

Influence of Sanitization Process on Maintaining Sweet Potato Quality for Export

Saneya M. El Neshawy¹, Tharwa M. Elkholi² and Salah H. Hegazy³

1. Department of Post-harvest Diseases, Plant Pathology Research Institute, Agricultural Research Center (ARC), Giza 12619, Egypt

2. Central Administration for Medical Services, Ministry of Agriculture, Dokii 12611, Egypt

3. General Manager of AgroFood Company Limited, Dokii 12611, Egypt

Abstract: The whole cold-chain for exporting sweet potato (native variety “Abees”), to foreign market included immediate curing operation directly after harvest helped in healing skin texture, however, in order to reduce postharvest soft rot (*Rhizopus stolonifer*) incidence following trimming, and washing, ultraviolet light (UV-C) treatment was used as a main sanitizer for eliminating the soft rot. Exposure of the roots to UV-C (254 nm) was applied in a UV-C room on freshly harvested and cured sweet potato while rolling up on a movable line at 20 cm distance for 1, 2, and 3 hr. As combining UV-C treatment with chlorine (200 ppm) on roots, marked and significant reduction of the total microbial load and *Rhizopus* potential was achieved on root surfaces respectively compared with chlorine alone. It also reduced soft rot percentage to almost 0% infection. After 3 months of cold-storage, quality assessment of sweet potato showed that root characteristics were markedly maintained. The ability of UV-C light to induce phenylalanine ammonia lyase (PAL) enzyme activity in root tissue and maintain the activities of peroxidase and polyphenol oxidase, however with slight increase, was detected. UV-C caused an increase of phenol content in sweet potato tissue that made an activation of defense reaction against the rot causal pathogen. As the exposure time to UV-C light increased, a higher content of phenols occurred. Moreover, UV-C application caused decrease in sugar content of root tissue that is flavored by soft rot-causal pathogen.

Key words: Sweet potato (*Ipomoea batatas*), soft rot, *Rhizopus stolonifer*, UV-C light, cold storage, microbial load.

1. Introduction

Protection of sweet potato (*Ipomoea batatas* L.) in particular the variety “Abees” which is dominant in Egypt is necessary; it has high sugar percentage which is favored by the sugar like-fungi. More than 50% of sweet potatoes are harvested using spade that causes damaged roots after lifting and this facilitates the entrance of fungi into roots and causes great losses.

In the presence of moisture content, the root’s tissues are attacked by high percentage of fungi as *Rhizopus* soft rot (*Rhizopus stolonifer*), bacterial soft rot (*Erwinia chrysanthemii*), *Fusarium* root rot (*Fusarium solani*) as the major diseases that can occur commonly on sweet potato, and their causal pathogens can enter the roots through wounds [1]. The host specific fungus on sweet

potato is the sugar-like fungus, *Rhizopus stolonifer*, which easily attacks the high sugar variety “Abees” and ultimately causes full deterioration of root’s body due to the developed soft rot.

Snowdon [2] recorded the causal pathogen of soft rot i.e. *Rhizopus stolonifer* on sweet potatoes as a limiting factor of healthy roots during the whole handling system.

Careless handling in the presence of wounds or high moisture content in sweet potato roots increases the losses and decreases the export, meanwhile quantitative and qualitative losses may arise from post-harvest physical, physiological or pathological factors or various combinations of them [3].

Therefore, an urgent need for proper postharvest handling exists as it is the most important step in the

Corresponding author: Saneya M. ELNeshawy, Ph.D, professor, research fields: postharvest & gender research fields.

long process of sweet potato. It begins immediately after harvest with curing process that helps in healing the root surface-skin and eliminates free water proliferation during storage under controlled conditions. Clark [4] assured the importance of curing after harvest as control measure of diseases during storage, as it enhanced the culinary characteristics, and healed the wounds as well as helped set the skin.

The objectives of this study are to apply sanitization processes on sweet potato roots as curing operation immediately after harvest, chlorine or/with ultraviolet (UV-C) light in the whole cold chain of postharvest handling system of sweet potato to extend cold storage period, control soft rot caused by *R. stolonifer* and maintain high quality.

2. Materials and Methods

Sweet potato roots ("Abees" variety) were produced based on the multiplication of virus-free stocks for growing in AgroFood Company Limited (AF)'s land and providing facilities needed for production of sweet potato. Harvest was carried out by post-harvest team work, Dept. of Postharvest Pathology, Plant Pathology Research Institute at mature stage (firmness at 18-20 g part/inch²) as soon as a sufficient number of roots reached market size. Harvest was conducted manually using spades, by cutting the line aside and removing the soil from around the roots.

2.1 Curing Treatment

Curing operation began immediately after harvest, or at maximum one day after, roots were set at 25-29 °C and 85% to 90% relative humidity (RH) for 5-7 days. Ventilation was installed to supply fresh air and help maintain the proper temperature and RH.

2.2 Sanitization Process

In addition to curing, sanitization of sweet potato roots was done using chlorine at 200 ppm or/and UV-C light after trimming, grading, sorting and then storing sweet potato for up to three months, it was applied to

disinfect the root surfaces from possible contaminants.

UV-C 254 nm was applied in an installed UV-C room (Agro Food company limited) to freshly harvested sweet potato while rolling up on movable line set at the height 70-100 cm distance from the Lamp for 1, 2, and 3 hr, then stored for up to three months at 15-16 °C and 85%-90% RH.

2.3 Microbial Load on Tuber Surfaces

The total amount of different types of organisms on root surfaces was isolated and determined as percentage (%) after three-month storage.

The effect of UV-C light at different exposure times. (1, 2 or 3 hr.) on soft rot (%) caused by *Rhizopus stolonifer* upon natural infection and stored for three-month storage was tested.

The effectiveness of the UV-C treatment was determined by comparing roots upon sanitizing using chlorine (200 ppm) only or chlorine combined with UV-C treatment.

Possible contamination potential on root surfaces upon the effect of UV-C in addition to chlorine (200 ppm) after three-month cold storage was determined. Through dilution of total microbial load, the developed colonies were sorted out and counted as colony forming unit (CFU/mL) based on their morphological characteristics.

Colonization by *R. stolonifer* on root surface was recovered immediately following sanitizing with chlorine at 200 ppm or/and UV-C light and stored for three months in cold storage room.

2.4 Quality Characteristics

Data of quality parameters were recorded on the roots that exposed to UV-C light for 3 hr at 0-time, and after storage for one and half month or three months -storage.

Firmness (g/inch²), shrinking (%), blemishing (%), weight loss (%), and root sprouting ($\pm$) were determined upon 3 hr exposure and at 0-time, 1.5-month or 3-month storage at appropriate conditions (14-16 °C and 90% RH).

2.5 Biochemical Changes

Starch content was determined as percentage (%) of dry matter after UV-C light exposure following curing and storage for up to three months at appropriate conditions (14-16 °C and 90% RH).

Phenol and sugar contents were determined as mg/g fresh weight/min in root tissue exposed to UV-C for 1, 2, or 3 hr and storage for up to 3-month cold storage at appropriate conditions.

Enzymatic activities of peroxidase, polyphenol oxidase, and phenylalanine ammonia lyase (PAL) in root tissue were determined as mg/g fresh weight/min after 1, 2 or 3 hr of exposure to UV-C and storage for three months in cold storage at appropriate conditions.

2.6 Statistical Analysis

The results of the previous experiments were statistically analyzed according to Statistical Package for the Social Sciences (SPSS) analysis of variance (ANOVA) one and two ways program [5]. The means of all treatments were compared by the least significant difference (LSD) value at 5% level of probability.

3. Results and Discussion

Fungi were found to be the most dominant contaminants on raw sweet potato-root surfaces through wounds and

dead end tissues (Fig. 1). This finding was in accordance with Ye et al. [6] who found fungal component is communally present in the moist air in cold storage rooms where fruits and vegetables were stored. Therefore, the cutting (trimming) of dead tissues of the root that act as a source of fungal infection delays the rapid progress of rot to the whole root body. Furthermore, the immediate curing of roots after harvest of roots provides a good measure of control and helps in healing the wounds and other breaks occurring during harvest [7].

UV-C treatment as a major sanitizing element is considered a promising method to reduce the wound-induced decay during storage [8]. The Primer sanitizing treatment of sweet potato using chlorine caused significant reduction of the microbial load on root surfaces, however more significant reduction and thus increased protection against soft rot was obtained when combining chlorine with UV-C treatment (Table 1). Similar level of protection against soft rot causal pathogen *R. stolonifer* extended to three-month storage of treated roots at appropriate conditions (Table 2). *In vivo* test revealed that UV caused a complete inhibition of soft rot upon 3 hr exposure after three-month storage at appropriate conditions (Fig. 2). Similarly, Stevens et al. [9] indicated that UV-C light reduced the incidence of *Rhizopus* soft rot of tomatoes and sweet potatoes.

Table 1 Colonization by potential microbial load (CFU/mL) on sweet potato root surfaces upon the effect of UV-C with chorine 200 ppm after three-month cold storage.

	Dilution of microbial load (CFU/mL)			
	I	II	III	Mean
UV-C exposure + chlorine	3.67 ^a	3.33 ^a	1.67 ^a	2.89
Chlorine	8.67 ^b	4.00 ^a	1.67 ^a	4.78
Untreated roots	17.67 ^c	70.0 ^b	49.67 ^b	45.78
LSD (0.05)	1.46	1.59	1.03	

Values with same letters are not significantly different; CFU: colony - forming units.

Table 2 Colonization by *Rhizopus stolonifer* (CFU/mL) on sweet potato roots following sanitizing with chlorine at 200 ppm or/and UV-C light after three-month cold storage.

Treatment	<i>Rhizopus stolonifer</i> (CFU/mL)
Chlorine (200 ppm)	20 ^a
Chlorine (200 ppm) + UV-C exposure	8 ^b
Untreated roots	300 ^c

Values with same letters are not significantly different; CFU: colony - forming units.

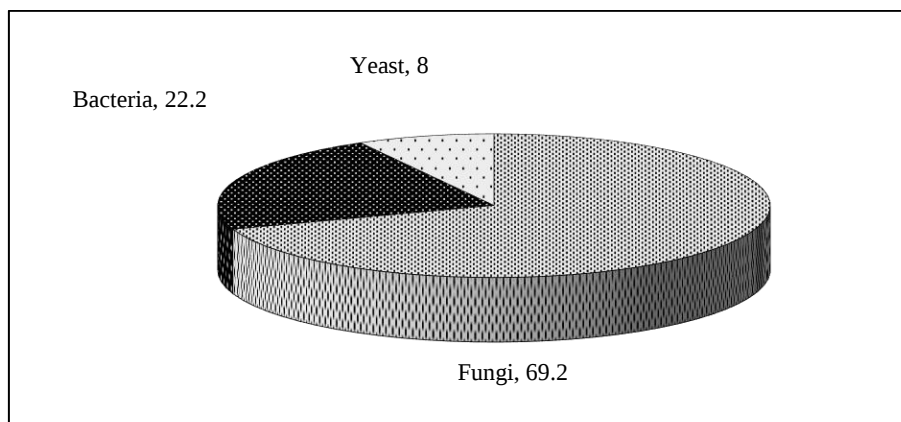


Fig. 1 Percentage (%) of potential organisms on surfaces of raw sweet potato roots stored in cold storage room for three months.

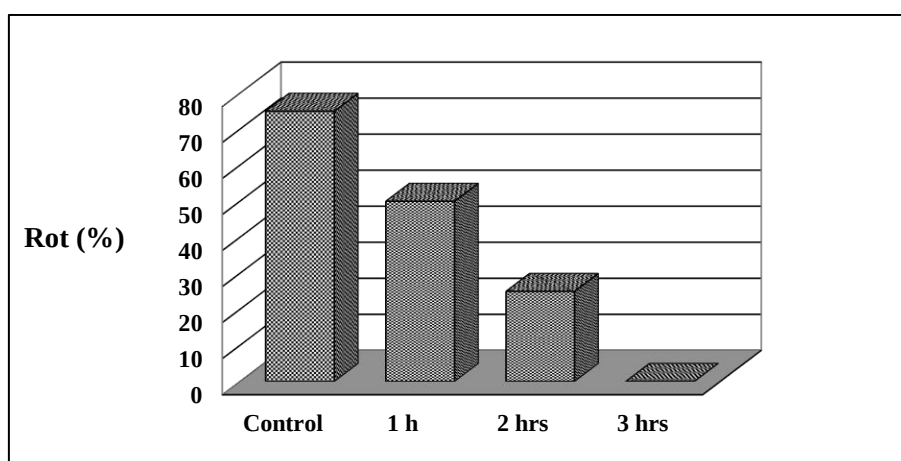


Fig. 2 Effect of UV-C light at different exposure time on soft rot (%) of sweet potato caused by *Rhizopus stolonifer* upon natural infection after three-month storage.

The study revealed a reduction of sugar content in sweet potato tissues due to UV treatment; however, a reverse effect was detected in terms of phenol content as the UV-C caused an increase in phenol content. The findings by Lu et al. [10] on peaches explained it as a cause of inducing resistance and may signal the activation of defense reaction in the tissue of the roots against the possible pathogens inside the cold storage room. Delay of ripening and resistance to spoilage might probably act as a result of stress imposed upon the host by UV application which might have resulted in hermetic effect.

Root starch content (%) immediately after curing or UV-C light exposure and cold storage for 1.5 months did not significantly differ; however after three months significant difference was determined (Table 3). This result was explained by degradation from starch to sugar as confirmed by Stevens et al. [8] who found that

UV treatment of sweet potato caused a slight reduction in hydrolysis of starch to sugar and increased percent of dry matter. A similar result was also obtained when sweet potato was treated by x-ray and sucrose concentration increased linearly in response to dose as starch concentrations decreased [11].

Evaluation of certain quality characteristics after cold storage upon treatment with UV-C for up to three months was determined. No weight loss or sprouting occurred in sweet potato roots stored at 16 °C and 85%-90% RH for three months. The root color was maintained at dark red skin with bright dark orange flesh. Maintaining the ventilation and full drying of roots all the way through the handling processes until reaching the last destination has its impact on root safeness (Table 4). Mbilinyi et al. [12] found that storage methods differently affected weight loss,

rotting, sprouting, rooting and production of bad smell and that the incidence of rotting increased with the increase in humidity. The UV-C effect on root firmness, blemishing or shrinking of the roots was maintained through the three-month storage period. The findings by Nigro and Ippolito [13] proved the positive effects of UV-C light to reduce decay and improve quality of stored fruit and vegetables.

Systemic effect of UV-C was indicated by an increase in phenolic compounds (Fig. 3) that seems to be correlated with the induction of PAL enzyme activity (Fig. 4). The reduction of postharvest rot by UV-C has

largely been attributed to induced resistance effects related to the production of substances (mainly phenols) toxic to the pathogens and incited by an increase in the activity of key synthetic enzymes [14]. Meanwhile, Gleitz et al. [15] reported that UV light also acts as an effective elicitor of antifungal substances and activity involved in their biosynthetic pathway. Other studies were carried out by Liu et al. [16] who confirmed the positive effect of UV-C at certain doses on inducing resistance against *Rhizopus stolonifer* on tomatoes through slowing ripening and resistance to storage soft rots.

Table 3 Starch content (%) of sweet potatoes following curing, UV-C and cold storage for up to three-month storage.

	Starch content (%)
Curing	70 ^a
UV-C light	69.5 ^a
UV-C + cold storage for 1.5 months	65.9 ^a
UV-C + cold storage for 3 months	60 ^b

Values with same letters are not significantly different.

Table 4 Effect of UV-C light at different exposure time (0, 1.5, and 3 hr) on certain characteristics of sweet potato stored for up to three months at appropriate conditions.

Time after exposure	Firmness (g/inch ²)	Shrinking %	Blemishing (%)	Weight loss (%)	Sprouting (+, -)
0-time	7.5	10	50	00.0	-
1.5 months	8.5	15	25	00.0	-
3 months	8.5	20	10	00.0	-
Control	7.5	25	75	2.9	++
Mean	8.0	15	40		
LSD (5%)	1.2	3.2	7.3		

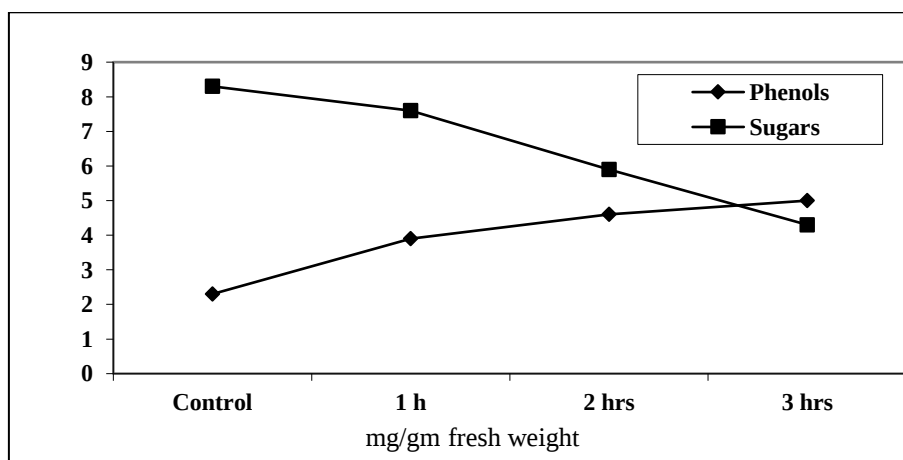


Fig. 3 Effect of UV-C light at different exposure time (1, 2, and 3 hr) on phenol and sugar contents in sweet potato tissue after three months in cold storage room at appropriate conditions.

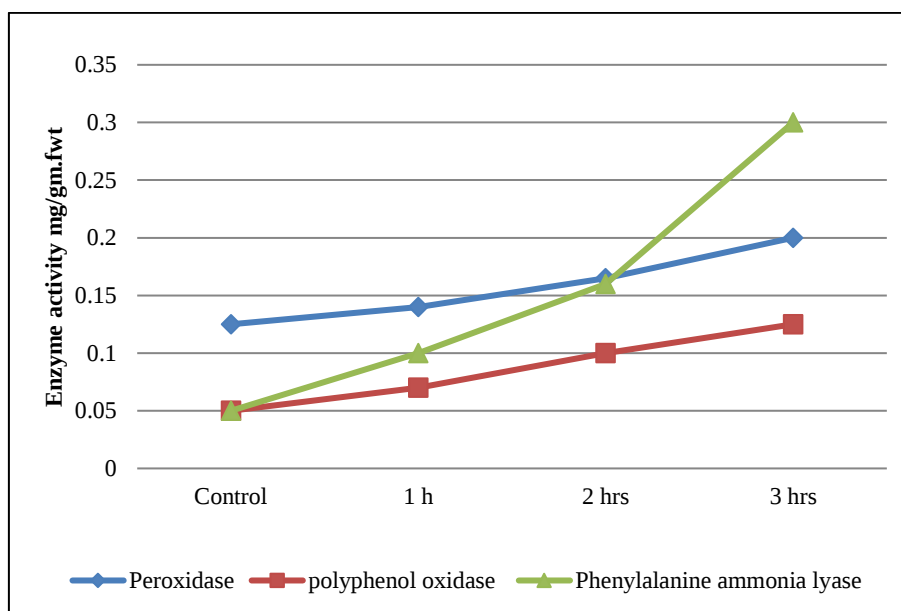


Fig. 4 Effect of UV-C light at different exposure time (1, 2, and 3 hr) on peroxidase, polyphenol oxidase and phenylalanine ammonia lyase (PAL) activities in sweet potato root tissue after three months in cold storage room at appropriate conditions.

4. Conclusion

The applied methods of sanitization including curing process directly after harvest and the UV-C exposure with chlorine at 200 ppm following the curing process on sweet potato, which help in healing the root wounds, caused a significant reduction of microbial load on sweet potato roots. Moreover, sweet potato exhibited tolerance to infection by soft rot caused by *R. stolonifer*, maintained the export quality and induced root resistance due to induction of PAL enzyme activity that relates to increased phenolic compounds. The overall impact was a significant reduction in postharvest rots and a tangible impact on regular handling system.

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