

Use of neutral electrolysed water (EW) for quality maintenance and shelf-life extension of minimally processed lettuce

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Abstract

Experiments were conducted to determine the effectiveness of different treatments based on the use of neutral electrolysed water (EW) on fresh-cut lettuce. EW was diluted to obtain different free chlorine concentrations (120, 60 and 12 ppm) and to compare with standard washing treatment of 120 ppm chlorine solution. Shelf-life quality and safety markers were studied at the beginning and at the end of the 7-day-storage at 4 °C. The use of EW decreased the respiration rate of the samples which might be related with the observed reduction in microbial spoilage. The use of EW also increased the activity of a browning-related enzyme (polyphenoloxylase) although sensory results showed all samples as acceptable at the end of the 7 day-storage. Perhaps longer storage time might increase the risk to browning development in the samples treated with EW. The highest EW concentration (120 ppm free chlorine) was the most effective treatment in reducing sample microbial load; however this treatment also affected the final produce with effects such as loss of turgor, plasmolysis and a reduction in mineral content.

Results suggest an intermediate EW concentration with 60 ppm free chlorine could be an alternative to 120 ppm chlorine (from sodium hypochlorite) for sanitizing fresh-cut vegetables, reducing to half the amount of chlorine used and maintaining the antimicrobial effectiveness and without differences affecting the quality. However further studies will be necessary in order to observe the effect of the oxidising capacity of EW on other quality and safety markers as pathogens and nutritional content.

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Industrial relevance: Chlorine solutions have been widely used to sanitise fruit and vegetables in the fresh-cut industry. However, the association of chlorine with the possible formation of carcinogenic chlorinated compounds in water has called into question the use of chlorine in food processing. The efficacy in controlling the microbial load and browning of samples treated with electrolysed water shows it as a promising decontaminant agent for fresh-cut lettuce. Due to the high oxidising potential of the EW quality requirements must be balanced to obtain the optimal treatment conditions keeping satisfying safety levels. The use of EW-60 showed similar safety and quality (browning) results as the use of chlorine or double EW concentration (EW-120). However the treatment EW-120 affected negatively the textural properties. The study suggests the use of EW-60 as an alternative to sodium hypochlorite solution with 120 ppm available chlorine, obtaining similar safety and quality results and reducing the amount of chlorine needed. Further investigations in the effect of EW on lettuce, such as those on pathogens or nutritional markers (e.g. carotenoids and vitamin C) are recommended in order to explore this alternative that might reduce the increasingly concerning use of chlorine to decontaminate this type of product.

1. Introduction

The fresh-cut fruit and vegetable market has undergone a rapid growth within the food industry. Much of the growth has come from the healthy alternative in restaurants, but also the change of new trends in life-style, increased awareness of the importance of diet for health (Willey, 1994; Parish et al., 2003). There has been

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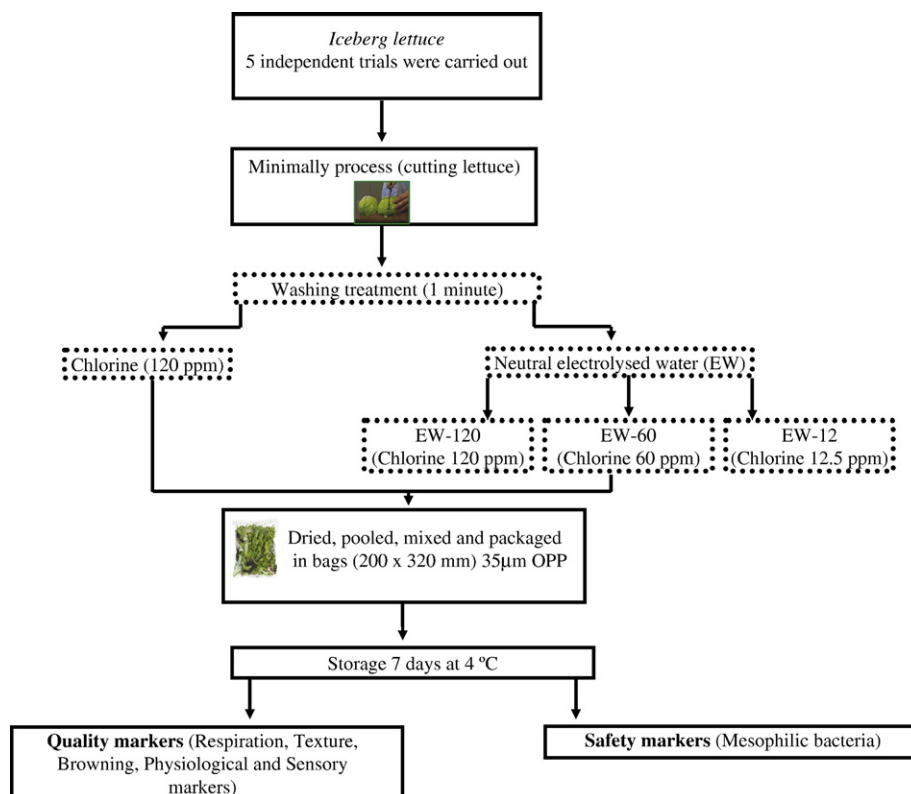


Fig. 1. Flow diagram showing the procedure for the production of minimally processed fresh-cut lettuce treated with 120 mg/L chlorine (I), EW-120 (II), EW-60 (III) and EW-12 (IV) and stored for 7 days at 4 °C.

growth in public knowledge about how diet and health are linked and the importance of maintaining physical fitness throughout life. These claims can be seen to have benefited both fresh and processed fruits and vegetables in that the balance between the fresh and processed products is virtually unchanged from the balance that existed 20 years ago. Although it is a new market it represents 20% of the total of vegetable sales in supermarkets (Piagetini, Mendez, Guemes, & Pirovani, 2005).

However, the marketing of fresh-cut vegetables is limited by their short and their decline in post-processing quality. This is due to undesirable biochemical reactions associated with wounding when compared to non-treated vegetables (Watada, 1997; Brecht, 1995).

Food spoilage can be defined in several ways; generally a fresh-cut product is considered spoiled when it is no longer acceptable to the consumer (Singh & Anderson, 2004). The worst case of spoilage is considered when it affects safety, however changes in quality (browning, off-odours, and loss of textures) can be considered spoilage since it deteriorated to the point that it is no longer acceptable.

Chlorine has been the biocide of choice for the fruit and vegetable industry for many decades. When used correctly, it is regarded as both inexpensive and effective. Many regulations and guidelines applied to the food industry stipulate minimum free chlorine concentrations in water streams. Chlorine and chlorine derivatives, in particular, have become a focus for environmental concern, and some environmental groups suggest a phase-out of chlorine use globally. The United States

Environmental Protection Agency (US EPA) has initiated studies and rulemakings which support that direction (Garfield, 1995).

Since disinfection and decontamination is an important and inevitable step in ensuring safety and extend the shelf-life of ready to eat vegetables a generation of a new trend in order to find new alternatives to chlorine derivatives. Among these alternatives can be included organic acids, essential oil treatments, irradiation, heat-shock or ozone. A compromise must be reached between palatability (quality), safety and nutrition in the final product when using fresh-cut products due to the high liability; however studies have shown that new alternatives cannot guarantee a safety of the minimal processed vegetable (Beuchat, 1998; Beuchat & Ryu, 1997; Seymour, 1999).

The electrolysed water (EW) is a relatively new concept which is based on a new, previously unknown law of anomalous changes of reactional and catalytic abilities of aqueous solutions subjected to electrochemical unipolar (either anoxic or cathodic) treatment. EW of solutions is necessarily associated with alteration of their chemical composition, acidity and (or) alkalinity within a wide range. That is why EW application makes it possible to exclude reagent methods of solution properties' regulation from routine technological processes, to improve production's quality, to reduce the number and duration of technological operations, to decrease their labour-consuming nature, to facilitate and simplify processes of sewage purification.

Unlike well-known electrochemical procedures, in the processes of electrochemical activation initial substances are

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