A novel pasteurization method for solid foods: a case study

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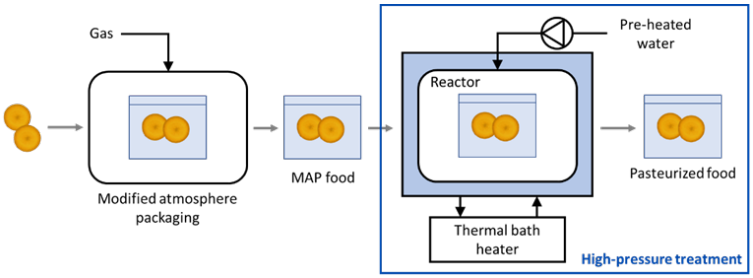
1. Introduction

During the last years, the global increasing demand for healthy and fresh food called for an evolution of the current available food processing technologies[1]. A new low-temperature pasteurization process patented at the University of Padova (Italy) promises to address the gap of the existing technologies[2,3]. This method exploits the well-known bactericidal properties of carbon dioxide under supercritical conditions ($scCO_2$) and it is applied to pre-packed solid food, avoiding the risk of post-process contamination. The process (Figure 1) consists in pressurizing, through an incompressible liquid (water), a high barrier Modified Atmosphere Packaging (MAP) rich in CO_2, until reaching the critical point of CO_2 contained, that inactivate microorganisms and enzymes present on the food's surface responsible for food spoilage.

2. Materials and Methods

High pressure equipment



Treatments were conducted inside a high-pressure system able to pump pre-heated water inside a vessel of 4dm^3 of volume, pressurize it up to a maximum pressure of 200 bar and to maintain pressure and temperature constant for the entire duration of the process thanks to an external heating cable system.

Figure 1. Process scheme.

Product screening

As this technology has the potential to be applied on a large variety of different food matrices, a preliminary product screening was carried out on the attitude to resist high pressures. Three different categories (vegetable, seed, fruit) were considered. An internal panel evaluated this last aspect on the basis of the visual aesthetic acceptance of the samples treated at fixed process conditions based on previous tests (40 °C, 10 MPa, 15 min, MAP 100% CO_2, MAP gas/product ratio 4:1).

Process parameter optimization

Different process variables were identified, namely pressure, time, temperature to optimize the process following a full factorial Design of Experiment, based on the color change between treated and untreated samples. Total color change is relatively easy and quick to measure and it is one of the most important aspects of consumer acceptance[4]. The color of each sample was determined, before and after the treatment, using the CIElab color space and measured using a colorimeter (NR100, 3nh, China). Total color difference (ΔE) was calculated by following the CIE76 (International Commission on Illumination, 1976) reported in the following equation:

$$\Delta E = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2}$$

Microbial inactivation degree and evolution during a storage test

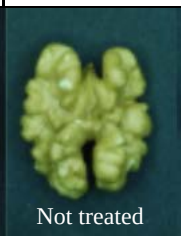
Total mesophilic bacterial count of untreated and treated samples was carried through standard plate count technique by inclusion in plate count agar medium (PCA, Sacco, IT). Inoculated plates with serial dilution were incubated at 30°C for 48h before reading the results.

3. Results and discussion

Product screening

From the first screening, 26 different food products between fruit, vegetables and seeds categories were considered compatible with the process at fixed condition, based on the overall sensory acceptance by an internal panel. Samples of the selected products (dates, carrots, and walnut) are reported in Table 1.

Table1. Imagines of three different products selected from a first products screening.

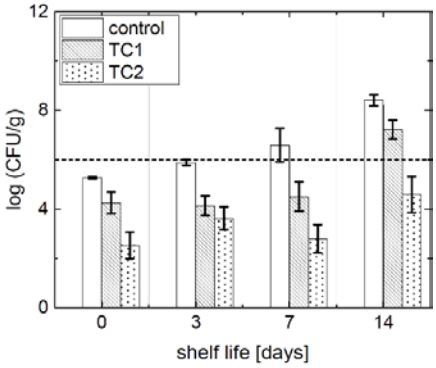
Date (whole, dried)		Carrot (slice)		Walnut	
					
Not treated	Treated	Not treated	Treated	Not treated	Treated

Process optimization

Following, the process conditions were optimized to maintain the color change (ΔE) <5, without affecting the global appearance of the sample. Carrots is reported as case study. The optimal temperature, pressure and time conditions were: TC1 (32.5 °C, 9 MPa, 30 min) and TC2 (40 °C, 6 MPa, 15 min).

Microbial analysis

Microbial analysis was performed under the processing conditions TC1 (32.5 °C, 9 MPa, 30 min) and TC2 (40 °C, 6 MPa, 15 min). The microbial population of fresh-cut carrots during storage period at 4° C in terms of mesophilic microorganisms is reported in Figure 2.



Control samples packaged in 100% CO_2 exhibit a steady growth in the population of mesophilic microorganisms during the shelf life, reaching after 1 week a charge >6 log (CFU/g), usually considered a threshold value by the food industry. Samples treated at TC1 and TC2 conditions showed an initial reduction respectively of 2.9log and 1.2log (CFU/g). According to these results, CO_2 itself is not able to inhibit the growth of total mesophilic bacteria, while the combination of high temperature (40 °C) and pressurized CO_2 determines a more efficient inactivation than supercritical CO_2 at low temperature (32.5 °C).

Figure 2. Mesophilic microbial population profile of treated carrots(slice) during storage period at 4° C. The dotted line indicates the 6 log (CFU/g) threshold to define a sample spoiled. Untreated stored sample in MAP 100% CO_2 (control); 32.5 °C, 9 MPa, 30 min (TC1); 40 °C, 6 MPa, 15 min (TC2).

4. Conclusions

This work shows the first optimization steps of an innovative food pasteurization process that exploits the antimicrobial capacity of carbon dioxide under supercritical conditions. Results from screening of different food products and process optimization based on color change and mesophilic microbial inactivation showed that this technology has the potential be an effective pasteurization technique able to lower the microbial charge without significatively affecting appearance.

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