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Calcium lactate washing treatments for salad-cut Iceberg lettuce: Effect of temperature and concentration on quality retention parameters

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Abstract

Salad-cut lettuce was washed in calcium lactate solution at different concentrations (0.5%, 1.5% and 3%) and temperatures (4, 25 and 50 °C) for a period of 1 min. The treated salad-cut lettuce was packaged and stored at 4 °C for 10 days. Markers of quality retention: colour, texture, browning, texture related enzymes and sensory properties, were analysed during storage. The use of high temperatures (50 °C) showed a positive effect on enzymes related to quality maintenance. It reduced the activity of the browning-related enzymes polyphenol oxidase and peroxidase but it increased the activity of pectin methyl esterase, an enzyme involved in the maintenance of texture. High calcium lactate concentrations (3%) produced a reduction in the respiration rate of the salad-cut lettuce during storage, but also a loss of luminosity and greenness (a^*). The use of high temperatures and intermediate calcium lactate concentrations (1.5%) proved to be the best washing treatment to maintain the quality of salad-cut lettuce over 10 days storage. These conditions (50 °C and 1.5% calcium lactate) gave higher freshness scores and lower browning scores than conventional chlorine treatment when evaluated by a sensory panel.
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Keywords: Salad-cut Iceberg lettuce; Enzymatic browning; Calcium lactate; Temperature; Quality markers

1. Introduction

The minimally processed fruit and vegetable market has grown rapidly in recent years due to the health benefits associated with these foods. Its growth has heightened awareness about the microbiological and physiological parameters associated with quality in fresh ready-to-use vegetables (Lund, 1989). The negative effects of postharvest stress in terms of quality loss is well known (Wiley, 1994), but the beneficial effects of such treatments are not always appreciated. The use of postharvest abiotic stresses to enhance the nutritional content of fresh fruits and vegetables has been described (Cisneros-Zevallos & Krochta, 2003; Estrada, Pomar, Diaz, Merino, & Bernal, 1999; Kalt, Howell, Duy, Forney, & McDonald, 2001; Lee & Kader, 2000). Such abiotic stresses affect either photochemical accumulation or loss by inducing changes in key enzyme activities of secondary metabolic pathways (Dixon & Paiva, 1995). For example, different studies have shown that wounding increases the phenolic content and antioxidant capacity in carrot tissue (Heredia & Cisneros-Zevallos, 2002) and similar responses were reported for lettuce tissue (Kang & Saltveit, 2003).

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The extension of quality retention for fresh-cut products is relevant for industry due to its economic impact. It is important that the washing treatments applied to fresh vegetables and fruit help maintain their quality (colour, absence of excessive exudate in the package, crisp texture, etc.) since consumers demand a fresh product as well as convenience and long shelf life (Ohlsson, 1994).

Future regulatory restrictions on the use of chlorine for washing of ''ready-to-eat'' vegetables are likely and will require the development of functional alternatives (Ahvenainen, 1996; Cherry, 1999; Fan, Toivonen, Rajkowski, & Sokorait, 2003; Gould, 1995; Graham, 1997; Seymour, 1999; Wiley, 1994). In several European countries including Germany, Netherlands, Switzerland and Belgium the use of chlorine in ready-to-use products is already prohibited (Carlin & Nguyen-the, 1999).

Calcium maintains the cell wall structure of vegetables by interacting with pectin to form calcium pectate. Calcium is reported to maintain firmness by crosslinking with cell wall and middle lamella pectins (Grant, Morris, Rees, Smith, & Thom, 1973). Thus, fruit and vegetables treated with calcium are generally firmer than controls during storage (Camire, Ismail, Work, Bushway, & Halteman, 1994; Lester & Grusak, 1999; Luna-Guzman, Cantwell, & Barrett, 1999; Suutarinen, Anakainen, & Autio, 1999). Calcium lactate (0.5–2%) has been used as a firming agent for fruits such as cantaloupes, strawberry and others (Main, Morris, & Wehunt, 1986; Morris, Sistrunk, Sims, Main, & Wehunt, 1985). It has been reported to be a good alternative to calcium chloride because it avoids the bitterness or off-flavours associated with this salt (Luna-Guzman & Barrett, 2000). The antibacterial properties of calcium lactate washing solutions have been described for treatment of honeydew melon and minimally processed vegetables (Martin-Diana, Barry-Ryan, Frias, Mulcahy, & Henehan, 2004; Saftner, Baj, Abbott, & Lee, 2003).

Heat shock treatments, alone or combined with other agents, have also been used to prevent browning reactions in various vegetables and fruits (Hisaminato, Murata, & Homma, 2001; Loaiza-Velarde, Tomas-Barberan, & Saltveit, 1997). For example, heat treatment results in tissue firming in potatoes (Bartolome & Hoff, 1972) and tomatoes (Floros, Ekanayake, Abide, & Nelson, 1992). Firming effects obtained from heat treatments alone or combined with calcium treatments have been attributed to the action of heat-activated pectin methylesterase (PME) and/or to increased calcium diffusion into tissues at higher temperatures (Bartolome & Hoff, 1972; Garcia, Herrera, & Morilla, 1996).

To the best of our knowledge no studies have been carried out using calcium lactate washing treatment of lettuce. The objective of this research was to evaluate the effect of calcium lactate washing treatments at different concentrations (0.5%, 1.5% and 3%) and different temperatures (4, 25 and 50 °C) on selected quality parameters for Iceberg lettuce.

2. Materials and methods

2.1. Sample preparation

Iceberg lettuce (*Lactuca sativa* sp.) grown in Ireland was purchased from a local supermarket (Dunnes Stores, Ireland) and stored at 4 °C until use. The lettuce was treated according to minimal processing procedures: the two outer leaves were discarded and the core of the heads of lettuce was removed with a stainless steel knife. The lettuce was cut in half and each half was cut into four equal parts.

In the calcium lactate test series, a full factorial screening design containing nine tests was used (Table 1). The salad-cut lettuce was dipped in water solutions of different calcium lactate (Sigma–Aldrich, St. Louise, USA) concentrations (0.5%, 1.5% and 3%) and different temperatures (4, 25 and 50 °C) for 1 min with constant agitation. Then, water was removed using a spin dryer for 5 min. Immediately after the treatment the processed salad-cut lettuce were packaged in bags (200 × 320 mm) made from 35 μm-thick-oriented polypropylene (OPP) (Amcor Flexibles, Gloucester, UK). Each package contained ~100 g of salad-cut lettuce. The top half of the lettuce was selected for texture analysis since, in previous studies in this laboratory, this part of the lettuce was found to have lower texture variability. The processed product was stored at 4 °C in a cooling cabinet for 10 days.

2.2. Quality markers

2.2.1. Headspace gases

A Gaspace analyser (Systech Instruments, UK) was used to monitor levels of CO_2 and O_2 in the package during storage. Headspace gas samples were obtained using a hypodermic needle inserted through an adhesive septum fixed to the bags. The gas content was expressed in percentage (%).

Table 1
Experimental design of washing treatment in salad-cut lettuce

Experiment label (combinations)	Temperature of washing solution (°C)	Calcium lactate concentration (%)	Washing time (min)
1	4	0.5	1
2	4	1.5	1
3	4	3	1
4	25	0.5	1
5	25	1.5	1
6	25	3	1
7	50	0.5	1
8	50	1.5	1
9	50	3	1

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