Pungency of Radish Sprouts Cultivated in Electrolyzed Alkaline Solutions

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An electrolyzed solution is the one generated by electrolyzing a solution containing dissolved electrolytes. Pungency is the most important component contributing to the quality of radish (Raphanus sativus L.) sprouts. The pungency of radish sprouts depends on the 4-methylthio-3-butenyl isothiocyanate (MTB-ITC). This study was conducted to determine the effects of electrolyzed alkaline solutions on the pungency of radish sprouts with different electrolytes and strengths. The pungency was evaluated by the analysis of MTB-ITC content and the score of sensory evaluation. The MTB-ITC content of plants was observed to be lower in solutions of strength 1/1 and 1/2 than in that of strength 1/5 among KCl electrolyzed alkaline solutions. That of plants was observed to be the lowest in KCl electrolyzed alkaline solution, followed by commercial sea salt one, and the highest in NaCl one among solutions electrolyzed with different electrolytes. The scores of the sensory evaluations were similar to the results of the MTB-ITC contents.

Keywords: MTB-ITC, quality, sensory evaluation

INTRODUCTION

An electrolyzed solution is the one generated by electrolyzing a solution containing dissolved electrolytes such as NaCl or KCl. In our previous study (Tamaki et al., 2005), we determined the effects of the alkaline solution with different strengths, which was electrolyzed with the KCl electrolyte, on the growth of radish sprouts. We reported that the electrolyzed alkaline solutions of strength 1/1 and 1/2 promoted the growth of radish sprouts.

Few studies have been performed on the effects of electrolyzed alkaline solutions on the quality of garden crops. Pungency is the most important component contributing to the quality of radish sprouts. The pungency of radish sprouts depends on the 4-methylthio-3-butenyl isothiocyanate (MTB-ITC), which is enzymatically converted from 4-methylthio-3-butenyl glucosinolate (MTB-GSL) (Carlson et al., 1985).

The purpose of this experiment was to determine the effects of electrolyzed alkaline solutions with different electrolytes and strengths on the pungency of radish sprouts.

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MATERIALS AND METHODS

Culture conditions
Six urethane chips (each 30 mm × 22 mm × 25 mm) were placed in a plastic container (500 mL), and 30 radish seeds were sown on the urethane chips. They were germinated in a controlled environment chamber at 25 ± 1°C and 80% RH under dark conditions for 4 days, thinned to 20 uniform plants on each of urethane chip, and grown at 25 ± 1°C and 80% RH under 14-h day/10-h night cycle for additional 4 days. The plants were illuminated with fluorescent lamps (FLR40S-W, National Co., Ltd., Japan) at 300 μmol m⁻² s⁻¹ PPFD on the top of them.

Experimental solutions
Experiment 1
An electrolyzed solution was generated by dissolving 2 g of KCl, as an electrolyte, in 4 L of distilled water and electrolyzing it for 15 min using the electrolyzed solution generation apparatus (Disappear, PBM Co., Ltd., Japan). The apparatus consists of two wells separated by a septum with anode and cathode electrodes installed in either well. The alkaline solution was generated from the well with the cathode. Experimental solutions were alkaline solutions of strength 1/1, 1/2, and 1/5. The alkaline solutions of strength 1/2 and 1/5 were obtained by diluting the alkaline solution of strength 1/1 with distilled water. In our previous study (Tamaki et al., 2005), we observed that the growth of radish sprouts was better in KCl electrolyzed alkaline solutions of strength 1/1 and 1/2, and it decreased with an increase in the dilution degree of alkaline solutions of strength greater than 1/2. The control solution was distilled water. One hundred mL of each solution was infused in the container with six urethane chips at sowing, and 50 mL of each solution was added after 4 days from sowing.

Experiment 2
An electrolyzed solution was generated by dissolving 2 g each of KCl, commercial sea salt, and NaCl as electrolytes in 4 L of distilled water and electrolyzing it for 15 min using the electrolyzed solution generation apparatus (Disappear, PBM Co., Ltd., Japan). The electrolyzed alkaline solutions of strength 1/1 of each of the electrolytes were diluted with distilled water to a strength of 1/2. In Experiment 2, KCl, commercial sea salt, and NaCl electrolyzed alkaline solutions of strength 1/1 and 1/2 were used. The control solution was distilled water. One hundred mL of each solution was infused in the container with six urethane chips at sowing, and 50 mL of each solution was added after 4 days from sowing.

Analysis of MTB-ITC in radish sprouts
The MTB-ITC was extracted using the method described by Ito and Anan (1993). Analysis of MTB-ITC was carried out with a GC (GC-17A, Shimadzu Co., Ltd., Japan) equipped with a flame photometric detector, an integrator (C-R7A, Shimadzu Co., Ltd., Japan), and a 60 m × 0.25 mm i.d. capillary column (DB-WAX, J&W Scientific Co., Ltd., USA). The MTB-ITC was determined using an internal standard and was identified using a gas chromatography-mass spectrometry (GC-MS) (QP5050, Shimadzu Co., Ltd., Japan) analysis. The resulting GC-MS data for MTB-ITC was identified in comparison with those in the NIST mass spectral database and in the study of Ishii et al. (1989).

Sensory evaluation
A sensory evaluation of the pungency of radish sprouts was carried out by twenty students in Hiroshima Prefectural University, the untrained sensory evaluation panel. The panelists were asked to rate the pungency of radish sprouts using a five-point scale: 1 denoted “very weak” and 5 denoted “very strong.”

Statistics
A randomized complete block design with two containers for each experiment was carried out.
PUNGENCY OF RADISH SPROUTS

Three replicates of the experimental design, using a total of 6 containers with plants, were performed. The MTB-ITC data were subjected to analysis of variance (ANOVA) and the least significant differences (LSD) test ($P<0.05$). The sensory evaluations for each experiment were conducted 3 times and so was the analysis of MTB-ITC. The results were subjected to ANOVA and the LSD test ($P<0.05$).

RESULTS

Experiment 1

Figure 1 shows the MTB-ITC contents and scores of the sensory evaluations of radish sprouts cultivated in KCl electrolyzed alkaline solutions of strength 1/1, 1/2, and 1/5 and distilled water. The MTB-ITC content of plants was observed to be lower in solutions of strength 1/1 and 1/2 than in that of strength 1/5 among KCl electrolyzed alkaline solutions. That of plants cultivated in distilled water was the highest. The scores of the sensory evaluations were similar to the results of the MTB-ITC contents.

Experiment 2

Figure 2 shows the MTB-ITC contents and the scores of the sensory evaluations of radish sprouts cultivated in KCl, commercial sea salt, and NaCl electrolyzed alkaline solutions of strength 1/2. Those of plants cultivated in KCl, commercial sea salt, and NaCl electrolyzed alkaline solutions of strength 1/1 were similar to the results of the alkaline solutions of strength 1/2 (Data not shown). The MTB-ITC content of plants was observed to be the lowest in KCl electrolyzed alkaline solution, followed by commercial sea salt one, and the highest in NaCl one among different electrolyzed alkaline solutions. That of plants cultivated in distilled water was between those of plants cultivated in KCl and commercial sea salt electrolyzed alkaline solutions. The scores of the sensory evaluations were similar to the results of the MTB-ITC contents.

DISCUSSION

Glucosinolates are enzymatically broken down mainly into isothiocyanates, cyanides, and
thiocyanates by myrosinase, many of which are the actual active principles responsible for the biological activity (Chew, 1988). The isothiocyanate in radish was identified with MTB-ITC and the pungency of radish sprouts depends on the MTB-ITC (Carlson et al., 1985).

Radish sprouts with higher MTB-ITC content were observed to be more pungent on the basis of the results of the sensory evaluations. Okano et al. (1990) also reported that cultivars with higher MTB-ITC content were proportionately more pungent on the basis of the results of the sensory evaluations of grated radish.

Hayashi et al. (1989) reported that the MTB-ITC content of radish sprouts was lower in plants with better growth. In our previous study (Tamaki et al., 2005), we reported that the growth of radish sprouts cultivated in KCl electrolyzed alkaline solutions of strength 1/1 and 1/2 was better in comparison with that observed in the alkaline solution of strength 1/5. Moreover, in our another study, we found that the growth in KCl electrolyzed alkaline solutions of strength 1/1 and 1/2 was better in comparison with that observed in commercial sea salt and NaCl electrolyzed alkaline solutions of strength 1/1 and 1/2 (Data not shown). In the present and our previous study (Tamaki et al., 2005), the MTB-ITC contents of radish sprouts with better growth were lower, and the results were in agreement with those reported by Hayashi et al. (1989).

REFERENCES


