Healthy Individuals, Resilient Communities, and Global Food Security

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Carrot blanching by ohmic heating with Pulsed Electric Fields

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Introduction

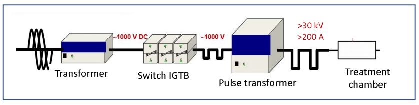
Pulsed Electric Fields (PEF) applied at high intensity (E>1 kV/cm) and at high frequencies (>50Hz) in static conditions can be used as a rapid and volumetric ohmic heating process of solid foods. This effect, combined with the cell permeabilization, is of great interest for blanching vegetables in order to inactivate spoilage enzymes and to improve the texture of the food.

Objective

The objective of this work is focused on optimizing carrot blanching by PEF and evaluating its efficiency for peroxidase enzyme inactivation.

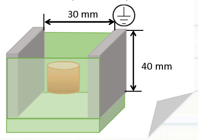
Materials and methods

PEF treatment



Generator ScandiNova PG (ScandiNova, Uppsala, Sweden) 30 kV y 200 A

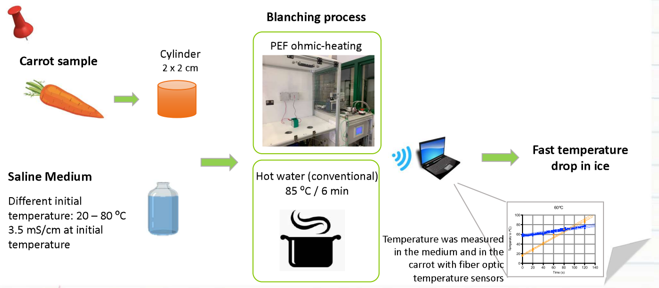
Parallel square PEF chamber (GAP 30 mm)



Parameters:

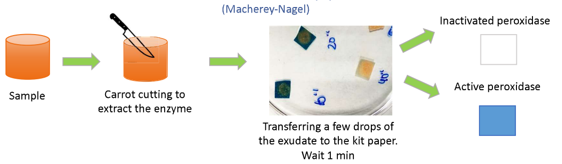
- Frequency: 50 - 150 Hz
- Electric Field: 1.0 – 1.7 kV/cm
- Medium: 84.6 – 159.3 mg/mL $CaCl_2$ solution
- Initial temperature: 40-80 °C

Carrot Blanching



Analyses

Determination of blanching efficiency: Qualitative test paper Peroxtesmo KO for Peroxidase in food (Macherey-Nagel)



Modelling of peroxidase inactivation as a function of temperature

The theoretical inactivation of the peroxidase enzyme was carried out with the following equations:

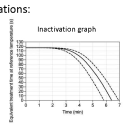
$$z = \frac{Tref\_T}{\log TDT - \log TDT_{ref}}$$

$$\log TDT = \frac{T_{ref} - T}{z} + \log TDT_{ref}$$

Z = 15.8 °C

TDT_{85} = 1,85 min

TDT (thermal destruction time) : time required to inactivate the enzyme



Texture analysis

Texture Profile Analysis (TPA)

Cylindrical aluminium probe of 38mm diameter.

Probe-to-sample distance: 4 mm.

Probe speed: 60 mm/min.

Results and discussion

Previous studies showed that increasing the frequency, electric field or initial electrical conductivity of the medium did not improve heating uniformity. Therefore, 3 different initial temperatures of the saline medium (3.5 mS/cm) were evaluated. As shown in Figure 1, starting at 80 °C allowed reaching 85 °C in only 90 s in both the carrot (orange line) and the saline medium (blue line) , being a fast and uniform treatment.

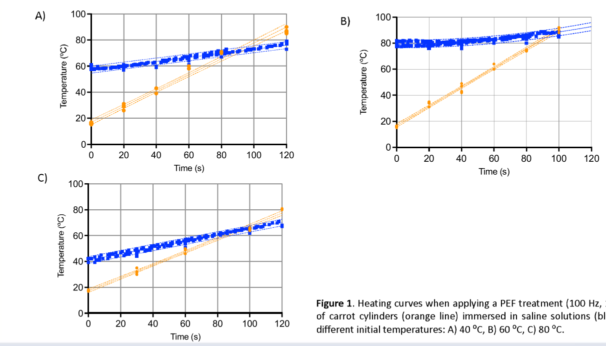


Figure 1. Heating curves when applying a PEF treatment (100 Hz, 1.3 kV/cm) of carrot cylinders (orange line) immersed in saline solutions (blue line) at different initial temperatures: A) 40 °C, B) 60 °C, C) 80 °C.

After studying how to apply PEF blanching, we characterized the thermoresistance of the peroxidase enzyme which is an indicator of the efficiency of this process. Results obtained were Z-value = 15.88 °C and TDT_{85} = 1.85 min. Figure 2A shows the PEF-assisted blanching for which 219s were needed to inactivate the enzyme. In order to achieve this, pulses are applied for 90s to reach 85°C in the sample, then the sample is transferred to a bath at 85°C to complete 220s and maintain the temperature at 85°C. If this time is compared with that shown in Figure 2B corresponding to a conventional blanching (6.9 min), the time is reduced by 53.14 %.

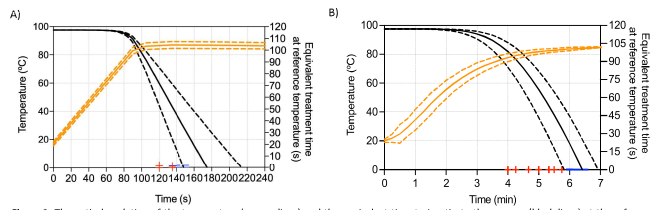


Figure 2. Theoretical evolution of the temperature (orange lines) and the equivalent time to inactivate the enzyme (black lines) at the reference temperature in carrot cylinders immersed in saline solution when applying: A) a PEF treatment (100Hz, 1.33 kV/cm, 90s) followed by a water bath at 85°C for 2:10 min; B) conventional blanching in water at 85°C. Experimental inactivation data are shown with a + sign when the enzyme is still active and - when it is inactivated.

Finally, the texture of blanched carrots immersed in a solution with (850ppm Ca_2) or without calcium, after freezing and thawing, was evaluated (Figure 3). It was observed that those treated with PEF and immersed in a solution with calcium improved the texture giving rise to higher hardness values than the rest

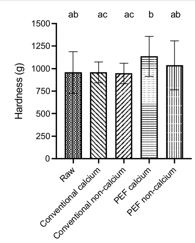


Figure 3. Evaluation of the hardness of carrot cylinders after blanching, conventional freezing and thawing at 4°C for 24h.

Conclusions

Ohmic PEF heating could be an alternative to traditional food heating systems allowing rapid heating and, therefore, improving the sensory properties of foods.

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