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Keeping Quality of Use of Fresh 'Kurdistan' Strawberry by UV-C Radiation

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Abstract: Fresh strawberry is a highly perishable product. As many chemicals used as postharvest treatments cause ecological problems or are potentially harmful to humans. Short wavelength (254 nm) UVC light is considered to be germicidal. In fruits, it is has been shown that low UV doses induce production of anti-fungal compounds, ripening delay and reduction of chilling injury. The equipment is relatively inexpensive, but the technique is subject to certain safety precautions easy to use and the radiation is lethal to most type of microorganisms. Fresh 'Kurdistan' strawberry *(Fragaria×ananassa, Duch. cv Kurdistan)* was exposed to different doses (0.25 and 0.5 kJ/m^2) of ultraviolet-C (254 nm, UV-C) radiation and stored up to 7 days at-1-5°C. All UV-C radiation doses decreased growth of yeast, but only significant differences were found when the highest level was applied. UV-C radiation at an appropriate dose could reduce microbial loads without adversely affecting sensorial quality of' Kurdistan' strawberry. Fruit treated with the highest doses (0.5 kJ/m^2) is significantly firmer on day 7 ($p<0.05$) and this dose improved the sensory quality of the product. This UV technology could be an alternative technology, instead of application of antimicrobial compounds.

Key words: Ultraviolet radiation · UVC · Fungi · Sensory quality · Strawberry

INTRODUCTION

Strawberry is a non-climacteric fruit with fast development and ripening, which overlaps with senescence in the late stages [1]. During ripening there is an important loss of fruit firmness, which decreases about 11-fold from unripe to ripe fruit [2]. Fresh strawberry is a highly perishable product. The major cause of postharvest losses during transport and storage of horticultural crops is the development of fungi [3].

As many chemicals used as postharvest treatments cause ecological problems or are potentially harmful to humans, with increasing concern of consumers about residues on fruit and vegetables, they have been progressively restricted in most countries [4]. Nowadays, consumers prefer low levels of preservatives in foods or preservative-free products [5]. The food industry needs new alternative in processing and preservation techniques in order to meet the consumer expectations with safer and fresher horticultural products. Most of these emerging technologies (modified atmosphere packing (MAP), O3, H2O2, ultraviolet, etc.) are milder, less damaging to product quality and more natural than current techniques [6].

Hormesis has been defined as the use of potentially harmful agents at low doses in order to induce a beneficial stress response [7]. UV light is categorised on the basis of wavelength as UVA (320-400 nm), UVB (280-320 nm), UVC (200-280 nm) and UVV (100-200 nm) [8]. Hormetic doses of UV-C irradiation have been used as a physical treatment to extend postharvest life of several fruit and vegetable products. In fruits, it has been shown that low UV doses induce production of anti-fungal compounds [9, 10], ripening delay [11-13] and reduction of chilling injury [14-16]. Softening is one of the processes involved in fruit ripening that is affected by UVC and a softening delay was reported in tomato [17, 18], mango [19] and strawberry [11, 20]. among other fruits. Exposure to UV-C delays fruit softening, one of the main factors determining fruit postharvest life. This softening delay might be caused by changes in the activities of enzymes and proteins involved in cell wall disassembly. Expansins,

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polygalacturonases (PGs). Endoglucanases (EGs) and pectin-methylesterases (PMEs) are cell wall proteins or enzymes involved in fruit softening. The efficiency of UV-C radiation against a wide variety of microorganisms already has been reported [21-23]. and there has long been an interest in its application for the disinfection of foods [24]. Exposure to low UV-C radiation doses has been reported to reduce postharvest decay of onions [25], sweet potatoes [26], carrots [27], tomatoes [28, 29], strawberry [30], apples [31], peaches [32], lemon fruits [33], table grape [34] and zucchini squash [10]. Fruit juices can be processed using ultraviolet (UV-C) light to reduce the number of microorganisms [35]. UV-C radiation may be used in many ways in a processing plant: for the radiation of food contact surfaces, of water used for rinsing in food or process plants or of air in a food preparation area. The equipment is relatively inexpensive, but the technique is subject to certain safety precautions easy to use and the radiation is lethal to most types of microorganisms [36].

Short wavelength (254 nm) UVC light is considered to be germicidal as it can cause a physical shifting of electrons and breaking of bonds in deoxyribonucleic acid (DNA) in most micro-organisms, thus causing their inactivation [37]. The antimicrobial activity of ultraviolet (UV) light is well known and has been utilized to reduce microbial contamination in hospitals, the pharmaceutical industry, public buildings, water treatment plants, fresh food products and agricultural products. In addition high intensity UV-C lamps have become available and enhanced the potential of destroying surface bacteria on foods by UV radiation [38, 39].

Botrytis cinerea and Monilinia fructigena, two major post harvest spoilage fungi of strawberries and cherries, were completely inactivated by UVC treatment at 1.00 J/cm2 and 0.50 J/cm2 respectively [3]. Stevens *et al*., (1998) reported the efficacy of UVC on peaches infected with Monilinia fructicola. UVC doses of 4800 and 7500 J/m^2 appeared to be the most effective in reducing the surface inoculum of the fungus. UVC light could reduce the incidence of storage rot disease caused by *M. fructicola* of peach, green mold (Penicillium digitatum) of tangerine, Rhizopus soft rot of tomato and sweet potato [40]. Tomato diseases caused by Alternaria alternata, B. cinerea and Rhizopus stolonifer were effectively reduced by UVC treatment at 1.3 to 40 KJ/m^2 [28]. Hidaka and Kubota (2006) reported that a 90% inactivation of Aspergillus and Penicillium species on the surface of wheat grain was achieved by applying a UVC dose of 97 J/m2 for 5.6 h [41].

As far as we know, there is no available scientific literature about the use of UV-C radiation for maintaining quality and extending shelf life of fresh' Kurdistan' strawberry.

Consequently, the aim of this study was to determine the effect of UV-C radiation for controlling fungal growth of fresh ' Kurdistan' strawberry. The collateral incidences of UV-C radiation on sensory quality and fruit firmness also were studied.

MATERIALS AND METHODS

'Kurdistan' Strawberry: Twenty kilograms of fresh 'Kurdistan' strawberry (Fragaria×ananassa, Duch. cv Kurdistan) at 50% red ripening stage, commercially grown in Sanandaj suburb (Kurdistan of Iran), were obtained from a local producer. Strawberry were placed in polystyrene trays at 5°C for about 1 h before UV-C radiation treatments were applied.

UV-C Treatment: The UV-C radiation equipment consisted of a bank of 17 stainless-steel reflectors with unfiltered germicidal emitting lamps (Sylvania, G30T8, Philips, The Netherlands).

Polystyrene trays were placed below the lamps at a distance of 60 cm simulating a processing line. A fan was placed to avoid a temperature increases by the illuminated lamp. Fresh 'Kurdistan' strawberry was placed in a single layer on the plastic trays for treatment. The UV-C radiation doses varied by altering the duration of the exposure time at the fixed distance. The UV-C intensity measurement was taken with a Blak-Ray J-225 photometer (Ultra-Violet Products, Inc., San Gabriel, CA, USA) to determine the radiation intensity of the lamps, which was measured at nine different positions on the tray. The final value of the lamps intensity was calculated as the mean of the UV-C radiation readings. Two UV-C treatments were applied to the product. The corresponding doses (kJ/m^2) were (1) 0.25, (2) 0.5. Untreated product was considered as control. After UV-C treatment, fresh 'Kurdistan' strawberry was placed in polystyrene trays and stored at 5°C for about 1 h before packaging.

Strawberry Packaging: A total of 150 bags (package dimensions: 20_30 cm) containing 100 g of fresh 'Kurdistan' strawberry and made of bioriented polypropylene (PPB) film (Shahab pooshesh plastic, Booshehr, Iran) were prepared. The O2 transmission rate of the PPB film was 1800 ml O2/m2_24 h_atm and 25 mm thickness (data provided by the supplier). Bags were heat-sealed and placed at 5°C during the storage period. Three replications were made for each treatment at each sampling time.

Enumeration of Yeasts and Molds: Samples of 30 g from each bag were homogenised in 270 ml of sterile peptone saline solution (8.5 g/l NaCl, Merck, Germany) +1 g/l neutralised peptone bacteriologic (Merck, Germany) in a sterile stomacher bag with a Colworth Stomacher 400 (Steward Laboratory, London, UK) for approximately1 min. Ten-fold dilution series were made in peptone saline solution, as needed for plating. The following medium and incubation conditions for yeast and molds were used: yeast extract dextrose chloramphenicol agar (YGC) (Merck, Germany) incubated aerobically at 30°C for 48 and 72 h. Microbial counts were expressed as log10 cfu/g [42]. Samples for analyses were taken on days 0 (production day),1,2,3,4,5,6 and 7.

Fruit Firmness: Fruit firmness was determined using a universal testing machine (Lloyd Instruments, LRX), that measured the force needed by a probe (diameter 0.5 cm) to penetrate 0.5 cm deep in a strawberry with a velocity of 2 mm/s.

Sensory Quality: Three members of a trained sensory panel rated the produce using a hedonic unstructured graphic range denominated interval scale. In this scale, the answer of the panellists was estimated from a mark on a line of 9 cm. The distance between the left extreme and the mark were measured. The extremes and centre were represented as follows: 1 'dislike extremely, no characteristic of the product', 5 'neither like nor dislike, limit of acceptance from the consumers point of view' and 9 'like extremely, very characteristic of the product [43]. The evaluated characteristics were general appearance, aroma, texture and color [44]. The sensory evaluation was done on days 0 (production day), 1,2,3,4,5,6 and 7.

RESULTS AND DISCUSSION

Microbial Growth: Compared with control, a decrease in yeast growth was observed when UV-C doses were applied (Fig. 1). It could be concluded that these two UV-C treatments prolonged the shelf life of the product by three days based on microbial growth. As expected, the most efficient UV-C radiation treatment was 0.50 kJ/m^2. Our results agree with those reported by Erkan *et al*., (2001). So the factor dose have a significant effect on fungal development ($p<0.05$).

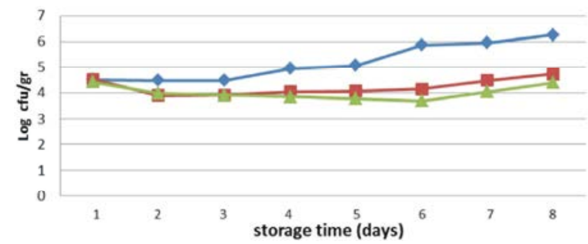

Fig. 1: Yeast growth (log10 CFU/g) from fresh strawberry stored at-1-5°C for 7 days. Error bars indicate a 95% confidence interval

Table 1: Maximum force (N) required for penetrating 0.5 cm deep in the strawberry for different UV-doses (measurements made at 0,1,2,3,4,5,6 and 7 days after UV-treatment)

Storage time (days)	Control	T1 =0.25 kj/m^2	T2 =0.50 kj/m^2
0	2.400	2.476	2.508
1	2.400	2.466	2.495
2	2.250	2.360	2.400
3	2.310	2.420	2.315
4	2.260	2.290	2.360
5	2.230	2.260	2.330
6	2.180	2.230	2.305
7	2.150	2.205	2.290

No development of mold growth was detected and their number remained relatively constant from day 0 to7 (data not shown). Additionally, no significant difference in mold growth was found between control and UV-C treated strawberry.

It has been reported that reduction in postharvest diseases and delaying decay in low UV-C radiated commodities might be related to the increase in decay-resistance of tissues due to the accumulation of antifungal compounds [10].

Firmness: Table 1 shows the effect of UV-treatment on fruit firmness: fruit treated with the highest doses (0.5 kj/m^2) is significantly firmer on day 7 ($p<0.05$). No external damage of ultraviolet irradiation was noticed on the fruit surface.

Liu *et al*., (1993) showed that UV-C treatment on some fruits delays senescence and maturity [28].

Sensory Quality: No decay symptom was observed on strawberries throughout the survey period (data not shown).

Only overall visual quality showed significant differences among treatments. After 6 days of storage the quality for the untreated product was scored under the limit of acceptance by consumers (lower than 5 in Fig. 2).

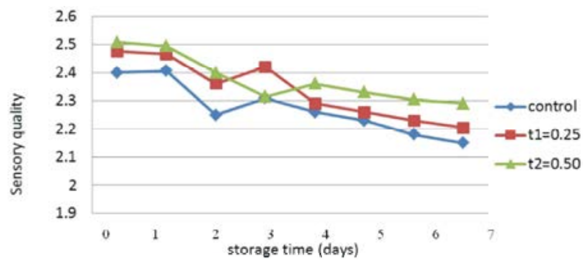

Fig. 2: Score means for consumer acceptance of fresh strawberries stored at-1-5°C for 7 days. Bars indicate a 95% confidence interval. The straight horizontal line indicates the limit of acceptance by the consumer point of view

Based on these results it could be concluded that the highest UV-C radiation dose (0.50 kJ/m^2) improved the sensory quality of the product.

CONCLUSIONS

The UV-C treatments were effective in reducing growth of yeast and molds. The highest UV-C dose was more effective in reducing microbial growth than the lowest radiation dose. Therefore, the effect of UV-C was correlated with the dosage.

The best scores were obtained when the highest UV-C dose was applied (0.50 kJ/m^2). Our results confirm the hypothesis that short UV-C radiation doses are effective in delaying senescence and deterioration in fresh fruit by reducing the microbial populations and thereby improving the keeping quality.

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