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USE OF ULTRA VIOLET LIGHT (UV-C) TO REDUCE POSSIBLE MICROBIAL POTENTIAL IN COLD STORAGE ROOMS LOADED WITH SWEET POTATOES FOR EXPORTATION

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ABSTRACT

Irradiation with Ultraviolet-c (UV-C) light (254 nm) was applied on sweet potatoes (*cv. Abees*) as well as the major recovered organisms that are accounted as contaminants in either the internal atmosphere or on sweet potato tuber roots loaded in cold storage room set at 17 °C and 65-70% RH for 3 months. The captured types of microorganisms from either the internal atmosphere of cold storage room or surfaces of sweet potato tuber roots were fungi, yeast and bacteria with the greatest percentage of fungi that recorded 90% and 70%, respectively. The major individuals of recovered fungi were *Penicillium* spp., *Alternaria alternata*, *Rhizopus stolonifer*, *Aspergillus* spp., *Botrytis cinerea*, and *Fusarium* sp. in descending order of their existence percentages. Upon exposure, the internal atmosphere to UV-C light for one, two and three hours inside cold storage room, a significant reduction of the total number of different types of organisms was obtained with the greatest effect for the three hour - exposure time. Exposure of sweet potatoes to UV-C light at three exposure times (1, 2 and 3 hr) and stored in cold rooms for one month caused a reduction of rot percentages upon natural infection conditions with a full reduction (0 %) when irradiated for 3 hr at the same conditions. Rot percentages were decreased as the exposure time increased. Fruit characteristics in terms of tuber root firmness, shrinking and blemishing of irradiated tuber roots were remarkably maintained than which of the non irradiated ones. UV-C light caused a significant increase in phenol contents in tuber root tissue, while a reverse effect in sugar content was detected; such effects were correlated increasingly or decreasingly with the increase of exposure time. The activity of peroxidase, polyphenoloxidase or polyphenylalanine ammonia lyase (PAL) enzymes in irradiated tuber root tissues were significantly enhanced as the exposure time increased.

Keywords: Cold storage room, UV-C irradiation, sweet potatoes, contamination, microbial load.

INTRODUCTION

The importance of control possible contamination potential inside cold storage rooms comes to the priority of maintaining the quality of fresh fruits and vegetables during the storage of fresh fruits and vegetables in cold storage rooms. The control of microbial load in either the internal atmosphere of cold storage rooms or on the stored fresh products is of great concern to minimize and/ or eradicate such contamination potential. There are several control methods to be applied for this purpose among which the use of UV-C light inside the storage rooms at certain conditions such as wavelength, height, field area or time of exposure that are necessarily taken into consideration. The effect of UV-C light is often accounted as a non-germicidal effect as it in most cases does not affect the development of the microbes which communally originate in the storage atmosphere and may act as a source of contaminant to the stored fruits. UV-C causes delaying fruit ripening due to induce resistance

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in the tissue. Several articles have been published on the effect of exposure to UV-C light on the development of the disease causal-organisms. Some of these studies were carried out by Liu *et al.* (1992) who confirmed the positive effect of UV-C at certain doses on inducing resistance against *Alternaria alternata*, *Botrytis cinerea* and *Rhizopus stolonifer* on tomatoes through slowing ripening and resistance to relevant storage rots. Nigro *et al.* (1998) and (2000) described the effect of UV-C light on lowering numbers of what on infected table grape berries and reducing post harvest decay of strawberries caused by *Botrytis cinerea* on both crops.

Sweet potatoes are one of the major vegetable crops subjected for export in particular to Europe market. During storage in cold rooms, packing houses or through shipping operation, sweet potatoes are easily attacked with the host specific organism, *Rhizopus stolonifer*, the sugar like fungus; in addition to other major post harvest organisms. In order to manage the storage operation of sweet potatoes in terms of control the possible organism(s) that may contaminate either the internal atmosphere of cold storage rooms or infect the sweet potato tubers in cold storage rooms.

The present study is designed and aimed to:

- Monitoring the microbial potential in cold storage rooms loaded with sweet potatoes.
- Applying the exposure to UV-C light (254 nm) short wave to reduce possible contaminants in either internal atmosphere or on sweet potato surfaces inside cold storage rooms as well as studying its effect on fruit characteristics and its chemical components.

MATERIALS AND METHODS

Recovery of Possible Existing Microorganisms at Certain Conditions

Internal atmosphere (IA)

Sterilized Petri dishes containing 10 ml of sterilized potato dextrose agar (PDA) medium were left open in sweet potatoes cold storage room set at 17°C and 65-70% relative humidity (RH) for 90 days. Three periods i.e. 1, 2 or 3 days were considered for capturing the possible microorganisms in internal atmosphere of the cold storage room. Three dishes served for one replicate at each period (one treatment), then dishes were closed following each period and incubated at 28°C for 3 days. The microbial development colonies were verified according to its morphological characteristics and counted separately for each dish as colony forming unit (cfu/cm^2). The average cfu/cm^2 per each treatment was calculated. Each fungus, bacteria or yeast developed from relevant single colony was transferred and maintained on PDA slants, incubated at 28°C for 10 days for full growing then kept in a refrigerator for further studies.

Sweet potato surfaces

Possible existing organisms on surfaces of sweet potato tuber roots 10 cm length were washed off by dipping a number of tuber roots (8 tubers) one by one in 500 ml distilled sterilized water inside 1000 ml sterilized glass piker. One droplet of tween 80 was added to the washing water as a spreader material. Tuber root inside pickers was gently agitated for 5 minutes for loading off the possible existing organisms, then tuber root was removed. One ml of the washing water was added to 9 ml distilled sterilized water in test tubes and dilutions were made for 10^{-2} and 10^{-3}. One hundred micro liter from each dilution i.e. 10^{-1}, 10^{-2} or 10^{-3} of the washing water was drawn using a manual micropipette and then inoculated onto sterilized PDA medium. Inoculum was then spread onto PDA surface using glass spreader rode. Dishes were then incubated at 28°C for three days for the development of possible existing organism's colonies. Upon the growth of existing organisms, colonies were counted using a digital colony counter, then the developed colonies were verified according to thier morphological characteristics and counted separately as colony forming unit (cfu %). The average cfu % per each concentration, was calculated.

The percentage of each organism i.e. fungi, bacteria or yeast relative to the total number of organisms recovered from either internal atmosphere or from sweet potato tuber surfaces were calculated for each treatment (Cooke *et al.*, 2006) as follows:

$$\text{Percentage (\%) of organism} = \frac{\text{Average number of colonies of each organism}}{\text{Total colony numbers of all organisms}} \times 100$$

Percentage (%) of Screened Recovered Fungi from Either Internal Atmosphere or from Surface of Sweet Potatoes

The recovered fungi from either internal atmosphere of cold storage room or from surfaces of sweet potatoes were purified and subjected to identification processes described by Barnett and Hunter (1998) at the Department of Post Harvest Diseases, Plant Pathology Research Institute, Agricultural Research Center (ARC)/ Giza. The identified fungi were screened and calculated as percentage (%).

Exposure the Recovered Organisms to UV-C Light

Ultraviolet lamp

Ultraviolet cabinet (ULTRA LUMP MODEL UV C-06) with short wave UV-C light was used. The long life UV-C transmitting in the UV-C 06 modes assures a peak wave length emission of 254 nm. UV-C irradiation was measured using a UV-x digital radiometer (UVP,INC., San Gabriel, CA 9/ 778, USA), equipped with UV-x 25 nm sensor. The lamp was assembled 20 cm a part from exposed materials and the area under the lamp was 60x 88 cm. UV-C irradiation was undertaken in the dark.

Exposure to UV-C light (254 nm) against the major recovered organisms on PDA medium (*in vitro*)

Through laboratory experiment, the antifungal effect of ultraviolet (UV-C Light) short wave length at 245 nm was tested for growth reduction percentage and spore density of the major recovered fungi from cold storage rooms (internal atmosphere or on stored sweet potato surfaces).

UV-C light was tested against *Penicillium italicum*, *Aspergillus flavus*, *Alternaria alternata*, *Rhizopus stolonifer*, and. *Botrytis cinerea* in UV-C cabinet under the previous conditions. A disk 5mm in diameter of a pure culture of each fungus was loaded off and placed in the center of sterilized PDA dishes. Dishes were exposed to UV-C light either at 0 time or at 3 days growth old culture each for ½ or 3 hr then incubated at 28 ±2°C. Daily measurements of radial growth were determined up till the mycelial growth of control treatment fully covered the PDA medium. The average mycelial growth diameter for each treatment was calculated, then recorded as a percentage of growth reduction (%) comparing with full radial growth of control dishes. Sporulation of fungi was visually determined and recorded as ± readings.

Exposure to UV-C light (254 nm) and the total number (cfu/ cm^2) of different types of major recovered fungi existed inside cold storage room (*in vitro*)

Exposure to UV-C light (254 nm) was applied as a decontaminant to reduce contamination potential existed in internal atmosphere inside cold storage rooms.

Sterilized Petri dishes containing 10 ml of sterilized PDA medium were utilized for capturing the possible existing microorganisms before and after exposure to UV-C light inside cold storage room. Three set of dishes (three per each) each served for one single treatment, dishes of each single treatment was left opened for 10 minutes in the internal atmosphere inside cold storage room either before exposure to UV-C light (control treatment) or during exposure at three exposing times (1, 2 and 3 hr) to capture the possible organisms from internal atmosphere of cold storage room that are not affected or affected with the UV-C influence. Dishes were covered following each time then incubated at 28°C for development of existing microorganisms colonies. The developed colonies were then differentiated according to their morphological characteristics and counted separately as colony forming unit (cfu/ cm^2). Colonies in dishes after exposure to UV-C light were compared with that were determined before exposure.

Exposure to UV-C light (254 nm) against soft rot naturally occurring on sweet potato (*ex vitro*)

Mature healthy sweet potatoes (cv. Abees), free from injuries and defects, were obtained from El-Nubaria farms and stored at 17°C and 65-70% RH until use. Tuber roots were washed with tap water, sterilized using wetted cotton pad with 95% ethanol then left to dry. Tuber roots were grouped into four groups; first group was exposed to UV-C light for one hour; second for 2 hours, third for 3 hours and fourth non-exposed group (control). Exposure to UV-C

light was carried out in UV-C cabinet for the mentioned exposure time separately and kept in the dark at room temperature for 24 hour then stored at 16°C and 60-70% RH for a month. Rot percentage due to the infection naturally occurred on tubers, was determined after storage period.

Fruit Characteristics

Shrinking and blemishing (±)

Shrinking and Blemishing of sweet potato tuber roots were evaluated visually and recorded as ± readings.

Firmness (g/inch^2)

Tuber roots firmness (g/inch^2) was measured on one side of the tuber with a penetrometer (Mc cormic fruit firmness pressure tester FT 0-11# (0-11 Ibs) using 5/11 plunger tip. The reading was expressed as g/inch^2.

Soluble solid Contents (SSC%)

Soluble solid contents were determined in one juice sample of treated and non-treated tuber roots using hand-held Refrectometer (PZORR. 13, 0-35% (m/m), 30-130° – 0, ochsle) as described by (Lu *et al.*, 1991).

Chemical Components

Phenol contents

Phenol contents were extracted and measured on absorbance spectrophotometer Miltonroy Spectronic 601 at 520 nm as mentioned before by Snell and Snell (1953).

Sugar contents

Sugars were extracted as described by Snell and Snell (1953) and Color optical density of the reacted mixture was measured on absorbance spectrophotometer Miltonroy spectronic 601 at 540 nm using the picric acid technique as described by Thomas and Dutcher (1924).

Enzymes

Enzymes were determined in tuber tissue after storage period as follows:

Peroxidase

Enzyme activity was recorded as the change in absorbance per minute at 430 nm immediately after the addition of substrate according to Kochba *et al.* (1977).

Polyphenoloxidase

Polyphenol oxidase activity was measured following the method described by Maxwell and Bateman (1967).

Polyphenylalanine ammonia lyase (PAL)

The enzyme preparation was obtained from acetone powders of tuber roots and added to borate buffer, pH 8.8 according to the method of Lisker *et al.* (1983).

Statistical analysis

The results of the previous experiments were statistically analyzed according to SPSS ANOVA one and two ways program (Snedecore and Cochran 1980). The means of all treatments were compared by the least significant difference value "LSD" at 5% level of probability.

RESULTS AND DISCUSSION

Recovery of Possible Microorganisms Existing in Cold Storage Room Loaded with Sweet Potatoes for Exportation

Data in Fig. 1 presented higher percentages of the recovered fungi from the internal atmosphere of cold storage room loaded with sweet potatoes for 90 days at 17°C and 65-70% RH, than which recovered from sweet potato surfaces. The percentage recorded 90, 7.0 and 3.0% for fungi, bacteria and yeasts, respectively. Thus the greatest percentage was recorded for fungi. Meanwhile, the highest percentages of the recovered microorganisms from sweet potato surfaces were 70.0, 22.0 and 8.0% for fungi, bacteria and yeasts, respectively. The findings of contamination potential in cold storage room in terms of fungi and bacteria population was in accordance with what has been found by Ye Sheng Ying *et al.* (2009) who found that spores of *Penicillium expansum* are the most important airborne component of fungal contamination and are communally present in the moist air in cold storage rooms where fruits and vegetables were stored. In addition, Fan *et al.* (2003) found that the bacteria *Pseudomonas fluorescence* and *Erwinia carotovora* caused decay of many fresh fruits and vegetables during storage.

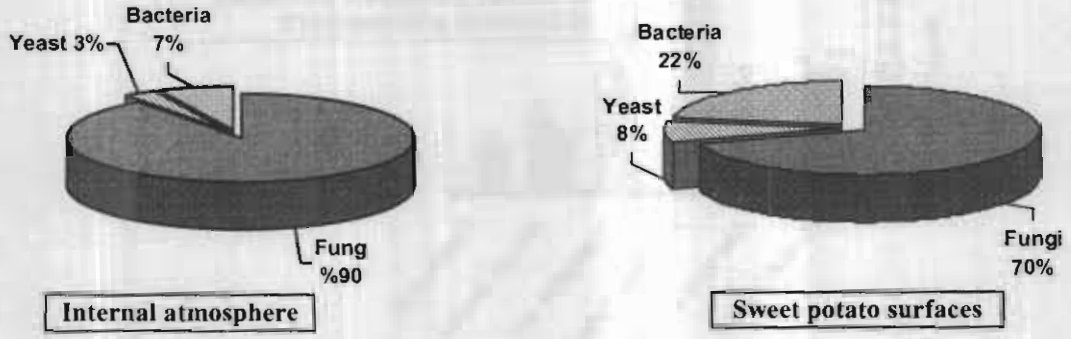

Fig. 1. Percentage (%) of total type of recovered organisms from internal atmosphere or from sweet potato surfaces inside cold storage room set at 17 C ° and 65-70 % RH for 90 days

Screening the Individual Fungi Recovered from Cold Storage Room Loaded with Sweet Potatoes (*in vitro*)

Data in Fig. 2 show that the highest percentage of fungi presented in internal atmosphere of cold storage room was for *Aspergillus* spp. (26.0%) but the lowest one was for *Rhizopus stolonifer* (13.0%). *Penicillium* spp., *Alternaria alternata* and *Botrytis cinerea* percentages recorded 24.0, 22.0 and 15.0% respectively. However, the highest percentage of recovered fungi from sweet potato surfaces was for *Rhizopus stolonifer* (38.6%), but the lowest one was for *Fusarium* sp. (9.2%) *Penicillium* spp., *Alternaria alternata* and *Botrytis cinerea* percentages were 24.8, 17.2 and 10.2%, respectively. The individuals of recovered fungi from cold storage room are frequently investigated, Palou, *et al.* (2001) indicated that fungal population that recorded was very high and mostly due to *Cladosporium* and *Penicillium* genera in the atmosphere of cold storage room and on surfaces of equipment and facilities.

Efficacy of Exposure to UV-C Light on the Major Recovered Microorganisms at Certain Conditions

Efficacy of UV-C light at 0 time on the percentage of growth reduction (%) or on sporulation (±) on PDA medium (*in vitro*)

Data in Table 1 revealed growth reduction percentage (%) or sporulation of fungi exposed to UV-C light for 1/2 or 3 hr at 0 time or 3 days after inoculation. It indicated that the highest reduction percentage occurred as a result of exposing the whole tested fungi, *Penicillium* spp., *Botrytis cinerea* or *Alternaria alternata* to UV-C light at 0 time for 3 hr of inoculation. UV-C has almost no effect on *Rhizopus stolonifer* growth. Meanwhile, sporulation of fungi of almost the whole tested fungi was highly affected by the UV-C light and greatly affected as medium or light sporulation compared to the control treatment (non exposed treatment that was heavy sporulated).

Efficacy of exposure to UV-C light for one, two or three hours on the total number of major microorganisms existing in the internal atmosphere of cold storage room (*in vitro*)

Data in Fig. 3 show that numbers of colony forming unit (cfu/cm^2) of each type of microorganisms (fungi, yeast or bacteria) in the internal atmosphere of cold storage room significantly decreased as UV-C light exposure-time increase. The highest percentage of recovered fungi recorded 195 cfu/cm^2 before exposing to UV-C light, this number was decreased to 131 cfu/cm^2 as the internal atmosphere was exposed to 1 hr, 65 cfu/cm^2 when exposed to 2 hr and 34 cfu/cm^2 when exposed to 3 hr. Meanwhile, bacteria cfu/cm^2 significantly decreased from 97 cfu/cm^2 before exposing the internal atmosphere to UV-C light and to 4 cfu/cm^2 when exposing for 3hr. In addition, exposure to UV-C light for 1 or 2 hours, significantly reduced the total number of recovered yeasts, however, when exposure for 3 hr the yeast was absent.

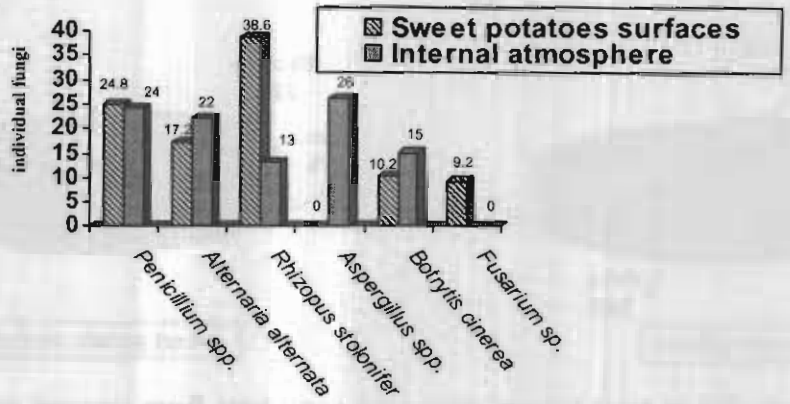

Fig. 2. Percentage (%) of individual fungi recovered from internal atmosphere and on sweet potato tuber- surfaces inside cold storage rooms at different storage conditions

Table 1. Effect of UV-C light on growth reduction percentage (%) and sporulation (±) of the major recovered fungi isolated from either internal atmosphere or from stored sweet potatoes at 0 time or 3 days after inoculation on PDA medium (*in vitro*)

UV-C treatment		*Penicillium italicum*		*Aspergillus flavus*		*Rhizopus stolonifer*		*Botrytis cinerea*		*Alternaria alternata*	
		GR (%)	S (±)	GR (%)	S (±)	GR (%)	S (±)	GR (%)	S (±)	GR (%)	S (±)
0 time	1/2 hr	89	±	22	+	0	-	48	±	22	-
	3 hr	100	-	33	±	0	-	89	±	78	-
after 3 days	1/2 hr	56	+	22	+	0	±	56	+	33	-
	3 hr	78	±	44	±	0	±	78	+	56	-
Control		0	+	0	+	0	+	0	+	0	-
Mean		64.6		24.4		0		60.2		37.8	-
LSD 5 %		7.0		3.2		0		5.3		6.2	

GR (%): Growth reduction percentage
S: Spoulation (Spore formation)
(-) : (no sporulation)
(±) : light sporulation
(+) : Heavy sporulation

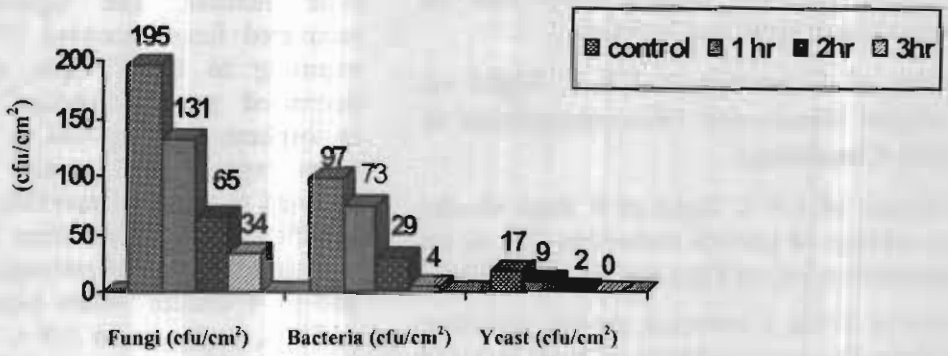

Fig. 3. Effect of exposure to UV-C on the total number (cfu/cm^2) of different type of microorganisms existed in internal atmosphere of cold storage room

Efficacy of exposure to UV-C light on tuber roots rot percentage and certain characteristics as affected by *R. stolonifer* under natural conditions (*ex vitro*)

Data in Table 2 revealed significant effect of exposure sweet potatoes to UV-C light for 1,2 and 3 hr upon natural infection on rot percentage (%) caused by *Rhizopus stolonifer* and on certain fruit characteristics. Significant effect of the UV-C light on rot reduction (%) caused by *Rhizopus stolonifer* was obvious at the three exposure times with greatest effect at 3hr exposure time, at which the UV-C light eliminated rot development, as the exposure time increase, the rot percentage decreased.

The effect on maintaining fruit firmness and reducing shrinking and blemishing was remarkable on firmness and blemishing that were maintained as the exposure time increase, however, the effect on shrinking was not parallel with the increasing of exposure time. Exposure to UV-C light for one hr was less effective on either rot reduction or on maintaining fruit characteristics comparing to the exposure for two or three hr. The efficacy of exposure to UV-C light was experienced in several researches from which Stevens *et al.* (1997) confirmed that UV-C light reduced the incidence of brown rot of Peach, green mold of storage rots of Tangarine and *Rhizopus* soft rot of tomatoes and sweet potatoes. Using UV-C light at low dose as an alternative to synthetic fungicides for the control of post harvest diseases was carried out by Wilson *et al.* (1994) on onions and sweet potatoes; it was found to reduce storage rots and extended the shelf life of these commodities. The effect of UV-C on some physical characteristics was studied by Lu *et al.* (1993) who found that treated peach fruits with UV were firmer than the control fruits ($p< 0.05$). The explanation of such results could be due to that radiation might delay ripening process thus disease resistance is greater for less ripened tubers causing minimal damage to the internal cellular structure.

Efficacy of UV-C light on oxidative enzymes activities, phenols and sugar contents of tuber roots, under natural conditions (*ex vitro*)

Data in Table 3 revealed significant effect of exposing sweet potatoes to UV-C light for 1,2 and 3 hr upon natural infection on certain enzyme activities of Peroxidase, Polyphenoloxidase or PAL enzyme. The effect of the UV-C light indicated an increase in enzyme activity due to exposure for 3hr. The enzyme activity increased by increasing exposure time. In addition, data revealed significant different effect on phenol or sugar contents due to exposure sweet potatoes to UV-C light for 1,2 and 3 hr, UV-C light caused an increase in phenol content in sweet potato tissues, however, caused a decrease in sugar contents. The highest effect of the UV-C light occurred due to exposing for 3 hr on Phenol or sugar. Low sugar contents might be deduced to that UV delay ripening since sugars generally increased during the ripening process. UV treated tubers were also firmer in texture, further studies support this interpreparation. Phenol contents increased by increasing the exposure time. The chemical components of the treated sweet potatoes with UV-C light was determined by Droby *et al.* (1993) who found in terms of PAL and Peroxidase enzymes that the activity of both enzymes in the peel of UV treated grape fruit increased within 24 hour after the UV treatment and remained high at 48 and 72 hr. This was in accordance with what has been detected in this study. In terms of phenol and sugar contents, the finding by Lu *el al.* (1993) on peaches was in agreement with what has been found in this study that revealed a reduction in sugar content due to UV treatment, however, a reverse effect was detected in terms of phenol content as the treatment with UV-C caused an increase in phenol content in sweet potato tissues which may be explained as a cause of inducing resistance and may signal the activation of defense reaction in the tissue of the tubers against the possible pathogens inside the cold storage room. Delay of ripening and resistance to spoilage might probably as a result of stress imposed upon the host by UV application which might have resulted in hermetic effect.

UV light has been also reported to act as an effective elicitor of antifungal substances and activity involved in their biosynthetic pathway (Gleitz *et al.* 1991).

Table 2. Effect of UV-C light at different exposure times (1, 2 or 3 hr) on fruit rot (%) naturally caused by *Rhizopus stolonifer* and on certain fruit characteristics of sweet potatoes after one month storage

Exposure time	Rot (%)	Fruit characteristics		
		Firmness (g/inch^2)	Shrinking (%)	Blemishing (%)
1hr	50	7.5	10	50
2hr	25	8.5	15	25
3hr	0	8.5	20	10
Control	75	7.5	25	75
Mean	37.5	8.0	15	40
LSD 5 %	12.3	1.2	3.2	7.3

Table 3. Effect of UV-C light at different exposure times on Peroxidase, Polyphenol oxidase or Polyphenyl alanine Ammonia Lyase (PAL) activity; and phenol or sugar contents in sweet potato tissues upon natural infection

Exposure time	Peroxidase (mg/gm fwt/min)	Polyphenol oxidase (mg/gm fwt/min)	Polyphenyl alanine ammonia lyase (mg/gm fwt/min)	Phenol (mg/gm fwt)	Sugar (mg/gm fwt)
1hr	0.132	0.073	0.097	3.9	7.6
2hr	0.164	0.108	0.167	4.6	5.9
3hr	0.201	0.123	0.300	5.00	4.3
Control	0.121	0.056	0.046	2.3	8.3
Mean	0.155	0.090	0.145	4.00	6.5
LSD 5 %	0.05	0.02	0.06	1.01	2.9

fwt: fresh weight

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استخدام الأشعة فوق البنفسجية (UV-C) لخفض الكم الميكروبى المحتمل بحجرات التخزين المبرد المعبأة بالجذور الدرنية للبطاطا المعدة للتصدير

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استخدمت الأشعة فوق البنفسجية UV-C (٢٥٤ نانومتر) للتحكم فى كم الملوثات الموجودة فى الجو الداخلى أو الموجودة على أسطح جذور درنات البطاطا المخزنة داخل ثلاجات التخزين على ١٧°م ورطوبة نسبية ٦٥-٧٠% لمدة ثلاثة أشهر. كانت أنواع الميكروبات المعزولة سواء من الجو الداخلى للثلاجة أو من على أسطح جذور درنات البطاطا هى الفطريات، الخمائر والبكتيريا حيث كانت النسبة الأكبر للفطريات إذ سجلت ٩٠٪، أما أهم الفطريات المعزولة هى *Penicillium* spp., *Alternaria alternata*, *Rhizopus stolonifer, Aspergillus* spp., *Botrytis cinerea*, and *Fusarium* sp. بالترتيب التنازلى لنسب وجودها فى الأماكن المعزولة منها. أدى تعريض الجو الداخلى لثلاجات التخزين للأشعة فوق البنفسجية لمدة ساعة أو ساعتين أو ثلاث ساعات إلى اختزال معنوى للعدد الكلى لأنواع الميكروبات المعزولة خاصة عند التعريض لمدة ثلاث ساعات. كما أدى تعريض جذور درنات البطاطا للأشعة فوق البنفسجية UV-C لمده ساعة أو ساعتين أوثلاث ساعات ثم تخزينها لمدة شهر إلى خفض نسب الإصابة بالعفن الطرى المتسبب عن الفطر *Rhizopus stolonifer* وذلك تحت ظروف العدوى الطبيعية مع اختزال كامل للإصابة (٠٪) عند التعريض لمدة ٣ ساعات تحت نفس الظروف حيث انخفضت نسبة العفن مع زيادة مدة التعريض. بالنسبة لصفات الجذر الدرنى كالصلابة والكرمشة والتلطخات كانت أفضل معنوياً فى الجذور الدرنية المعرضة للأشعة فوق البنفسجية UV-C عن تلك غير المعرضة. فيما يخص المستوى الكيماوى لها أدى التعرض لأشعة UV-C إلى زيادة معنوية فى محتوى نسيج الجذور الدرنية من الفينول، فى حين كان ذلك التأثير عكسيا بالنسبة لمستوى السكر، وارتبط ذلك على نحو متغاير بزيادة وقت التعرض. زاد النشاط الإنزيمي بشكل معنوي لكل من إنزيمات البيروكسيديز والبولى فينول أوكسيديز والبولي فينيل ألانين أمونيا لايز (PAL) فى أنسجة الجذور الدرنية المعرضة للأشعة فوق البنفسجية UV-C وذلك كلما زادت مدة التعرض للأشعة.