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Microwave Drying of 3D-Printed Carrot Purée Using an Evanescent Wave Antenna

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INTRODUCTION

3D printing is transforming food processing by enabling more efficient use of food inks. The integration of microwaves via an **evanescent wave antenna** is currently being investigated to apply thermal treatment, promoting drying to reduce **microbiological risks** and improve **stability**. In high-moisture formulations like carrot purée, effective drying is essential for safety and shelf life.

MATERIALS & METHODS

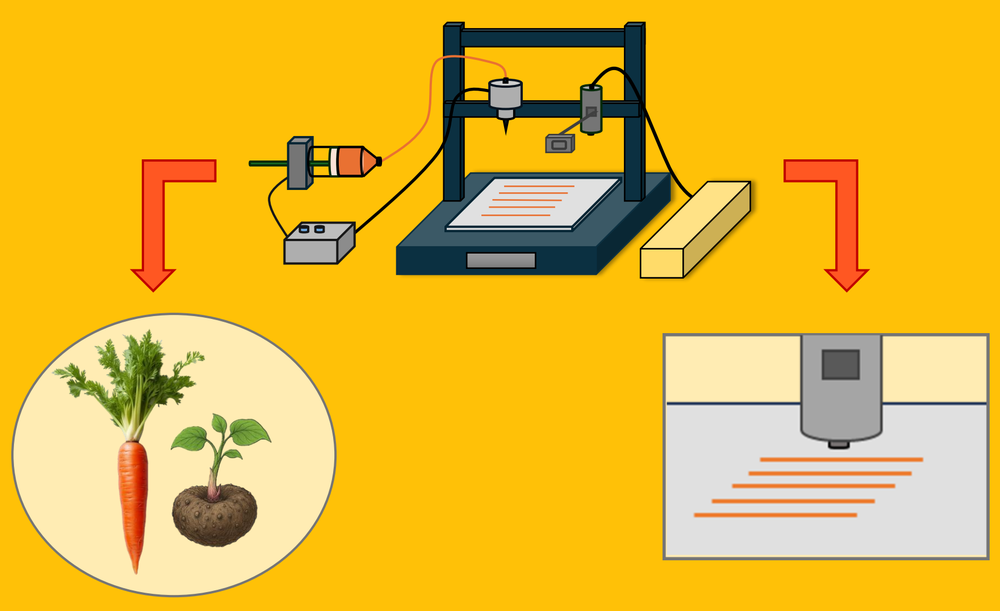

Figure 1. *3D food printer with microwave-assisted processing.*

A carrot purée containing 3.13% konjac was used to print 3D structures composed of five lines. These samples were then heat-treated using an evanescent wave antenna operating at **2490 MHz**. The effects of varying conditions were assessed by adjusting the **antenna speed (v = 1.5 mm/s and v = 2.25 mm/s)** and the **distance to the printed surface (h = 1.4 mm and h = 1.6 mm)**. Each parameter combination was tested in triplicate. Moisture loss was measured gravimetrically, and maximum temperatures were recorded using optical thermography.

RESULTS & DISCUSSION

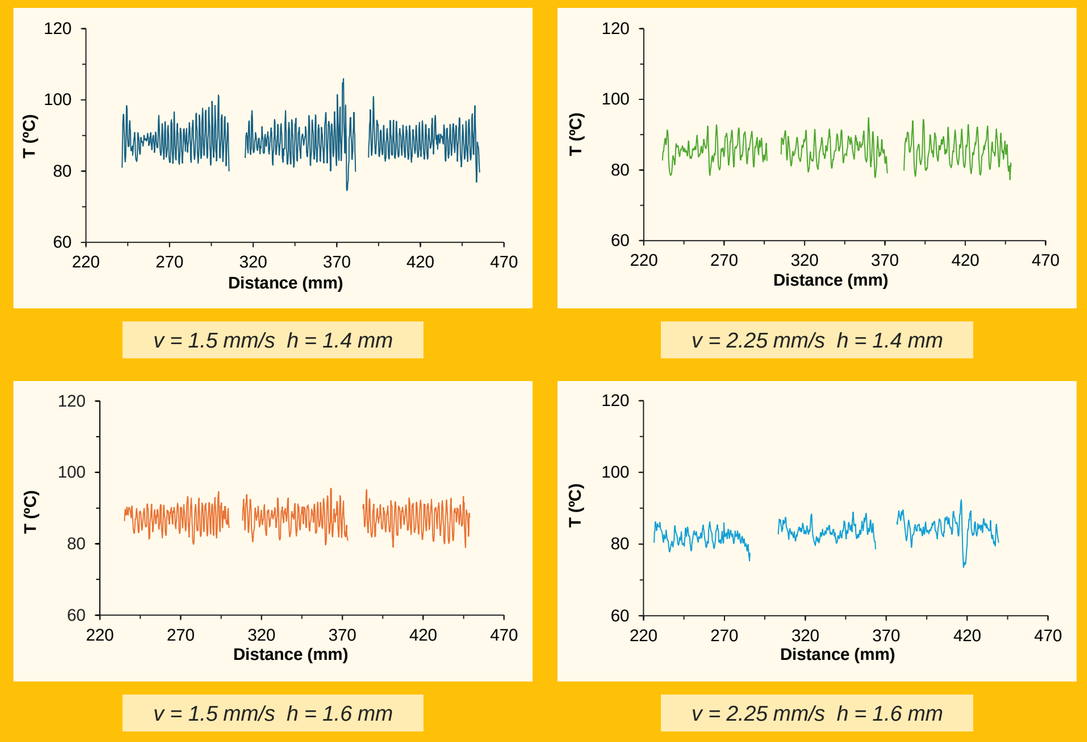

Figure 2. *Maximum temperature distribution along the last three lines of a 3D printed carrot purée structure heated using an evanescent microwave antenna. Four experimental conditions are compared, varying the antenna travel speed (v) and distance between the antenna and the food surface (h).*

- **Lower speed (*v = 1.5 mm/s*)** leads to higher temperatures, indicating longer exposure and more effective heating.
- **Greater antenna–food distance (*h = 1.6 mm*)** reduces the temperature, suggesting decreased energy transfer efficiency.
- **Combined high speed and large distance (*v = 2.25 mm/s, h = 1.6 mm*)** results in the lowest temperature, highlighting the compounded effect of both parameters.

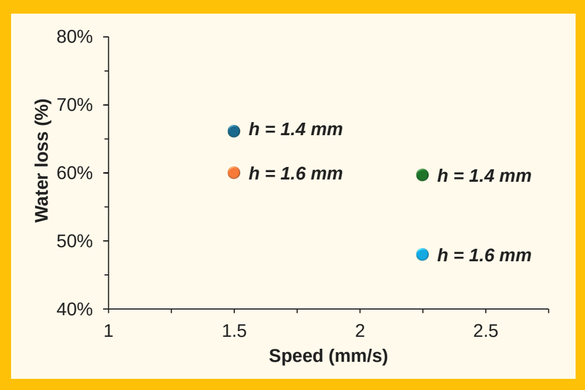

Figure 3. *Effect of antenna speed and height on water loss.*

Water loss in the carrot puree is directly linked to heating intensity. Conditions that produce **higher temperatures** also lead to greater **dehydration** during processing.

CONCLUSIONS

The results confirm that the use of an evanescent microwave antenna is effective for heating 3D printed food structures. Precise control of antenna speed and height allows modulation of heating and dehydration in the food. This approach provides a versatile tool for 3D food printing applications, enabling targeted thermal processing.

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