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Effect of UV-C Radiation on the Quality of Fresh-cut Pineapples

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Abstract

The effects of UV-C radiation on keeping the quality of fresh-cut pineapples (*Ananas comosus* L. Merr. cv. Comte de Paris) were investigated. The fresh-cut pineapples were treated with UV-C radiation for 60s and 90s respectively. And the slices were placed in plastic trays, sealed with polymeric films and stored at 10°C. Their firmness, browning, reducing sugar, titratable acidity, TSS and vitamin C were determined. UV-C radiation significantly inhibited the decrease in the firmness, TSS and sugar reduction and the increasing rate of titratable acidity in the fresh-cut pineapples. And at the same time, no statistically differences were noted when the slices treated for 60s and 90s exposure time were compared ($p<0.05$). However, UV-C radiation tremendously decreased the content of vitamin C in the fresh-cut pineapples. Likewise, no significant differences were noted when the slices treated for 60s and 90s were compared ($p<0.05$). Meanwhile, UV-C radiation induced browning throughout the storage period, and the extension of exposure time resulted in increase in the browning in the fresh-cut pineapples.

Key words: UV-C; Fresh-cut Pineapples; Quality

1. Introduction

Demand for fresh-cut fruit and vegetables has been increasing in recent years, mainly because consumers look for freshness and convenience when they purchase these commodities. However, fresh-cut processing includes unit operation such as peeling, trimming and cutting that alter the integrity of the commodities' tissues and can induce wounding stress. Consequently, microbial development from natural

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flora is promoted due to the destruction of the tissues and subsequent release of nutrients. Pathogens may form part of this microflora, leading to a potential safety problem.

Nonionizing, germicidal, artificial ultraviolet (UV-C) radiation is a novel physical sterilization technique. Unlike chemical sanitizers, UV-C does not leave a residue, and does not require extensive safety equipment [2]. Nevertheless, a few studies have focused on UV-C radiation on fresh-cut fruits and vegetables. But these few researches indicated it is effective in reducing natural microflora and extending the shelf-life of fresh-cut products such as lettuce[3], sliced mangoes[4], Watermelon cubes[5-6]. In our previous research, we also found that UV-C radiation could effectively kill the coliform in fresh-cut pineapples and the counts of mold, yeast and total colony can be reduced distinctly by UV-C radiation for 60 -90 s [7].

However, few studies have focused on the effect of UV-C radiation on the quality of fresh-cut fruit and vegetables. Our previous study had showed that UV-C radiation for 60 s and 90 s is able to effectively kill the coliform in fresh-cut pineapples and the counts of mold, yeast and total colony can be reduced distinctly. So the objective of this study was to analyze the effect of UV-C radiation for 60 s and 90 s on the sensory and nutrition quality of fresh-cut pineapples.

2. Materials and methods

2.1. Processing

The pineapples (*Ananas comosus* L. Merr. cv. Comte de Paris) were obtained from a local wholesale market and stored at 10 ℃ until used. Partially yellow ones were adopted in this experiment. The fruit were sorted to eliminate damaged or defective units, and cleaned, the crowns removed. Then, they were peeled, halved, and sliced transversely (1cm thick) with a sharp stainless steel knife.

2.2. UV-C radiation treatment and packaging

The UV-C radiation device was home-made（refer to Allende）[3]. The UV-C lamps were located 20 cm above and below the radiation vessel. The UV-C radiation doses selected for this experiment were 4.5 KJ/m^2 on each side of the produce. The samples were divided into six subgroups and radiated for 0 s, 60 s and 90 s respectively. Radiation on the products was carried out in the fresh-cut preparation room at 10℃ to avoid a temperature increase between the two banks of lamps during the treatment.

After the radiation, the fresh-cut pineapples were packed in a tray combining with polyethylene packaging film and stored at 10℃.

2.3. Sensory evaluation

Browning was evaluated by a four-member expert panel. The browning of the fresh-cut pineapples was scored on a 0–4 scale, where 0 = severe browning, 2= lightly browning, 3 = moderate browning and 4 = no browning.

The firmness of the lotus root slices was measured with GY-1 Firmness Tester（Mudanjiang mechanical institute, china）. All measurement was done in 10 times.

2.4. Quality evaluations

The content of reducing sugar reduction was measured according to the methods of Han [8]; Total soluble solids (TSS) was measured with a hand refractometer (Atago Co. Ltd., WYT-1, Tokyo, Japan).

The titratable acidity (TA) was calculated at g/100 g fresh weight of citric acid after titration with 10 mL of pulp against 0.01 M NaOH to end point (pH 8.2)[9];Ascorbic acid content (mg/100 g) of the pulp was determined volumetrically by the 2,6-dichlorophenol-indophenol method[9].

2.5. Statistical analysis

Each experiment had at least three replicates of each treatment and all experiments were run at least twice with similar results. Measurements from all the replicates were combined and the treatment effects were subjected to ANOVA, and 5% LSD values were calculated when significant treatment differences were detected.

3. Results and Discussion

3.1. Influence of radiation on the browning of fresh-cut pineapples

Production color is probably the most important attribute that determines the overall quality as it affects consumer perception. UV-C radiation had a noticeable influence on the browning of the fresh-cut pineapples. The browning development of the fresh-cut pineapples without radiation was slower than that with radiation. Especially, since the seventh day, the browning development of the fresh-cut pineapples with radiation accelerated. Extension of exposure time resulted in increase in the browning in the fresh-cut pineapples (Fig.1).

Some previous studies indicated that higher UV-C doses induced browning throughout the storage period[10]. In the present study, it indicated that radiation would also induce the browning of the fresh-cut pineapples with the extension of exposure time. The possible reason may be that UV-C treatments induced the enzymes related browning activity increase [11-12].

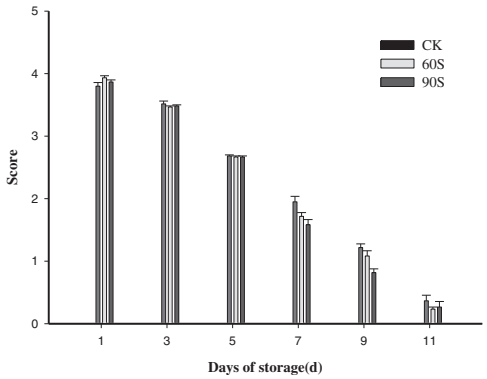

Fig. 1. The effect of UV-C radiation for 60s and 90s on the browning of fresh-cut pineapples

3.2. Influence of radiation on the reducing sugar of fresh-cut pineapples

The firmness of the fresh-cut pineapples showed a decrease trend, but the slices of the control group decreased faster compared with that in the samples with radiation (Fig.2). The fresh-cut pineapples treated with UV-C were observed in this study and they retained firmness better than the untreated fruit during storage. The difference in the firmness of the fresh-cut pineapples with radiation for 60s and 90s

was smaller in the early time of storage. But the firmness of the slices radiated for 60s decreased faster than the radiated for 90s storage duration, whereas, the firmness of the fresh-cut pineapples with radiation was significantly higher than that in the control group at anytime. Similar observations for firmness in tomatoes have been made by Liu et al. [13]. But higher dose UV-C radiation may result in the softening of lettuce [3], which could be related to the production of free radicals as a result of increase in senescence [14] and its effect on the cell wall.

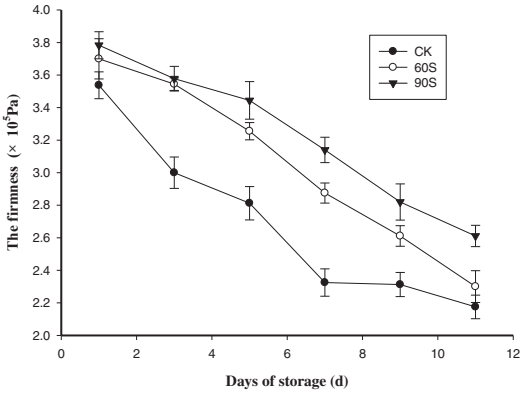

Fig.2 The effect of UV-C radiation for 60s and 90s on the firmness of fresh-cut pineapples

3.3. Influence of radiation on the reducing sugar of fresh-cut pineapples

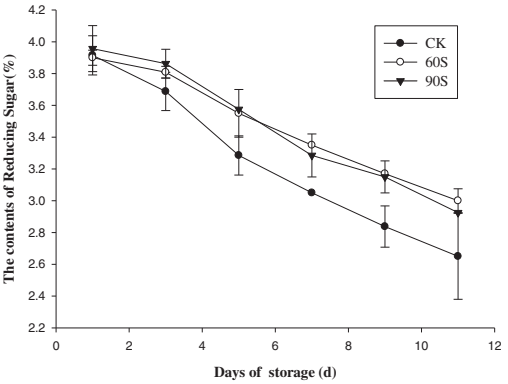

Fig.3 The effect of UV-C radiation for 60s and 90s on the contents of reducing sugar in the fresh-cut pineapples

UV-C treatment was found to affect the content of reducing sugar of treated slices significantly in comparison to the control group. The content of reducing sugar of the fresh-cut pineapples treated with UV-C was significantly higher than the untreated pineapple slices (Fig.3). It showed a significant difference in reducing sugar between UV-C irradiate with untreated slices（$p<0.05$). However, the fresh-cut pineapples radiated for 60s showed statistically similar behavior with that radiated for 90s（$p<$

0.05). It indicated that UV-C could obviously retard the reduction of reducing sugar in fresh-cut pineapples. However, some researchers reported that UV-C treatments had little or no effects on the sugar content in zucchini and lettuce [3, 15]. In the fruit that involve the ripening process (e.g. mangoes), UV-C radiation was found to increase their sugar levels probably as a result of enhancing the ripening process [4]. It indicated that UV-C may have different effect on the sugar in the different materials.

3.4. Influence of radiation on the Titratable Acidity of fresh-cut pineapples

The content of the titratable acidity in all the fresh-cut pineapples increased with storage duration, but UV-C radiation obviously slowed the rise in the titratable acidity of the fresh-cut pineapples. The titratable acidity in the slices radiated for 60s and 90s was obviously lower than that in the control group. However, the fresh-cut pineapples radiated for 60s and 90s had not statistical difference in titratable acidity（$p<0.05$) (Fig.4). In our previous study, we found that the titratable acidity always increased accompanying with an ascend trend of microbe [7]. Therefore, the reasons for the increase retard of the titratable acidity by UV-C radiation may be that UV-C irradiation reduced the number of microorganisms in the fresh-cut pineapples.

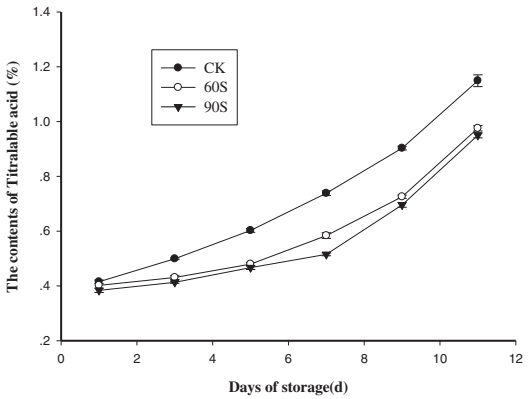

Fig.4 The effect of UV-C radiation on the contents of titratalable acid in the fresh-cut pineapples

3.5. Influence of radiation on the total soluble solids (TSS) of fresh-cut pineapples

The slices treated and untreated with UV-C showed an upward trend after the first drop in the TSS. A significant difference in the TSS was observed between the radiated and unradiated slices (Fig.5). The TSS of the control group declined from the second day, whereas, the fresh-cut pineapples with radiation began to decline from the third day. And at the same time, the TSS of the radiated slices had a larger reduction during storage. However, no significant differences were noted when the slices treated for 60s and 90 s were compared.（$p<0.05$). However, UV treatment had only a small and insignificant effect on the TSS of tomatoes during the post treatment storage and ripening [16-17].

3.6. Influence of radiation on the vitamin-C of fresh-cut pineapples

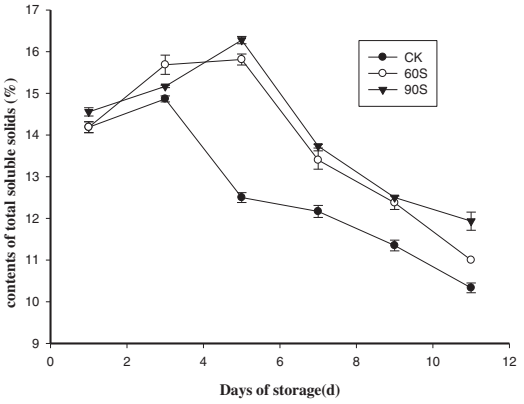

Fig.5 The effect of UV –C radiation for 60s and 90s on the contents soluble solids in the fresh-cut pineapples

The variations in vitamin-C constituent of fresh-cut pineapples followed a very similar decreasing trend both in radiated and the slices in the control group during the course of investigation (Fig. 6). It appeared to decrease with the increase in storage period. The content of vitamin-C of the radiated slices declined sharply within 3 days after the radiation and began to slow down. Nevertheless, the vitamin-C content of the unradiated slices declined slowly during the first 5 days and then a drop speeded up. And at the same time, the content of vitamin-C in the radiated slices was obviously lower than that in the unradiated slices during storage, and at the end of the storage, only 25% of vitamin-C was kept in the fresh-cut pineapples treated with UN-C. And at the same time, no significant differences were noted when the slices treated for 60s and 90s were compared（$p<0.01$). It indicated that UV–C radiation had a significant impact on the vitamin-C of fresh-cut pineapples.

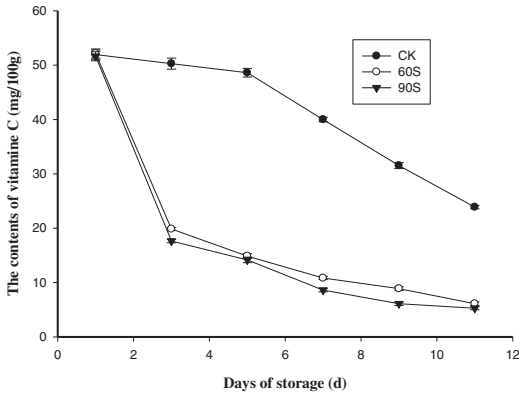

Fig.6 The effect of UV –C radiation for 60s and 90s on the contents of vitamin C in the fresh-cut pineapples

4. Conclusion

UV-C radiation significantly inhibited the decrease in the firmness, TSS and reducing sugar and the increasing rate of titratable acidity in the fresh-cut pineapples. And at the same time, no statistical

differences were noted when the slices treated for 60 s and 90 s were compared ($p<0.05$). However, UV-C radiation tremendously decreased the content of vitamin C in the fresh-cut pineapples. Likewise, no significant differences were noted when the slices treated for 60 s and 90 s were compared（$p<0.01$). Meanwhile, UV-C radiation induced browning throughout the storage period, and the extension of exposure time resulted in increase in the browning in the fresh-cut pineapples.

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