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THE EFFECT OF PRELIMINARY PROCESSING OF SHREDDED CELERIAC (*APIUM GRAVEOLENS*) USING A SODIUM HYPOCHLORITE SOLUTION ON THE QUALITY OF THIS MINIMALLY PROCESSED PRODUCT

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ABSTRACT

The study investigated the effect of soaking shredded celeriac in sodium hypochlorite solutions with the Cl^- concentration of 100, 200, 300, 500 ppm on the quality of this stored minimally processed product. Microbiological quality of the product (total counts of mesophilic and psychrophilic bacteria; counts of moulds and yeasts; coliform bacteria counts; counts of *Pseudomonas* bacteria and the presence of anaerobic bacteria (*Clostridium perfringens*)) was assessed along with the colour in the CIE L* a* b* system and sensory attributes of the product. The product was evaluated after 1, 6 and 12 days of storage at temperature of 4°C. In the samples soaked in a solution containing 500 ppm Cl^- mesophilic counts were approx. 2 logs CFU/g and coliform bacteria 2.3 logs CFU/g less those on the sample soaked in distilled water (control), after 12 days of product storage. However, in the samples soaked in sodium hypochlorite solutions with a higher Cl^- concentration (300,400 and 500 ppm) was observed deterioration in sensory attributes.

Key words: minimal processing; celeriac; hypochlorite sodium.

INTRODUCTION

In recent years the demand has been increasing for food which combines properties of a high quality product with the advantages of convenience food. Examples of such products are minimally processed vegetables and fruits. They are obtained as a result of cleaning the raw material, removal of its inedible parts and then its cutting, shredding. Such a product is most frequently packaged on trays wrapped in foil or in plastic bags.
The process of minimal processing of celeriac (peeling, shredding) causes changes in tissue physiology, which may lead to a deterioration of product sensory attributes. Shredded raw material constitutes moreover an excellent

medium for the development of microorganisms. An uncontrolled increase in the population size of certain microorganisms may lead to a deteriorated sensory quality of the minimally processed product, and thus to a shortening of its shelf life. This group of microorganisms includes e.g. bacteria from genera *Pseudomonas*, *Xanthomonas* and *Erwinia*, as well as certain types of yeasts and moulds [4, 10]. Moreover, pathogenic microorganisms causing a health hazard may also proliferate in the minimally processed product.

An important stage in the minimal processing technology is preliminary processing of the raw material, during which dirt is removed and the level of microbiological contamination is reduced. Frequently washing fruits and vegetables is repeated several times, also after raw material shredded. Apart from water, disinfecting solutions, reducing the level of microbiological contamination, are also used in the washing process. One of the more frequently used disinfecting preparations applied in food industry is a solution of sodium hypochlorite, which dissociates in water to hypochlorous acid. This compound exhibits biocidal activity against bacteria, yeasts, fungi and viruses; moreover, it destroys bacterial spores. Hypochlorous acid easily penetrates microorganism cells and as an unstable compound it is decomposed, releasing ionized oxygen, which denatures cellular protein structures and deactivates enzymes, especially those containing the –SH group. In the undissiociated form hypochlorous acid is found in the environment of pH below 7. The activity of hypochlorite is weakened by the reaction of chlorine with protein and its derivatives [12].

Thus, the effectiveness of the biogenic action of chlorine compounds is dependent to a large extent on pH and organic compound contents, as well as the type of microflora and properties of the raw material [1, 2, 9, 13]. Garg et al. [7] found a reduction by 3 log cycles in the total aerobic bacteria counts on lettuce leaves washed in water containing 300 ppm chlorine. In case of carrot and red cabbage the chlorine solution applied by those researchers did not contribute to a significant limitation of microbiological contamination.

The aim of this study was to determine the effect of processing celeriac flakes using a sodium hypochlorite solution with various Cl^- concentrations on the level of the microbiological contamination in stored minimally processed product. Moreover, the colour and sensory attributes of minimally processed celeriac were also analyzed.

MATERIAL AND METHODS

Experimental material consisted of celeriac (*Apium graveolens L. var. rapaceum*) cv. *Mentor*. Celeriac roots were washed, hand-peeled, washed again and shredded into flakes in a food processor (Zelmer), and next soaked in a sodium hypochlorite solution (Fluka) with the Cl^- concentration of 100, 200, 300, 500 ppm (300 g flakes/900 ml solution). The solution was prepared in distilled water, with citric acid added to obtain pH of 6.0. Flakes were soaked for 30 s. The control was obtained by replacing the NaOCl solution with distilled water.

Shredded celeriac after preliminary processing were strained from the solution and packaged 50 g each in 15 x 21 cm bags made from polyamide/polyethylene oriented laminate with layer thickness of 50/40 µm and gas permeability (in $cm^3/m^2/24h$ at the temperature of 23°C): carbon dioxide – 200, oxygen – 45 and water vapour: 2-3 $g \cdot m^{-2}/24h$. Bags were sealed with a vacuum closing machine type A-300 by Multivac. Analyzed samples were packaged in air atmosphere. The product was stored at the temperature of 4°C. The product was assessed after 1, 6 and 12 days of storage on the basis of:

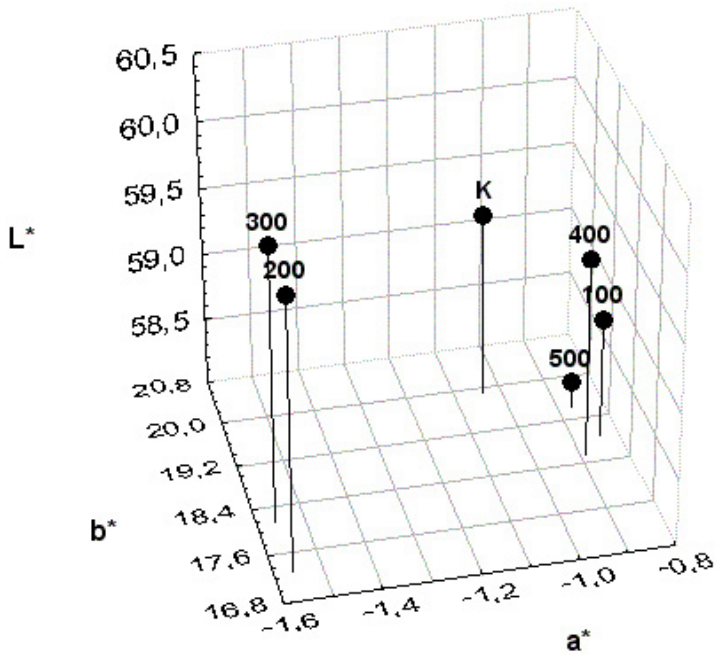
- measurements of colour parameters on homogenized flakes, in the CIE L* a* b* system, using a Hitachi U-3000 spectrophotometer,
- sensory attributes evaluated in a 5-point hedonic scale [3],
- analysis of microbiological quality conducted on samples soaked in a NaOCl solution with the Cl^- content of 100 and 500 ppm. It also included the assays of the total counts of mesophilic and psychrophilic bacteria, counts of moulds and yeasts (using the Koch plate method) [6], counts of coliform bacteria and *Pseudomonas* bacteria (the filtration method) [8], as well as the presence of anaerobic bacteria from the genus *Clostridium perfringens* (the Koch plate method). Morphology of microorganisms was examined on microscopic slides: *intra vitam* for moulds; fixed and Gram-stained for bacteria [6].

Statistical analysis was performed using computer software Statistica version 6.0 applying the analysis of variance and the LSD Fisher test.

RESULTS AND DISCUSSION

Among the investigated samples the highest values of brightness L* and the lowest values of colour parameter a* were found for shredded celeriac flakes soaked in a Cl^- solution of 200 or 300 ppm (Fig. 1). In the samples subjected to processing with a NaOCl solution, irrespective of the applied Cl^- concentration, lower values of colour parameter b* were observed in comparison to the control (soaked in distilled water) (Fig. 1). In case of sensory examination of colour after a 12-day storage the highest scores (4.0) were given to flakes soaked in a solution with the Cl^- concentration of 200 or 300 ppm (Table 1). They were defined as cream-yellow.

Fig. 1. Colour parameters of celeriac flakes soaked in distilled water (K) or in sodium hypochlorite solutions with Cl^- concentration of 100, 200, 300, 500 ppm after 12 of storage days



The application of a higher Cl^- concentration in the solution (400, 500 ppm) resulted in a deterioration of scores given in the sensory examination of colour in the analyzed samples already after 1-day storage (Table 1).

During storage, both in the control sample and in the shredded celeriac soaked in solutions with Cl^- concentrations of 100, 400 and 500 ppm, a significant ($p = 0.05$) decrease was found in scores of sensory examination of colour. These samples (after 12-day storage) were defined as cream-coloured with brown spots (score of 3.0 (Table 1)).

Table 1. A summary of sensory examination scores of celeriac flakes soaked in a NaOCl solution or in distilled water packaged in air atmosphere

Cl^- concentration [ppm]	Storage time [days]	Sensoric attributes			
		color	aroma	taste	texture
K	1 12	4.5 3.0 b	3.8 3.0 b	4.5 3.2 b	5.0 4.0 b
100	1 12	4.5 3.0 b	3.3 3.0	4.6 3.5 b	4.9 4.0 b
200	1 12	4.5 4.0 a	3.3 3.0	4.6 3.0 b	4.7 4.2 b
300	1 12	4.5 4.0 a	2.8 a 2.4 ab	3.8 a 3.2 b	4.6 a 4.0 b
400	1 12	3.6 a 3.0 b	2.8 a 1.6 ab	3.5 a 1.0 ab	4.6 a 4.0 b
500	1 12	3.6 a 3.0 b	2.7 a 2.0 ab	3.4 a 1.0 ab	4.6 a 4.0 b

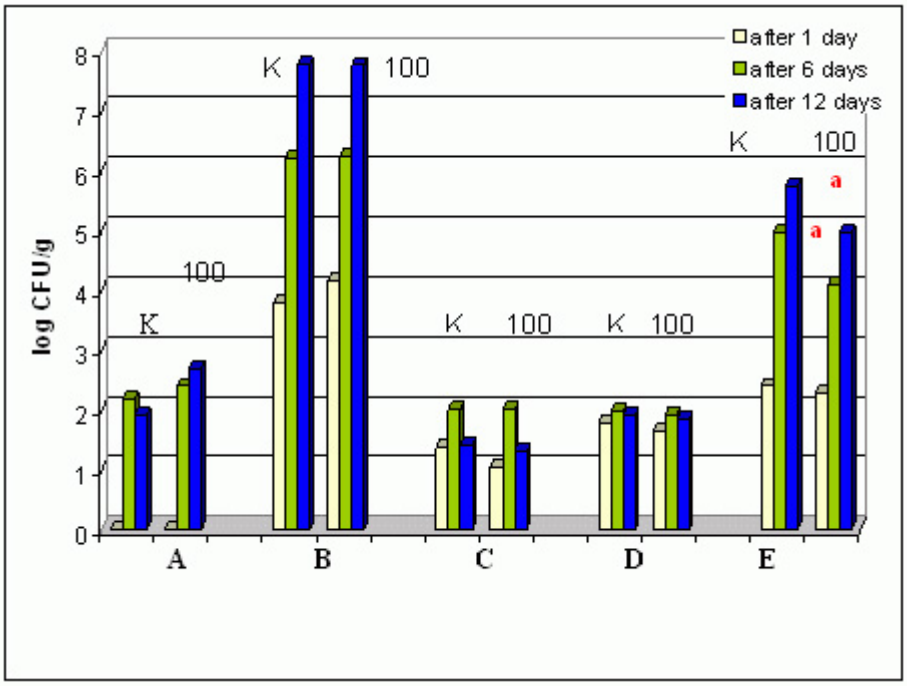
Captions under table:
a – statistically significant differences ($p = 0.05$) between scores of samples soaked in sodium hypochlorite solutions and scores of control after the same time storage (in the same column)
b – statistically significant differences ($p = 0.05$) within the sample between score (for respective attributes) of sensory examination after 12 days of storage and score after 1 day of storage

The taste and aroma of flakes soaked in a solution containing 100 or 200 ppm Cl^- and of the control sample after 12-day storage were evaluated as medium intrinsic and received scores of 3.0 or 3.0 – 3.5, respectively (Table 1). Increasing the solution Cl^- concentration resulted in a deterioration of the aroma, taste and texture (Table 1) of minimally processed celeriac in comparison to the sample soaked in distilled water (control) as early as after 1 day of storage.

On the basis of the obtained results it was found that soaking celeriac flakes in a solution with the concentration of 300, 400 and 500 ppm Cl^- resulted in a deterioration of sensory attributes of the analyzed samples. At a lower Cl^- concentration the sensory quality of the shredded celeriac was similar to that of the control samples.

In samples soaked in a NaOCl solution containing 100 ppm Cl^- a decrease was observed in the counts of *Pseudomonas* bacteria by approx. 1 log CFU/g product in comparison to the control after 6 and 12 days of storage. The other microbiological quality attributes were similar to the level in flakes soaked in distilled water (Fig. 2). In both samples, i.e. control and soaked in chlorinated water, the presence of anaerobic bacteria from genus *Clostridium perfringens* was detected in 1g of the product.

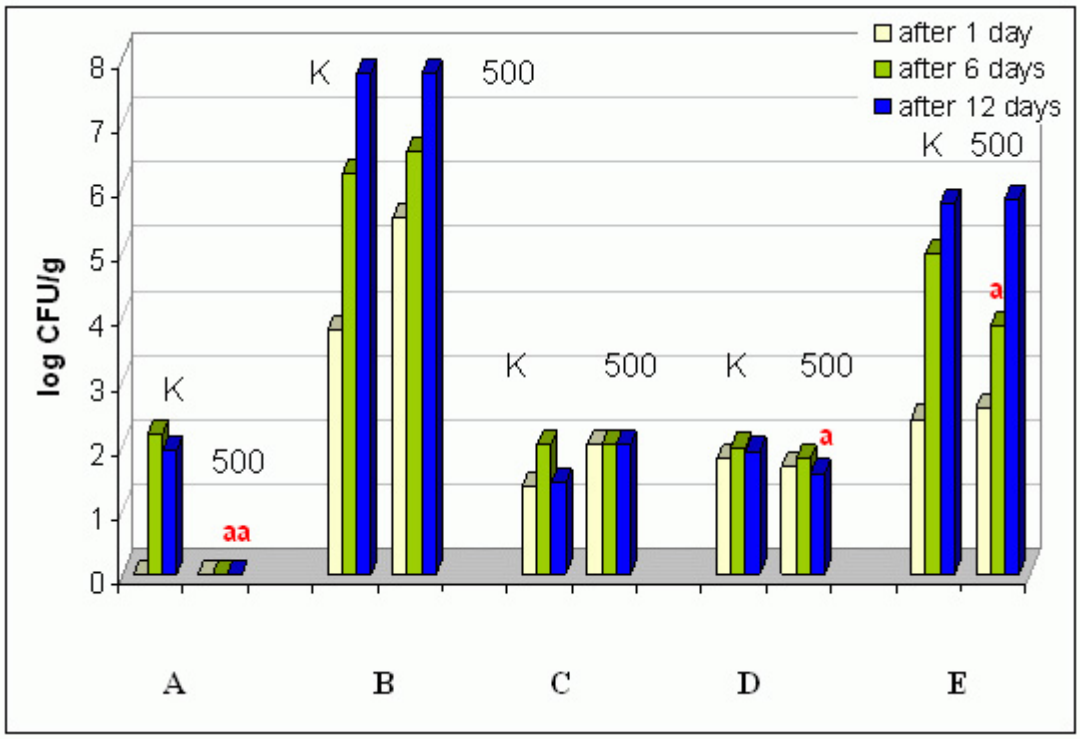
Fig. 2. Microbiological quality of celeriac flakes soaked in distilled water (K) or in NaOCl solution with Cl^- concentration of 100 (100) ppm



Captions under figure 2:
A – total mesophilic counts, B – total psychrophilic counts, C – moulds and yeasts counts, D – coliform bacteria counts, E – *Pseudomonas* bacteria counts,
a – statistically significant differences (p = 0.05) between microorganism counts in the sample soaked in sodium hypochlorite solution and in the sample soaked in distilled water (K), after the same time of storage

In samples soaked in a disinfecting solution with the Cl^- concentration increased to 500 ppm, a drop in the counts of mesophilic bacteria was found, which were not detected in 0.1g product on any day of the study. Moreover, significantly (p = 0.05) smaller counts of *Pseudomonas* bacteria (after 6-day storage) and coliform bacteria counts (after 12-day storage) were found in comparison to the control (Fig. 3). In flakes soaked in a solution containing 500 ppm Cl^- no presence of anaerobic bacteria from genus *Clostridium perfringens* was found in 1 g product.

Fig. 3. Microbiological quality of celeriac flakes soaked in distilled water (K) or in NaOCl solution with Cl^- concentration of 500 (500) ppm



Captions under figure 3:
A – total mesophilic counts, B – total psychrophilic counts, C – moulds and yeasts counts,
D – coliform bacteria counts, E – *Pseudomonas* bacteria counts, a – statistically significant differences (p = 0.05) between microorganism counts in the sample soaked in sodium hypochlorite solution and in the sample soaked in distilled water (K), after the same time of storage

The morphological analysis of mesophilic and psychrophilic bacteria in the investigated samples showed the presence of Gram-negative bacteria. Microscopic specimens from live colonies of moulds and yeasts made it possible to determine the moulds as belonging to genera *Aspergillus, Rhizopus* and *Penicillium.*
On the basis of results obtained in this study a decrease was found in the total count of mesophilic bacteria in the samples treated with a solution containing 500 ppm Cl^-. It results from literature data that Zhang and Farber [14] found a reduction in the count of mesophilic bacteria by 6% in comminuted lettuce already at the Cl^- content in water of 100 ppm.

Investigations conducted in this study showed that soaking shredded celeriac in a NaOCl solution resulted during their storage in a decrease in coliform bacteria counts (500 ppm Cl^-) and *Pseudomonas* bacteria (100 and 500 ppm Cl^-). Antimicrobial action of chlorinated water (50 ppm Cl^-) on *Pseudomonas fluorescens* microbes was also found by Sapers and Simmons [11] on fresh zucchini slices (reduction by 1.5 log CFU/g). The effect of chlorinated water on the level of contamination with coli bacteria was described e.g. by Beuchat et al. [5], who showed a reduction in *E. coli* 0157:H7 counts on whole and cut lettuce soaked in water containing 200 ppm Cl^- by approx. 1 log CFU/g in comparison to samples soaked in water.

CONCLUSIONS

On the basis of the obtained results it was found that soaking shredded celeriac in solutions with concentrations of 300, 400 and 500 ppm Cl^- caused a deterioration of sensory attributes of the tested samples. At a lower Cl^- concentration the sensory quality of flakes was similar to that of the control sample.

The application of a solution containing 100 ppm Cl^- did not have a significant effect on the improvement of the microbiological quality of shredded celeriac. In samples soaked in a solution with the 500 ppm Cl^- concentration a decrease in the count of mesophilic bacteria by approx. 2 log CFU/g and coli counts by 2.3 log CFU/g was found (after 12-day storage) in comparison to the control. In samples soaked in a solution with the concentration of 500 ppm Cl^- no presence of anaerobic bacteria from genus *Clostridium perfringens* was found in 1g storedshredded celeriac. In case of the other indexes of microbiological quality no significant (p = 0.05) differences were observed between the control and the sample treated with a sodium hypochlorite solution.

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