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Impact of printing and post-processing parameters on the texture of 3D-printed food products

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Introduction

3D food printing is a new technology which aims to offer different food textures and give more space to consumer personalization.

However, only few studies deal with the impact of printing and post-processing parameters on the texture of food products. In this study, a carrot puree based paste was used as a food ink model. Carrot appetizer cakes were printed with a food printer prototype and baked in an oven. Four parameters were studied: nozzle diameter, filling rate, baking temperature and baking time.

The aim of this project was to establish a predictive model based on the four parameters studied and to better understand their impact on textural, microstructural and dimensional properties of 3D-printed carrot appetizer cakes.

Methodology

Food-ink model

- Flour (T55) + water + carrot puree
- 65% total water content

Thermomechanical treatment to obtain a gelatinized printable recipe

- Kitchenaid : 120 rpm, 12 min, 20 °C
- Thermomix : 100 rpm, 15 min, 85 °C

Table 1. Printing and post-processing parameters

Independent variables	Level				
	-α	-1	0	+1	+α
Nozzle diameter (mm, printer)	2.5	3.4	4.3	5.1	6.0
Filling rate (% , printer)	40	55	70	85	100
Baking temperature (°C, oven)	120	145	170	195	220
Baking time (min, oven)	10	15	20	25	30

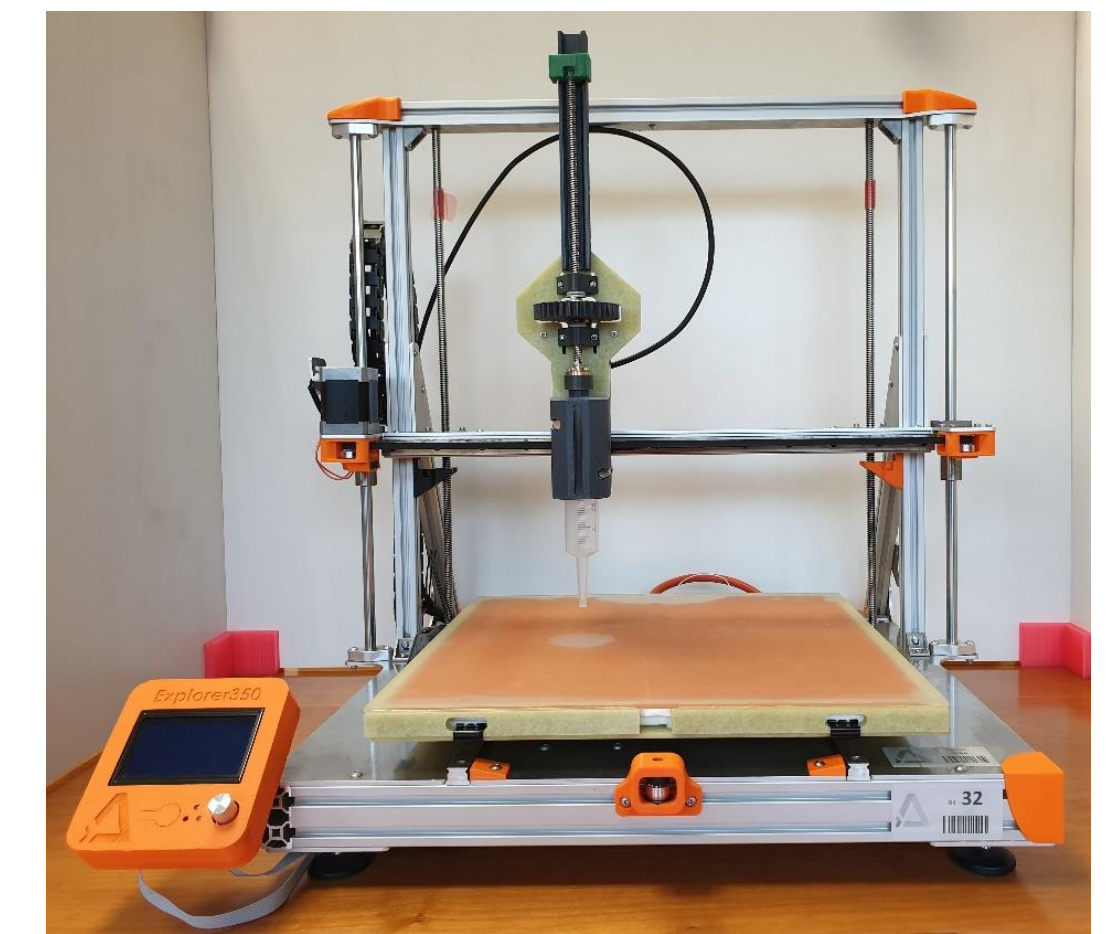


Figure 1. Food 3D printer

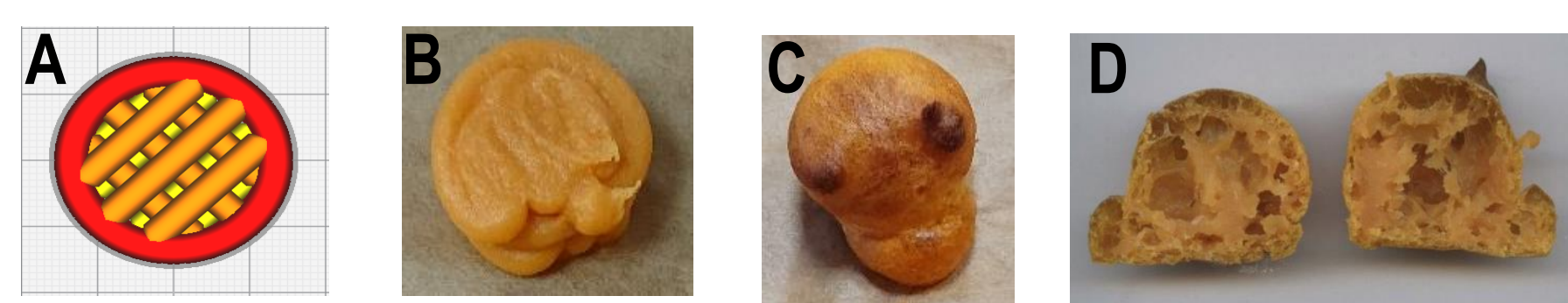


Figure 2. 3D model (diameter 3 cm, height 1.5 cm) (A), after printing (nozzle diameter 4.3mm, filling rate 70%) (B), after baking (170°C, 20min) (C), inside view (D).

Analysis of 3D-printed appetizer cakes

Crust strength, mean force inside the cake and gradient after crust penetration were analyzed by texture analyzer. Dimensional profile (maximum width (deformation) and height (swelling)) were measured with a laser-based scanner and total pore area was determined by image analysis^{1,2}.

Predictive model and back-engineering approach

A model was established in order to predict the textural, microstructural and dimensional properties. The back-engineering approach was also used to target the printing and post-processing parameters to obtain specific properties of 3D-printed food.

Results and discussion

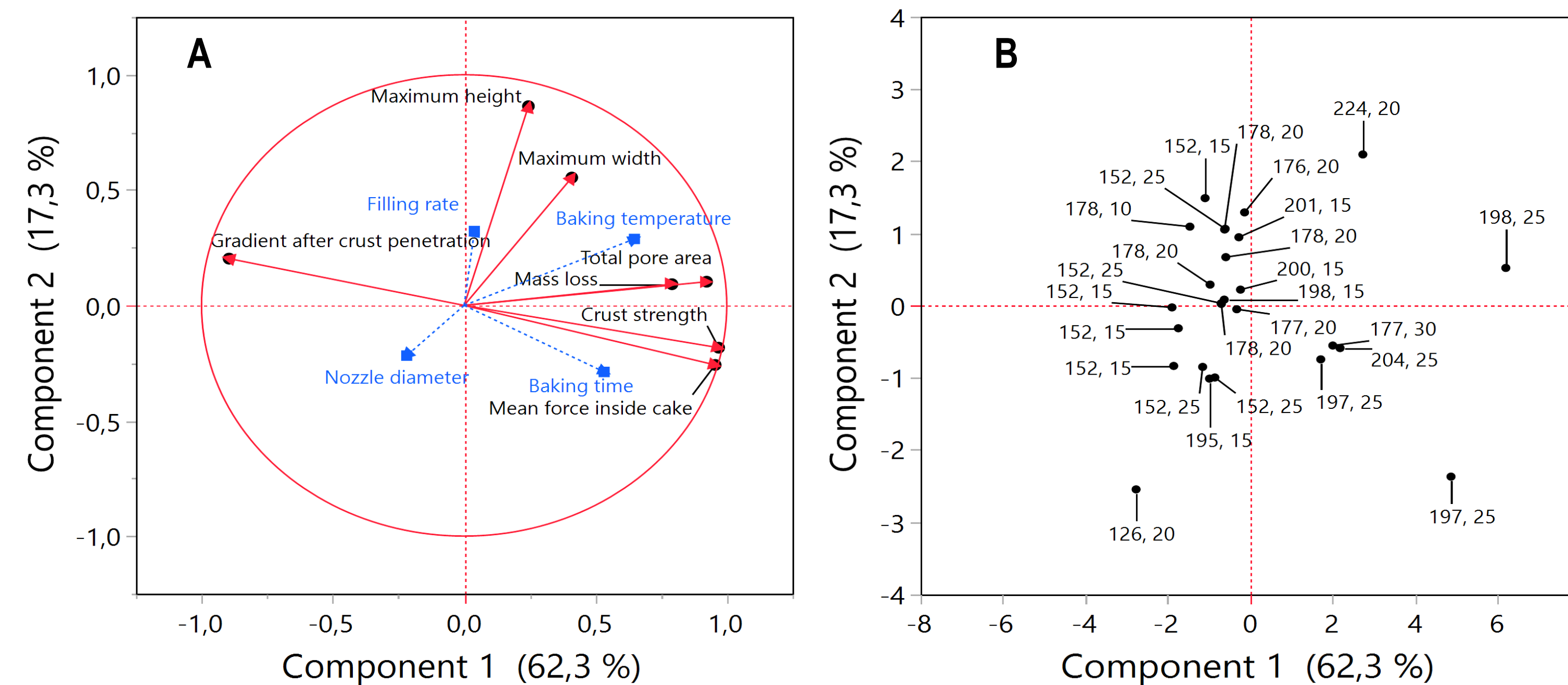


Figure 3. Correlation circle (A) and PCA map (B) of 3D-printed cakes

- ❑ To maximize desirability (95%) by limiting deformation (width) and targeting an intermediate total pore area (Figure 4), print at 3.4 mm (nozzle diameter), 40% (filling rate) and bake at 207 °C, 15 min.
- ❑ To obtain a compromise between high swelling and low deformation (desirability 82%), > nozzle diameter (6.1 mm) and < baking time (12min).
- ❑ To maximize textural properties (desirability 97%) print at 3.4mm and 85% and bake at 175°C, 30min.

- ❑ Majority of textural properties are modified by post-processing parameters (Figure 3).
 - ❑ > baking time and temperature explain > mass loss, total pore area, crust strength, mean force inside cake and < gradient after crust penetration.
- ❑ Printing parameters showed less impact than the post-processing parameters.
 - ❑ > filling rate and < nozzle diameter increased swelling and deformation of 3D-printed cakes.

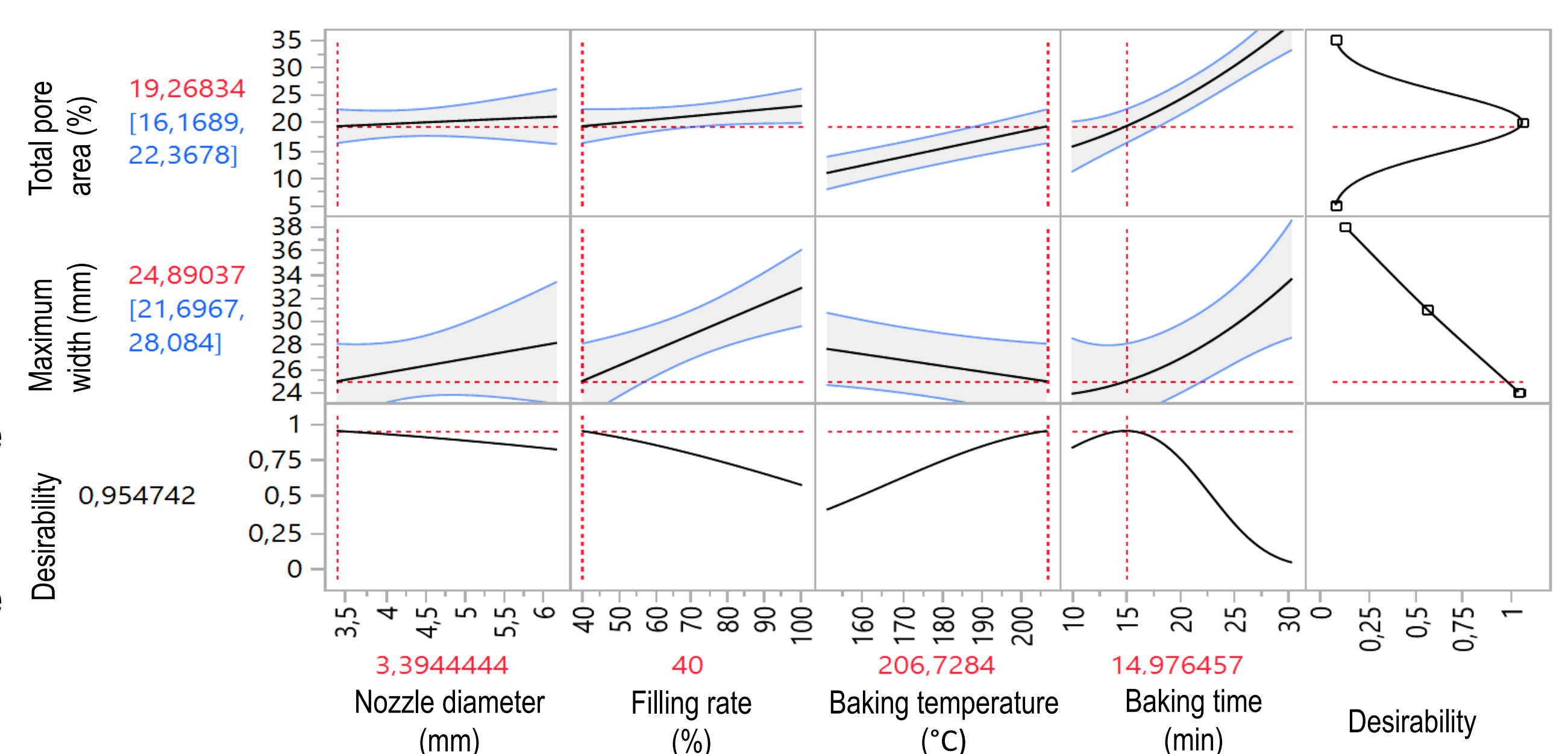


Figure 4. Maximization of desirability

Conclusions

- 3D food printing could be useful for varying the texture and visual aspect of food.
- Post-processing parameters had more impact than printing parameters on all textural and microstructural properties.
- Printing parameters mainly impacted the width and height associated respectively with the deformation and the swelling of 3D-printed cakes.
- It is not possible to simultaneously maximize the desirability of all textural, microstructural and dimensional properties of 3D-printed cakes.

References

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2. Le, X. T., & Turgeon, S. L. (2015). Food Hydrocolloids, 49, 216–223.

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