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The influence of edible coatings, blanching and ultrasound treatments on quality attributes and shelf-life of vacuum packaged potato strips

R.D.A. Amaral [a, b], I. Achaerandio [a], B.C. Benedetti [b], M. Pujolà [a, *]

[a] Department d'Enginyeria Agroalimentària i Biotecnologia, Escola Superior d'Agricultura de Barcelona, Universitat Politècnica de Catalunya BarcelonaTech, Barcelona, Spain
[b] Faculty of Agricultural Engineering, University of Campinas (UNICAMP), Brazil

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ABSTRACT

The aim of this work was to investigate the effect of using ultrasound or edible coating as a possible alternative to blanching on the quality of vacuum-packaged potato strips. The treatments assessed were blanching (85 °C, 3.5 min), coating with 20 g L^{-1} alginate and sonicating (40 kHz, 5 min) in an ultrasonic bath containing a 20 g L^{-1} citric acid solution. Vacuum-packaged samples were stored up to 12 days at 3 ± 1 °C. The pH, polyphenol oxidase (PPO) activity, sugars and microbial load were assessed. Also, the colour, shear-force and dry matter of the treated and fried potato strips as well as the oil adsorption and acrylamide after frying were evaluated. The PPO activity of the treated samples was not significantly different over time ($p > 0.05$). The treatments applied did not affect the attributes of the fried potato strips over time; there were no significant changes in oil absorption, acrylamide content or colour ($p > 0.05$). However, the visual quality of sonicated packaged potato strips was significantly better than that of the other treatments after storage. The loss of the texture of blanched potatoes was remarkable ($p < 0.05$) before and after frying. Sonicated samples maintained mesophilic bacteria counts better than blanched and alginate coated vacuum-packaged potato strips.

1. Introduction

Several treatments have been used to replace the current methods of prolonging shelf life and reducing the loss in quality of fresh-cut products. Blanching is a method that is commonly used in minimally processed potatoes to prevent enzymatic browning by inactivating polyphenol oxidase, promoting a more uniform colour after frying, limiting oil absorption and improving texture (Severini, Baiano, De Pilli, Romaniello, & Derossi, 2003). However, it is also known that this thermal treatment could lead to a loss of firmness and a loss of other attribute, such as nutrients, flavour and colour (Alvarez, Canet, & Tortosa, 2001).

The use of edible coatings and non-thermal technologies, such as ultrasound, can be a good alternative to avoid or minimize this loss of quality. Studies involving the use of ultrasound for mango juice showed improvements in the carotenoid content and phenolic compounds, in addition to a reduction in the microbial load, making it feasible as a substitute to thermal treatment (Santhirasegaram, Razali, & Somasundram, 2013). Ultrasound has been shown to reduce the loss of firmness of kiwi fruit (Meng, Zhang, & Adhikari, 2014) and plum fruit during storage (Chen & Zhu, 2011). Similarly, Amaral, Benedetti, Pujola, Achaerandio, and Bachelli (2015) applied ultrasound to vacuum-packaged potatoes and found that this treatment affected the tuber microstructure, but did not affect the firmness, and no colour changes were observed. The activities of PPO and POD decrease when ultrasound (40 kHz) is combined with ascorbic acid (10 g.L^{-1}) in fresh-cut apples stored for 12 days at 10 °C (Jang & Moon, 2011). However, the effectiveness of ultrasound varies according to the frequency and power used, type of micro-organism and enzyme, pH, temperature, and fruit or vegetable to which it is applied (Bilek & Turantaş, 2013; São José, de Andrade, Ramos, Vanetti, Stringheta, & Chaves, 2014).

However, edible coatings are widely used in industry for whole and fresh-cut products to preserve quality. Alginate has been used to reduce weight loss and microbial load in carrots (Amanatidou, Slump, Gorris, & Smid, 2000), to maintain the quality and prolong the shelf life of fresh-cut apples (Rojas-Graü et al., 2007), and to reduce the failure stress and browning during the storage of fresh-cut mangoes (Chiumarelli, Ferrari, Sarantópoulos, &

* Corresponding author.
E-mail address: montserrat.pujola@upc.edu (M. Pujolà).

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Hubinger, 2011). The association of alginate and nanomaterials can also exhibit beneficial effects on the quality of shiitake mushrooms during extended storage (Jiang, Feng, & Wang, 2013). Therefore, non-thermal processing technologies such has ultrasound and edible coatings could be alternatives to thermal processing methods, but specific studies are needed for each product. For this reason, the aim of this work was to investigate the effects of alginate and the combined use of ultrasound and citric acid as alternatives to blanching on the safety and quality attributes, such as microbial growth (Enterobacteriaceae, coliforms and mesophilic bacteria), visual appearance, oil absorption, texture and acrylamide content, of minimally processed potatoes and fried potatoes maintained under refrigeration for 12 days.

2. Materials and methods

2.1. Preparation of potato samples

Potatoes (*Solanum tuberosum* L. *cv* Asterix*)* were acquired from Mercabarna (Mercado de Abastecimientos de Barcelona SA., Spain). Tubers were selected, washed in tap water to remove surface dirt, dried and stored in the dark at a cool temperature (10 ± 2 °C). Potato tubers that were free of defects were hand-peeled, cut into rectangular strips with a cross-section of 10 × 10 mm with a manual slicer and rinsed in distilled water. No chemical washing was applied before or after cutting the potato. Then, strips were randomly assigned into four groups.

2.2. Treatments

Four treatments were applied to the raw material:

i) Control: the potato strips were rinsed in distilled water 1:4 ($kg \cdot L^{-1}$). The sample was stored for 10 min at room temperature and then dried with paper towels
ii) Blanching: the potato strips were blanched in hot water, 1:4 ($kg \cdot L^{-1}$) at 85 °C for 3.5 min (Pedreschi, Moyano, Kaack, & Granby, 2005). The sample was stored for 10 min at room temperature for these treatments and then dried with paper towels
iii) Ultrasound: the potato strips were dipped in an ultrasound bath (40 kHz frequency and 200 W of generation power, P-SELECTA 3000617, Barcelona, Spain) filled with citric acid solution 20 g L^{-1} at 1:4 ($kg \cdot L^{-1}$) for 5 min. The sample was stored for 10 min at room temperature and then dried with paper towels.
iv) Alginate: the potato strips were dipped in a coating solution with sodium alginate 20 g L^{-1}, glycerol 10 g L^{-1} and calcium lactate 20 g L^{-1} for 3 min (Chiumarelli et al., 2011). Coated strips were drained at 16 ± 2 °C for 1 h to dry the coating material.

Following treatment, 100 ± 5 g of potato strips were vacuum-packed in coextruded polyamide/high density polystyrene bags (Coex. PA/PEHD-70/150; thickness: 22 μm; O_2 transmission rate: $8 \cdot 10^4$ cm^3 $m^{-2} \cdot Pa^{-1}$ at 25 °C). The potato strips bags were then stored at 3 ± 1 °C for up to 12 days. Two bags of each treatment were randomly selected for analyses in sampling date (days 1, 4, 8 and 12).

The frying process was conducted for all treatments on days 1, 4, 8 and 12, in sunflower oil at 180 ± 5 °C for 6 min (this time was fixed according to the palatability of the fried strips) in an electrical fryer (Taurus Professional Compact, Oliana, Spain) at a proportion of 4:1 ($kg \cdot L^{-1}$) (Gökmen & Palazoğlu, 2009). After frying, the strips drained for 1 min and were then placed at room temperature on absorbent paper for 10 min to remove excess oil.

2.3. Ultrasound equipment

The ultrasound bath was made of a welded aluminium sheet, with a capacity of 9 L, and the dimensions were 15 cm × 50 cm x 14 cm (height x width x depth). The equipment had four steel cone-shape transductors (45 mm/38 mm in diameter; 47 mm length). The experiments were conducted in batch mode in a non-refrigerated system. The operating conditions had previously been optimized, and the distribution of the ultrasound in the bath was uniform (Amaral et al., 2015). The increase of the temperature in the water was less than 2 °C after 5 min of treatment.

2.4. Analytical determinations

All of the analyses were carried out on days 1, 4, 8 and 12 for vacuum-packaged and fried potatoes. Vacuum-packaged potato samples (control, blanched, ultrasound and alginate treatments) were characterized in triplicate. For PPO activity, reducing sugars, sucrose and acrylamide samples were collected, immediately frozen at −20 °C and subsequently freeze-dried (at −54 °C and 7.10^{-3} kPa vacuum) for 40 h by Telstar Cryodos-50 freeze-dryer (1 KVA of potency, model 2G-6, Telstar, Barcelona, Spain).

The dry matter content was determined by drying 5 g of potato at 65 °C for 24 h (AOAC 931.04). The pH of potato samples was measured with a potentiometer according to AOAC (981.12). Polyphenol oxidase (PPO) activity was determined in 3 g of lyophilized potato samples, using the supernant after homogenisation in Mcllvaine buffer solution (pH 6.5) together with 50 g L^{-1} of polyvinylpyrrolidone and 1 mol L^{-1} NaCl and centrifugation at 12,000*g* for 15 min. The reaction mixture contained 1.5 mL of extract, 1 mL of phosphate buffer (pH 5.0) and 0.5 mL of 100 mmol L^{-1} 4-methyl catechol. PPO activity was measured by determining the absorbance increase at 410 nm over a period of 3 min. Results of PPO activity were expressed in nkatal.

The sugar contend (glucose, fructose and sucrose) was determined according the method used of Hernandez, Gonzalez-Castro, Alba, & de la Cruz Garcia, 1998 with slight modifications. Three samples of 2 g of lyophilized potato were extracted by refluxing for 30 min with 20 mL of 700 mL L^{-1} ethanol. The extract was vacuum-filtered, and the filtrate was filled to 25 mL with 700 mL L^{-1} ethanol. A 5 mL aliquot of the solution was passed through a Waters Sep-Pak C column, filtered (0.45 μm pore size membrane) and analysed by HPLC (Hewlett Packard 1100, Santa Clara, USA) equiped with a refractive index detector (Beckman Instruments, inc., San-Ramon, USA) and a reverse phase-amide column (Phenomenex Luna (250 × 4.6 mm i. d)). The chromatography conditions were: constant temperature 28 °C, isocratic elution with acetonitrile-water (78:22 L L^{-1}) and flow rate 1.2 mL min^{-1}. By external calibration, the glucose, fructose and sucrose were identified and quantified. The average of the results of three replications was expressed as $g \cdot kg^{-1}$ of fresh weigh (FW).

In fried potatoes, oil uptake determination consisted of a Sohlext extraction of the dried potato sample and gravimetric quantification of the oil content (AOAC 922.06), and dry matter was also determined under the same conditions for vacuum-packaged potatoes.

Acrylamide was assessed in fried potato strips following the extraction procedure used by Yang, Achaerandio, and Pujolà (2016). One gram of lyophilized potato fried sample was mixed with 10 mL of 1 g L^{-1} formic acid solution for 20 min, then refrigerated for 40 min for easier removal of the top oil layer. The clarified aqueous phase was filtered through a 0.45 μm nylon syringe filter and stored for clean-up and analysis. Then, 2 mL of the filtered extract solution were subjected to SPE (CarboPrep™ 200 tube, 6 mL, 500 mg) pre-conditioned previously. The acrylamide residue in the SPE tube was