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# Improvement of the Drying Performance of Pre-cooked Beans (*Phaseolus vulgaris*) through Ultrasonic-Assisted Hulling

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## Introduction

- Beans are among the most important staple foods worldwide, containing indispensable nutrients for human wellbeing.

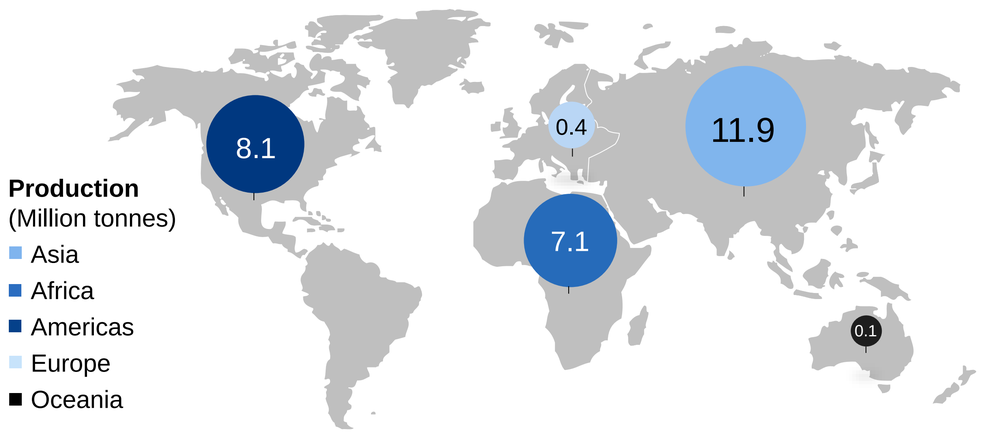


**Fig. 1.** Bean production by continents (FAOSTAT 2022)

- This study aimed to investigate the influence of ultrasonic-assisted hulling on the drying behavior of pre-cooked beans.

## Material and Methods

- Red kidney beans (*Phaseolus vulgaris*), unhulled (UHB) and hulled via ultrasonication (HB/UT), were used for the experiments.
- UHB and HB/UT beans were cooked and then a sensory evaluation of trained panelists was used to determine the optimal cooking time.
- The pre-cooked beans were dried at temperatures of 30, 50, 70°C with an air velocity of 0.2 $m \cdot s^{-1}$ and specific humidity of 10 $g \cdot kg^{-1}$.
- The drying characteristics, color and microstructure were investigated.

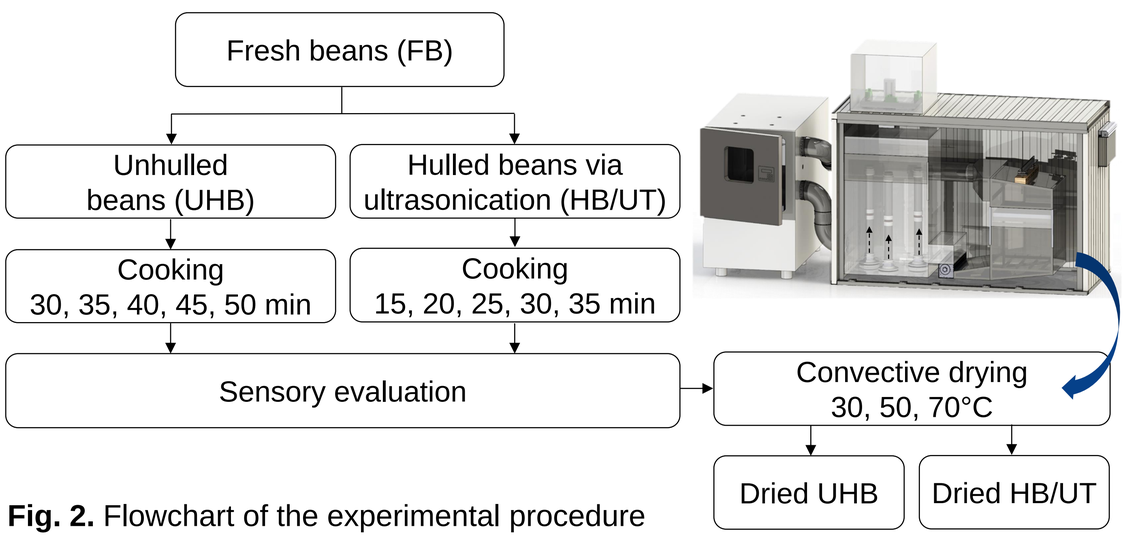


**Fig. 2.** Flowchart of the experimental procedure

## Results

- The cooking times of 50 and 25 min were found to be optimal for UHB and HB/UT beans, respectively.

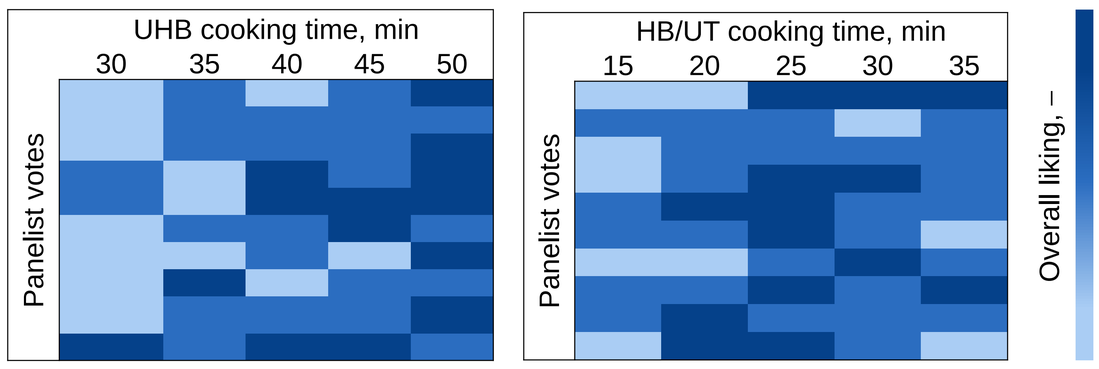


**Fig. 3.** Sensory evaluation results based on the overall liking of panelists

- A faster moisture transfer was observed for HB/UT compared to UHB beans, which was attributed to the lower resistance to moisture diffusion caused by hull removal.

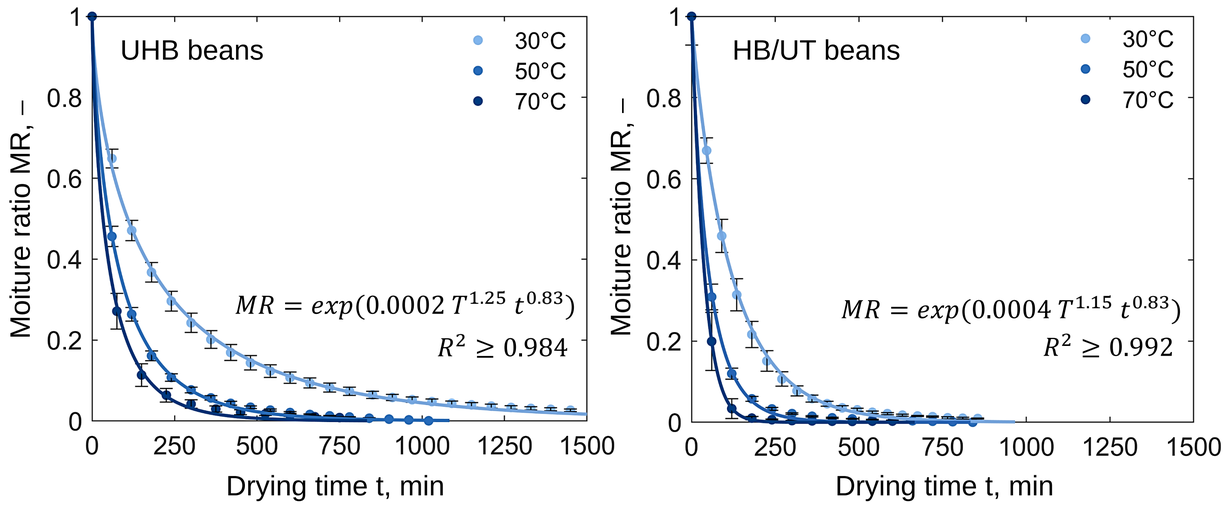


**Fig. 4.** Drying characteristics of UHB and HB/UT beans at temperatures 30, 50 and 70°C. Solid lines indicate fitting using a semi-empirical model.

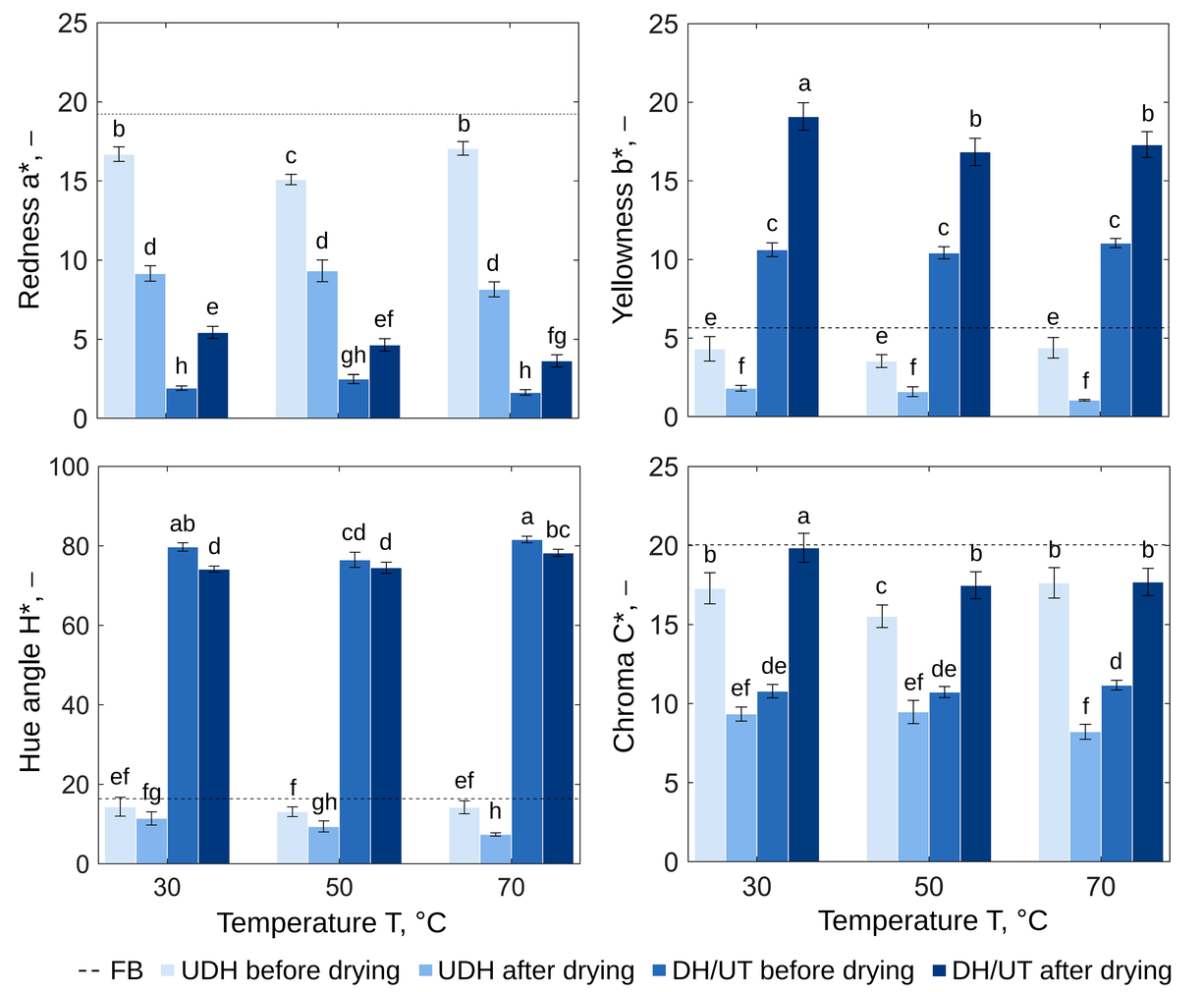


**Fig. 5.** Color changes before and after drying at temperatures 30, 50 and 70°C

- Cooking, hulling and drying had a significant effect on color change.
- Unlike 30 and 50°C, drying temperature 70°C degraded the cellular integrity of beans by breaking down the cell wall boundaries.

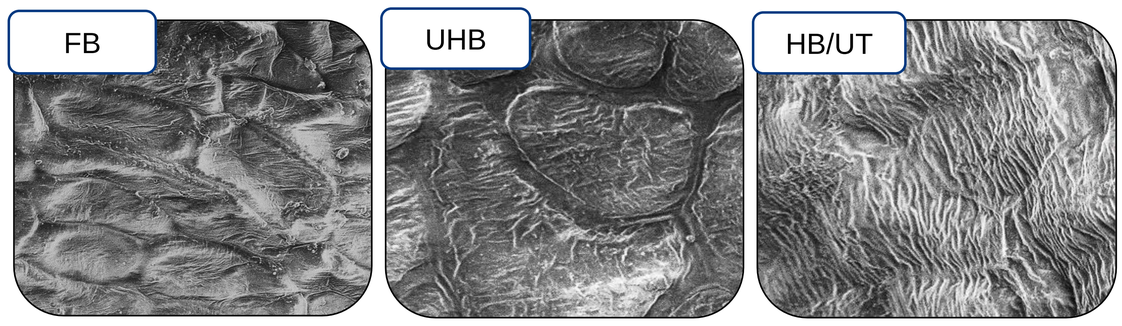


**Fig. 6.** Endosperm microstructure of FB, UHB and HB/UT beans after drying at 70°C, where the most evident changes occurred (magnification ×1000 μm)

## Conclusions

- Ultrasonic-assisted hulling has demonstrated a great potential for improving the drying performance of beans, thereby making it a viable alternative for practical applications.

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