Influence of cultivar and prewarming on texture retention of thermally processed potatoes

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Summary

Potato cubes (2.5 cm) of six cultivars were soaked in CaCl2 solution (0.004 % calcium) at 4 °C for 21 h, prewarmed at 75 °C for 30 min, and boiled (20 min) or microwaved (2 min, 15 sec). Prewarming treatment significantly retained fracturability (g force at first break point) of boiled samples over non-treated controls. Thirty min prewarming at 75 °C gave maximum fracturability retention for boiled samples; prewarming time had no effect on texture of microwaved samples. Cultivar differences in fracturability correlated with inherent tuber calcium content.

Introduction

Thermal processing, including microwave sterilization or pasteurization, often excessively softens the texture of vegetables, but holding fruits or vegetables at 50 – 80 °C for 10 – 90 minutes before heat processing improves firmness. Reeve (1954a, b) reported tougher texture in prewarmed potato slices and Potter et al. (1959) prevented potato sloughing by prewarming. They concluded that changes in the physical properties of potato starch, particularly retrogradation of gelatinized starch, were responsible for the firming effect. Increased firmness due to prewarming was also found in other fruits and vegetables including carrots (Chinnery, 1983), cauliflower (Hoogzand & Doesburg, 1961), cherries (Van Buren, 1974), Japanese chestnuts (Besshyo et al., 1973), cucumbers (Shiau & Chang, 1986), green beans (Steinbuch, 1976), radishes (Manabe, 1982), snap beans (Van Buren et al., 1960) and tomatoes (Hsu et al., 1965). Bartolome & Hoff (1972) proposed that the enzyme pectic methylesterase (PME) in or at the middle lamella of the tissue was activated by prewarming and by diffusion of cations from cells. PME demethoxylates pectic substances, increasing the number of free carboxyl groups which favors formation of calcium linkages, and increases the resistance to β-eliminative degradation. Moledina et al. (1981) emphasized the importance of calcium in the system over PME activity and demonstrated in model systems that calcium released from gelatinizing starch retarded pectic solubilization during heating.

No reports were found of the influence of microwave heating on prewarmed plant tissues and only a few on variation of the prewarming effect among vegetable cultivars.

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The objectives of this study were to determine: 1) the effects of cultivar, storage time and thermal processing on the firming of prewarmed potato tissues using six cultivars and boiling or microwaving, and 2) the influence of potato composition on prewarming responses among cultivars.

**Materials and methods**

*Potato samples.* Cultivars Cascade, Chieftain, Cobbler, Kennebec, Red Norland and Red Pontiac potatoes (*Solanum tuberosum* L.) were planted by one grower in Hollandale, Minnesota, and harvested in August and September 1987. The first samples of cvs Red Norland and Red Pontiac were sent to the University of Minnesota in early September and second samples from the same harvest and also samples of cvs Cascade, Chieftain, Cobbler, and Kennebec were sent in November 1987. After harvest the tubers were stored in warehouses under ventilated ambient conditions at Hollandale.

At the University, the tubers were held at 4 °C and 95 - 100 % relative humidity until used. Tubers 150 - 400 g were washed with tap water and the specific gravity of each tuber was calculated using the equation (Fong & Redshaw, 1973):

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\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight in air} - \text{Weight in water}}
\]

Tubers with bruises or a specific gravity greater than one standard deviation from the mean for each lot of the different cultivars were rejected.

*Pre-treatment procedures.* Tubers were hand-peeled and cut into 2.5 cm cubes, excluding at least 2 cm of the bud and stem ends and the pith area because these parts differ in texture from the main parenchymatous tissue (Bohler et al., 1987). The cubes were placed in distilled water and randomized. Potato cubes to be prewarmed were soaked at 4 °C for 21 h in a solution of calcium chloride 0.004 % (w/w) as calcium, a level approximating the concentration of calcium normally occurring in potato tissue (Johnston et al., 1968; True et al., 1978). The ratio of potato to soaking liquid was 1:5 w/w. Control cubes were soaked for 21 h in distilled water at 4 °C and subsequently heat treated without prewarming. After soaking, cubes for prewarming were packaged with the calcium solution, (1:3 ratio, w/w) in plastic pouches and immersed for 30 min in a hot water bath with an agitator and a temperature controller set at 75 °C, unless otherwise noted.

*Heating procedures.* In each experimental condition, seven soaked potato cubes (approximately 120 g) and 180 g of distilled water were used for both the prewarming and the non-prewarming samples. Water was added to equalize the heating rate among cubes and prevent moisture evaporation from them. For boiling, the potato cubes and the distilled water were packaged in a plastic pouch, heated in boiling water for 20 min and cooled to an internal temperature of 15 °C with tap water at 15 °C. The time needed to achieve an equilibrated internal temperature of 15 °C had been determined in preliminary experiments using a thermometer inserted into the cubes. For microwave heating, the cubes and distilled water were similarly packaged but leaving a 2 cm-wide opening at the sealing line allowing the generated steam to escape. A piece of polyvinyl tubing, 29 mm diameter by 20 mm, was placed at the center of the potato cube ar-