HB/UT), were used for the experimental analysis. The cooking time of beans was determined based on sensory evaluation, with 50 and 25 min proving to be optimal for UHB and HB/UT, respectively. Afterwards, the pre-cooked samples were dried in a high-precision through-flow laboratory dryer (HPD-TF3+) at 30, 50, and 70 °C with an air velocity of 0.20 ms^{-1} and specific humidity of 10 $g\,kg^{-1}$. Results revealed a faster moisture transfer of the HB/UT beans compared to UHB beans at $p < 0.05$, which was attributed to the lower resistance to moisture diffusion induced by the hull removal. Henceforth, a reduction of drying time up to 73.3 % was ascertained experimentally. A generalised semi-empirical model was developed from the analysis of the drying data, which was capable of predicting the drying behaviour of beans with $R^2 \geq 0.990$ and MAPE $\leq$ 10.0 %. In terms of colour, UHB and HB/UT beans differed significantly at $p < 0.05$ for redness a*, yellowness b*, hue angle H*, and chroma c* across all drying conditions, while no significant differences were observed for luminosity L*. Microstructural analysis revealed comparable structures after drying at 30 and 50 °C, with beans exhibiting an intact cellular structure. Temperatures of 70 °C, on the other hand, degraded the cellular integrity of beans by breaking down the cell wall boundaries, especially in HB/UT beans. In conclusion, ultrasonic-assisted hulling has demonstrated a great potential for improving the drying performance of beans, thereby making it a viable alternative for practical applications.

Keywords: Beans, cooking, dehulling, drying, microstructure, ultrasonic-assisted

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