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Blanching of red beet (*Beta vulgaris* L. var. conditiva) root. Effect of hot water or microwave radiation on cell wall characteristics

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ABSTRACT

The effect of enzymes inactivation through traditional (water, 90 °C) and microwave blanching (constant power of 350 W and changing power with values higher than 900 W) on cell wall polysaccharides as well as on microstructure of beet root tissue was studied with the goal of attaining a better understanding of the changes produced by treatment and its consequences on the functional properties of cell wall polymers. Powers higher than 900 W produced greater tissue microstructural damage due to alteration of the cell wall network. The contact between neighboring cells persisted after microwave treatment at 350 W while traditional blanching or blanching at higher microwave powers (90MW) produced separation of the middle lamella at different points and also cell separation was observed for the last mentioned treatment. The formation of entanglements of pectin-in-extensin in 350 W-treated beet root and the higher content of calcium and diferulated cross linked pectins in the case of traditional treatment may account for the better mechanical performance observed for these tissues. The microwaving at 350 W modified the cell wall polymers in such a manner that produced an increase in their hydrophilicity.

1. Introduction

Blanching is an important step in the industrial processing of vegetables and fruits. It is a thermal treatment applied before freezing, frying, drying and canning to inactivate deleterious enzymes and to reduce the microbial load. The efficiency of blanching process is usually based on the inactivation of heat resistant enzymes like peroxidase (POX) and polyphenoloxidase (PPO) (Dorantes-Alvares & Parada-Dorantes, 2005; Gökmen, Savas-Bahceci, Serpen, & Acar, 2005). However some adverse effects have been reported such as tissue softening, pigment modifications and nutrient losses (Goncalves, Pinheiro, Abre, Brandao, & Silva, 2007; Kidmose & Martens, 1999).

Microwave heating takes place in dielectric materials such as vegetables tissues due to the polarization effect of electromagnetic radiation at frequencies between 300 MHz and 300 GHz. According to Chen, Collins, Mc.Carty, and Johnston (1971), microwave energy may be used to blanch vegetable tissues as an alternative to conventional steam and water blanching.

The polysaccharides composition influences the structure of the cell wall and, consequently, the texture of vegetables and fruits (Ng, Harvey, Parker, Smith, & Waldron, 1998; Ratnayake, Melton, & Hurst, 2003). Kidmose and Martens (1999) studied carrot slices during blanching and observed that the thermal processing produced many changes in the cell wall structure and, consequently, the tissue suffered softening. These changes produced the cell membrane disruption and changes in cell wall polymers. On the other side, the cell wall is the source of dietary fiber, acquiring as such a nutritional importance (Dongowski & Ehwald, 1999; Ou, Kwok, Li, & Fu, 2001) and changes of polysaccharides during processing can affect fiber functionality.

According to Kratchanova, Pavlova, and Panchev (2004), microwave pretreatment leads to destructive changes in the plant tissue. These changes modify the capillary-porous characteristic and water sorption capacity of the plant material. The intermolecular friction produced by microwave heating may cause internal cell pressure leading to rupture resulting in a loss of cell contents

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List of acronyms

AIR	alcohol-insoluble residue
Ara	arabinose
CDTA	trans-1,2-cyclohexanediaminetetraacetic acid
DA	degree of acetylation
db	dry basis
dm	dry matter
DM	degree of methylation
DRW	dried residue weight
FT-IR	Fourier transform infrared spectroscopy
HG	homogalacturonan
HRGPs	pectin-extensin complexes
HRW	hydrated residue weight
IR	Infrared
NS	neutral sugars
POX	peroxidase
PPO	polyphenoloxidase
RG-I	rhamnogalacturonan I
Rha	rhamnose
ROS	reactive oxygen species
SW	swelling capacity
WHC	water holding capacity
WRC	water retention capacity
90C	traditional treatment in water at 90 °C
350W	treatment with constant microwave powers of 350 W
90MW	treatment with microwave powers higher than 900 W

and organization. The knowledge of the structure and chemical composition may help to highlight the modifications that occur during processing (Femenia, Sanchez, Simal, & Rossello, 1998). For that reason it is necessary to perform specific studies for different tissues, trying to state a systematic background of information that allows to find the optimum conditions (i.e.: time, power level) that permit to attain the goal of the process with minor nutritional and organoleptical damage.

Red beet (*Beta vulgaris* L. var. conditiva) is a traditional and popular vegetable in many parts of the world. It is especially rich in fibers as well as in sugars but with moderate caloric value. It has an important content of B-vitamins (B1, B2, B3 and B6) as well as folic acid. Red beet roots are consumed either fresh or after thermal processing or fermentation. The soluble and cell wall associated phenolics as well as betalains, the main pigments in red beet responsible for its reddish-purple hue, are bioactive compounds (Schwartz & von Elbe, 1980), being their antioxidant capacity beneficial for human health (Kanner, Harel, & Granit, 2001). Latorre, Bonelli, Rojas, and Gerschenson (2012) evaluated the effect of microwave (constant powers of 250, 350, 450 W or powers higher than 900 W) and water traditional blanching at 90 °C on peroxidase (POX) and polyphenoloxidase (PPO) inactivation, texture and color changes as well as time efficiency. The inactivation of POX and PPO was strongly influenced by temperature observing, in general, that higher temperatures resulted in more rapid inactivation by microwave treatment. The shortest time for enzyme inactivation was shown by a microwave treatment performed most of the time at powers higher than 900 W (called '90MW') and with a similar temperature profile to traditional blanching (treatment at 90 °C, called '90C'). Concerning textural characteristics, all treatments reduced the elastic characteristics of the tissue being this specially marked for 90MW treatment while treatment 90C produced the smaller changes. Latorre (2012) informed that the specific energy consumption was lower for microwave treatments, being 350W, 450W and 90MW those with the lower values.

The object of the present research was to evaluate the chemical and microstructural characteristics of red beet tissues submitted to blanching with water at 90 °C or with microwaves at powers higher than 900 W and at constant power of 350 W, with the goal of attaining a better understanding of the changes produced by treatment and its consequences on the functional properties of cell wall polymers.

2. Materials and methods

2.1. Chemicals

They were of analytical grade unless stated. In general, chemicals were provided by MERCK Argentina (Buenos Aires, Argentina). Ethanol was provided by SAPORITI S.A.C.I.F.I.A. (Buenos Aires, Argentina); gallic acid by Anedra S.A. (Buenos Aires, Argentina); D-galacturonic acid, glutaraldehyde, OsO_4 and Durcupan resin by SIGMA-Aldrich (St Louis, MO).

2.2. Sample preparation

Red beet (*B. vulgaris* L. var. conditiva) roots harvested in Argentina were obtained at the local market. They were carefully cleaned, peeled and cut into 10 mm-thick slices perpendicular to their longitudinal axis. Cylindrical samples of 15 mm diameter were then obtained from each slice by using a cork borer. This sample geometry was chosen by considering its adequacy for mechanical assays.

2.3. Microwave blanching

Batch microwave processing was carried out in a microwave system ETHOS Plus (Milestone SRL, Sorisole, Italy) with a magnetron of 2450 MHz. The microwave used the ATC-400 system for continuous monitoring and control of the internal temperature. The optical sensor used was fitted in a Teflon coated ceramic thermowell. The samples were distributed in six glass vessels and placed on a polypropylene container (cylindrical shape; 27.9 cm diameter and 19.7 cm height.) according to Latorre et al. (2012). A 360° alternate movement was programmed to avoid bending of the sensor connection during experiments while assuring a more homogeneous treatment of the samples. The container was covered with a lid that served as supporter of the ceramic coated optical fiber. For each batch, the thermal sensor was placed in the center of one of the tissue cylindrical samples placed into one of the vessels, and the temperature profiles were recorded during microwave processing.

Red beet root tissue cylinders (36 g) were immersed in a 300 ml-total volume of deionized water distributed among the mentioned vessels for performing the experience. After each treatment, samples were immersed rapidly in an ice/water bath (during 5 min) to stop the blanching effect. Non-treated cylinders (raw material) were used as control samples.

The following microwave treatments were performed:

a) Constant output powers of 350 W (350W).
b) The equipment was programmed so as to obtain, in the center of the tissue cylinders, a similar temperature profile to the one observed in water blanching at 90 °C-constant temperature (90MW).

In both cases, temperature profiles of sample cylinders and water bath, and the output power evolution were recorded during