RESEARCHES ON HORTICULTURAL PRODUCTS DECONTAMINATION DESIGNED TO FRESH CONSUMPTION, USING NON-IONIZING UV-C ULTRAVIOLET RADIATION
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CERCETARI PRIVIND DECONTAMINAREA PRODUSELOR HORTICOLE DESTINATE CONSUMULUI IN STARE PROASPATA, UTILIZAND RADIATIA NEIONIZANTA ULTRAVIOLETA UV-C

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***Abstract:** Consumed in fresh-state, horticultural products can be carriers of some optional pathogenic microorganisms: bacteria, yeasts, molds. These microorganisms can cause either loss of horticultural products in the storage process, due to the post harvest decay process or food-borne diseases with direct effects on consumer human health. In this context, the paper presents experimental researches on the possibility of using non-ionizing ultraviolet radiation UV-C within the conditioning technologies of horticultural products, by investigating the capability of an experimental model of installation for the decontamination of external surfaces of horticultural products, to apply the minimum dosage recommended for the destruction of the most representative pathogens.*

***Keywords:** post harvest treatment,, UV-C radiation, fruits and vegetable, shelf-life*

INTRODUCTION

Fruits and vegetables play an important role in the human nutrition. The nutritive value of horticultural products consumed in fresh-state, is given especially by large quantities of vitamins which they synthesize. Vitamins are biocatalysts of life processes, essential for life, their absence from the human metabolism causing serious functional disorders. The failure of keeping the vitamins into the body, implies the need for a permanent intake in daily food components. For the continuos supply of fresh fruits and vegetables, it is necessary to extend the shelf-life of these products, to eliminate the seasonality of consumption, to get closer the production areas to the consumption ones, to reduce as much as possible the loss due to the degradation of perishable food products.

Consumed in fresh-state, horticultural products can be carriers of some optional pathogenic microorganisms: bacteria, yeasts, molds. These microorganisms can cause either loss of horticultural products in the storage process, due to the post harvest decay process or food-borne diseases with direct effects on consumer human health. Losses of horticultural products, due to the post-harvest decay process, are at the level of 10-50% depending on the degree of development of the area and the facilities for temporary storage. In order to limit these losses, there have been used synthetic fungicide substances. Residues of these substances, which remain on the surface of horticultural products, after treatment, are considered a potential threat to consumer health and especially children [9].

***Rezumat:** Consumate în stare proaspătă, produsele horticole pot fi purtatoare ale unor microorganisme facultativ patogene: bacterii, drojdii, mucegaiuri. Aceste microorganisme pot provoca fie pierderi de produse horticole la pastrare, datorate procesului de descompunere postrecoltare, fie îmbolnăviri sau toxinfecţii alimentare cu efecte directe asupra sanatatii consumatorului uman. In acest context, lucrarea prezinta cercetari experimentale privind posibilitatea de utilizare a radiatiei ultraviolete neionizante UV-C in cadrul tehnologiilor de conditionare a produselor horticole, prin investigarea capabilitatii unui model experimental de instalatie pentru decontaminarea suprafetelor exterioare ale produselor horticole, de a aplica dozele minime de radiatie recomandate pentru distrugerea celor mai reprezentativi agenti patogeni.*

***Cuvinte cheie:** tratament post recoltare, radiatie UV-C, fructe si legume, perioada de valabilitate*

INTRODUCERE

Fructele si legumele joacă un rol important în alimentaţia umana. Valoarea nutritivă a produselor horticole consumate în stare proaspătă este dată în special de cantităţile importante de vitamine pe care le sintetizează. Vitaminele sunt biocatalizatori ai proceselor vitale, indispensabile vieţii, absenţa lor din metabolismul uman producând grave tulburări funcţionale. Imposibilitatea de păstrare în organism a vitaminelor, implică necesitatea unui aport permanent în componentele alimentare zilnice. Pentru aprovizionarea continuă cu fructe si legume proaspete, este necesar să se prelungească durata de păstrare a acestor produse, să se elimine cât mai mult caracterul sezonier al consumului, să se apropie zonele producătoare de cele consumatoare şi să se reducă într-o măsură cât mai mare pierderile prin degradarea produselor alimentare perisabile.

Consumate în stare proaspătă, produsele horticole pot fi purtatoare ale unor microorganisme facultativ patogene: bacterii, drojdii, mucegaiuri. Aceste microorganisme pot provoca fie pierderi de produse horticole la pastrare, datorate procesului de descompunere postrecoltare, fie îmbolnăviri sau toxinfecţii alimentare cu efecte directe asupra sanatatii consumatorului uman. Pierderile de produse horticole, datorate procesului de descompunere postrecoltare, se situeaza la nivelul a 10-50 % in functie de gradul de dezvoltare al zonei respective si facilitatile de pastrare temporara. In vederea limitarii acestor pierderi, s-au utilizat substante fungicide sintetice. Reziduurile acestor substante, care raman pe suprafata produselor horticole

Alternative methods to fungicide treatments have been studied in order to prevent horticultural products losses in the post harvest phase. Within these methods the applications of biological control agents, plant bioactive compounds and physico-chemical methods showed interesting results but still far from a practical application in Europe. Despite the substantial progress obtained with biological control agents, the use of them is limited due to their insufficient and inconsistent performance. The use of plant bioactive compounds has shown that the treatment conditions (concentration, form of application, time of treatment, etc.) can deeply influence their efficacy. A barrier to use the plant bioactive compounds may not be the efficacy, but rather the off-odours caused in horticultural products and/or the phytotoxicity. Physico-chemical methods include heat, ionising radiation, ultraviolet UV-C radiation and food additives which induce the resistance to pathogens [13].

Conventional thermal methods of food sterilizarion are unsuitable for fruits and vegetable destined for fresh consumption because of the heat which causes inevitable changes of color, smell, flavor and a loss of nutritional value [12].

Recent research has identified a number of energy-based alternative technologies to improve the safety of fresh and fresh-cut fruits and vegetables: ultraviolet radiation, electron-beam irradiation, technology with pulsed visible light and technology with cold plasma. In some cases, such as UV light, these technologies have a substantial database of information regarding the use in other domains, and can be adapted to use with fresh produce. In other cases, such as with electron-beam irradiation, advances in technology need new researches. Other technologies, such as pulsed visible light and cold plasma, are newer areas of research that hold promise as antimicrobial processes which can reduce the viability of bacterial pathogens on fresh products.

Within the methods earlier mentioned, a special potential has the use of non-ionizing ultraviolet radiation UV-C. The wavelength range that varies between 200 and 280 nm, which is considered lethal to most types of microorganisms, affects the DNA replication of these microorganisms [3], [4]. Non-Ionizing UV radiation can cause breaks of molecular chemical bonds and can induce photochemical reactions. The biological effects of UV radiation depend on the wavelength and the exposure time. UV-C ultraviolet radiation is already successfully used in various fields such as medicine (decontamination of air and medical instruments), environment (wastewater treatment), packaging industry (decontamination of packaging for various food products) etc. Worldwide, there are initiatives in using this method for decontaminating the outer surfaces of food products. As a postharvest treatment on fresh produce, UV-C irradiation has been proven beneficial to reduce respiration rates, control rot development, and delay senescence and ripening in different whole or fresh-cut fruits and vegetables, such as apples, citrus, peaches,

dupa tratare, sunt considerate o amenintare potentiala la adresa sanatatii consumatorilor si in mod special a copiilor [9].

Au fost studiate, de asemenea, metode alternative la tratamentele cu fungicide, in vederea prevenirii pierderilor de produse horticole in perioada postrecoltare. In cadrul acestor metode, utilizarea agentilor de control biologic, compusilor bioactivi obtinuti din plante si metodelor fizico-chimice au obtinut rezultate interesante dar inca departe de o aplicare practica in Europa. In ciuda progresului substantial obtinut in privinta agentilor de control biologic, utilizarea acestora este limitata datorita performantelor insuficiente si inconsistente obtinute. Utilizarea compusilor bioactivi obtinuti din plante a aratat faptul ca eficienta lor poate fi infuentata de conditiile de tratament (concentratie, forma de aplicare, timp de tratament etc.). Un obstacol in calea aplicarii nu este reprezentat de eficienta metodei ci de mirosurile nespecifice si/sau fitotoxicitatea induse materialului horticol. Categoria metodelor fizico-chimice include utilizarea caldurii, radiatiei ionizante, radiatiei ultraviolete UV-C si aditivilor alimentari ce induc rezistenta la agentii patogeni [13].

Metodele termice conventionale de decontaminare sunt improprii utilizarii pentru fructe si legume destinate consumului in stare proaspata datorita caldurii care produce modificari permanente ale culorii, mirosului, aromelor si pierderi ale valorii nutritionale [12].

Cercetarile recente au identificat o serie de tehnologii alternative bazate pe energie pentru a imbunatati siguranta fructelor și legumelor proaspete și proaspăt tăiate: radiatia ultravioleta, iradierea cu fascicul de electroni, tehnologia cu impulsuri de radiatie luminoasa vizibilă și tehnologia cu plasmă rece. In unele cazuri, cum ar fi radiatia ultravioleta, aceste tehnologii au o baza de date substanțiala de informații privind utilizarea in alte domenii, și pot fi adaptate pentru a fi utilizate pentru produsele proaspete. În alte cazuri, cum ar fi iradierea cu fascicul de electroni, progresele tehnologice necesita cercetari noi. Alte tehnologii, cum ar fi tehnologia cu impulsuri de radiatie luminoasa vizibilă și cu plasmă rece, sunt domenii noi de cercetare care promit a fi utilizate ca procese antimicrobiene ce pot reduce viabilitatea agenților patogeni bacterieni in cazul produselor proaspete.

In cadrul metodelor enumerate anterior, un potential deosebit il are utilizarea radiatiei neionizante ultraviolete UV-C. Lungimea de unda cuprinsa intre 200 si 280 nm, care este considerata letala pentru majoritatea tipurilor de microorganisme, afecteaza replicarea AND-ului microorganismelor patogene [3], [4]. Radiaţiile UV neionizante pot produce ruperi de legături chimice moleculare şi pot induce reacţii fotochimice. Efectele biologice ale iradierii cu ultraviolete depind de lungimea de undă şi de timpul de expunere. Radiatia ultravioleta UV-C este deja utilizata cu succes in diverse domenii precum medicina (decontaminarea aerului si a instrumentarului medical), ecologie (epurarea apelor uzate), industria ambalajelor (decontaminarea ambalajelor pentru diverse produse alimentare) etc. Pe plan mondial exista preocupari in domeniul utilizarii acestui procedeu pentru decontaminarea suprafetelor exterioare ale produselor alimentare. Ca si tratament postrecoltare al produselor horticole, iradierea cu radiatie ultravioleta UV-C s-a dovedit benefica in diminuarea ratei watermelon, grape berries, tomatoes, lettuce, baby spinach and mushrooms [5], [10], [1], [2], [6], [8], [7], [11].

The researches undertaken and presented in this paper, focus on the following approaches:

- performing experimental researches on the possibility of using non-ionizing ultraviolet radiation UV-C within the conditioning technologies of horticultural products;

- investigating the capability of an experimental model of installation for the decontamination of external surfaces of horticultural products, to apply the minimum dosage recommended for the destruction of the most representative pathogens.

de respiratie, controlul deprecierii produselor si in intarzierea proceselor de maturare si coacere la diferite fructe si legume, intregi sau maruntite, precum mere, citrice, piersici, pepene, boabe de struguri, rosii, salata verde, spanac si ciuperci [5], [10], [1], [2], [6], [8], [7], [11].

Cercetarile intreprinse si prezentate in aceasta lucrare, se focalizeaza pe urmatoarele abordari:

- realizarea de cercetari experimentale privind posibilitatea de utilizare a radiatiei ultraviolete neionizante UV-C in cadrul tehnologiilor de conditionare a produselor horticole;

- investigarea capabilitatii unui model experimental de instalatie pentru decontaminarea suprafetelor exterioare ale produselor horticole, de a aplica dozele minime de radiatie recomandate pentru distrugerea celor mai reprezentativi agenti patogeni.

MATERIAL AND METHOD

The most common microorganisms that can contaminate horticultural products, with adversely affect on storage or human health, are shown in table 1. For the destruction of these potentially pathogenic microorganisms, it is recommended to apply certain doses of UV-C radiation.

MATERIAL ŞI METODĂ

Cele mai frecvente microorganisme care pot contamina produsele horticole, cu efecte directe asupra pastrarii sau sanatatii consumatorului uman, sunt prezentate in tabelul 1. Pentru distrugerea acestor microorganisme potential patogene, se recomanda aplicarea anumitor dose de radiatie UV-C.

Table 1

Potentially pathogenic microorganisms and recommended UV-C radiation doses [14]

Microorganism	UV-C radiation dose [*mWs/cm²*] necessary for the destruction of	
BACTERIA	90 %	99 %
Bacillus anthracis	4.52	8.70
Clostridium tetani	13.00	22.00
Escherichia coli	3.00	6.60
Mycobacterium tuberculosis	6.20	10.00
Salmonella enteritidis	4.00	7.60
Shigella dyseteriae	2.20	4.20
Staphylococus aureus	2.60	6.60
MOLDS		
Aspergillus flavus	60.00	99.00
Penicillium expansum	13.00	22.00
Rhizopus nigricans	111.00	220.00
YEASTS		
Saccharomyces spores	8.00	17.60

Considering the data presented above, the experimental researches on the possibility of using non-ionizing ultraviolet radiation UV-C within the conditioning technologies of horticultural products, have focused on investigating the capability of applying the minimum dosage recommended for the most representative pathogens. In this respect, it was experimented a new technical equipment (fig. 1) - Installation for the decontamination of external surfaces of horticultural products, IDPH. The main technical characteristics of the decontamination installation are presented in table 2.

The installation is proposed to be used for the decontamination of external surfaces of horticultural products, as preliminary stage for the temporary storage phase itself. The main characteristic of the transport system is that it performs not only the transportation of the product along the installation but also the rotation of it around an axis perpendicular to the direction of advance. This characteristic assures a homogenous distribution of the UV-C radiation upon the exterior surfaces of the products.

Avand in vedere datele prezentate mai sus, cercetarile experimentale privind posibilitatea de utilizare a radiatiei ultraviolete neionizante UV-C in cadrul tehnologiilor de conditionare a produselor horticole, s-au focalizat pe investigarea capabilitatii de a aplica dozele minime de radiatie recomandate pentru distrugerea celor mai reprezentativi agenti patogeni. In acest sens, a fost experimentat un echipament tehnic nou (fig. 1) – Instalatie pentru decontaminarea suprafetelor exterioare ale produselor horticole, IDPH. Principalele caracteristici tehnice ale instalatiei de decontaminare sunt prezentate in tabelul 2.

Instalatia este propusa a fi utilizata pentru decontaminarea suprafetelor exterioare ale produselor horticole, ca etapa preliminara pentru faza de pastrare temporara propriuzisa. Principala caracteristica a sistemului de transport este aceea ca realizeaza nu numai transportul produsului de-a lungul instalatiei dar si rotirea acestuia in jurul unei axe perpendiculare pe directia de deplasare. Aceasta caracteristica permite o distributie omogena a radiatiei UV-C asupra suprafetelor exterioare ale produselor.

Fig. 1 - Installation for the decontamination of external surfaces of horticultural products, IDPH

Table 2

The main technical characteristics of the decontamination installation

Dimensions (LxWxH)	3420x1215x1340 mm
Length of the transport system	1500 mm
UV Generator type	discharge lamps at low pressure mercury vapor
The wavelength of the emitted radiation	253.7 nm (UV-C)
Power of the UV-C lamps	55 W / pcs.
Number of UV-C lamps	5 pcs.

The experimentation was aimed to determine the energetic indices and qualitative working indices of the decontamination installation. For this purpose, there were taken into account the following parameters:

- The minimum and maximum rotational speed of the driving system of the conveyor - there were determined by varying the frequency of the supply current of the gear-motor, through the frequency converter currently existing within the automation installation;

- The minimum and maximum transport time - there were determined by measuring the time needed for a product subjected to decontamination, to pass a length of the transport system, in terms of maximum and minimum rotational speed of the driving system.

In order to determine the intensity of non-ionizing ultraviolet radiation UV-C, there were performed measurements using a set of tools, sglux brand, Germany, comprising of the following elements: an intensity sensor for ultraviolet radiation, calibrated for the UV-C spectrum (UV Sensor "UV-Water-D"), a communication interface between the sensor and the laptop ("DIGIBOX" - CAN-to-USB converter) and a data acquisition software for the radiation intensity and air temperature, based on LabView programming environment ("DigiLog").

Experimentarea a avut ca obiectiv determinarea indicilor energetici si indicilor calitativi de lucru ai instalatiei de decontaminare. In acest scop, s-au luat in considerare urmatorii parametri:

- turatia minima si maxima a sistemului de actionare a transportorului - s-au determinat prin varierea frecventei curentului de alimentare a motoreductorului, prin intermediul convertizorului de frecventa existent in cadrul instalatiei de automatizare a echipamentului tehnic;

- timpul minim si maxim de transport - s-au determinat prin masurarea duratei in care un produs supus decontaminarii, parcurge o lungime a sistemului de transport, in conditii de turatie maxima si minima a sistemului de actionare;

In vederea determinarii intensitatii radiatiei neionizante ultraviolete UV-C, s-au realizat masuratori utilizand un pachet de instrumente de masura (fig. 2) marca *sglux*, Germania, avand in componenta urmatoarele echipamente: un senzor de intensitate a radiatiei ultraviolete, calibrat pentru spectrul UV-C (UV Sensor „UV-Water-D”), o interfata de comunicatie intre senzor si laptop („DIGIBOX” – CAN-to-USB converter) si un software pentru achizitia datelor privind intensitatea radiatiei si temperatura aerului, bazat pe mediul de programare LabView („DigiLog”).

Fig. 2 - Measuring instruments for UV-C radiation intensity

There were performed determinations at different distances from the source of radiation (50 mm, 75 mm, 100 mm and 125 mm), under a lamp and also in the space between two adjacent UV-C lamps. The first objective of the research was to investigate if the radiation intensity is homogenous, as well under the lamps, as between the two adjacent lamps, with or without the aluminium deflector for the lamps (a semicylindrical aluminium sheet). The second objective was to highlight the influence of the distance on the intensity of emitted UV-C radiation. Also, there were calculated the UV-C radiation doses, according to the measured radiation intensity and its duration of application, using the equation (1). The durations of application for the UV-C radiation were considered to be the minimum and maximum time that a product needs to pass through the transport system of the installation.

S-au efectuat măsurători la diferite distante fata de sursa de radiatie (50 mm, 75 mm, 100 mm si 125 mm), sub o lampa si de asemenea, in spatiul dintre doua lampi UV-C alaturate. Primul obiectiv al cercetarii sa se investigheze daca intensitatea radiatiei este omogena, atat sub lampi cat si intre doua lampi alaturate, cu sau fara deflectorul din aluminiu, pentru lampi (o tabla semicilindrica din aluminiu). Al doilea obiectiv a fost punerea in evidenta a influentei distantei asupra intensitatii radiatiei UV-C emise. De asemenea, s-au calculat dozele de radiatie UV-C, conform intensitatii masurate a radiatiei si duratei de aplicare, folosind ecuatia (1). Durata de aplicare a radiatiei UV-C s-a considerat a fi timpul minim si timpul maxim de care are nevoie un produs pentru a parcurge sistemul de transport al instalatiei.

$$D = I \cdot t \text{, [mWs/cm}^2\text{]} \quad (1)$$

RESULTS

After carrying out experimental researches on the installation for decontamination, there were achieved a series of results regarding the energetic indices and qualitative indices of the decontamination installation (tables 3, 4 and 5).

REZULTATE

Dupa efectuarea cercetarilor experimentale asupra instalatiei de decontaminare, s-au obtinut o serie de rezultate privind indicii energetici si indicii calitativi ai instalatiei de decontaminare (tabelele 3, 4 si 5).

Table 3

Energetic indices of the decontamination installation IDPH /

No.	Parameter	Measure unit	Parameter values determined from tests
1.	The length of the transport system	*mm*	1620
2.	The minimum rotational speed of the driving system of the conveyor	*rpm*	5.5
3.	The maximum transport time	*s*	45
4.	The minimum transport speed	*m/s*	0.036
5.	The energy consumption of the whole installation at minimum transport speed	*kWh*	0.335
6.	The maximum rotational speed of the driving system of the conveyor	*rpm*	72
7.	The minimum transport time	*s*	2.93
8.	The maximum transport speed	*m/s*	0.55
9.	The energy consumption of the whole installation at maximum transport speed	*kWh*	0.643

Table 4

The influence of aluminium deflector on the intensity of UV-C radiation

No.	Distance from the source of radiation [mm]	The intensity of UV-C radiation [W/m^2]			
		Under the lamp		Between two adjacent lamps	
		Without deflector	With deflector	Without deflector	With deflector
1.	50	37.66	64.01	59.51	64.04
2.	75	31.42	57.40	37.72	57.41
3.	100	27.16	55.52	31.46	55.53
4.	125	25.32	51.95	26.43	53.78

Table 5

Qualitative indices of the decontamination installation

No.	Parameter	Measure unit	Parameter values determined from tests			
1.	The distances from the source of radiation	*mm*	125	100	75	50
2.	The intensity of UV-C radiation	*W/m^2*	52.87	55.53	57.41	64.03
3.	The minimum UV-C radiation dose, according to the minimum transport time	*mWs/cm^2*	15.45	16.26	16.82	18.75
4.	The maximum UV-C radiation dose, according to the maximum transport time	*mWs/cm^2*	238.05	249.75	258.30	288.00

The radiation intensity values from table 5 represent the average of the values obtained with deflector, under the lamp and between the lamps. The minimum and maximum doses at various distances from the source of UV-C radiation were calculated based on relation (1), considering the minimum and maximum time that a product needs to pass through a length of the transport system.

Figures 3, 4 and 5 show the influence of the aluminium deflector on the intensity of UV-C radiation, under the lamp and between lamps.

Figure 6 shows the variation of the radiation intensity with the distance from the source.

Valorile intensitatii radiatiei din tabelul 5 reprezinta media valorilor obtinute, in prezenta deflectorului, sub lampa si intre lampi. Dozele minima si maxima la diferite distante fata de sursa de radiatie UV-C au fost calculate pe baza relatiei (1), tinand seama de timpul minim si timpul maxim de care are nevoie un produs pentru a parcurge lungimea sistemului de transport.

Figurile 3, 4 si 5 prezinta influenta deflectorului de aluminiu asupra intensitatii radiatiei UV-C, sub lampa si intre lampi.

Figura 6 prezinta variatia intensitatii radiatiei cu distanta fata de sursa.

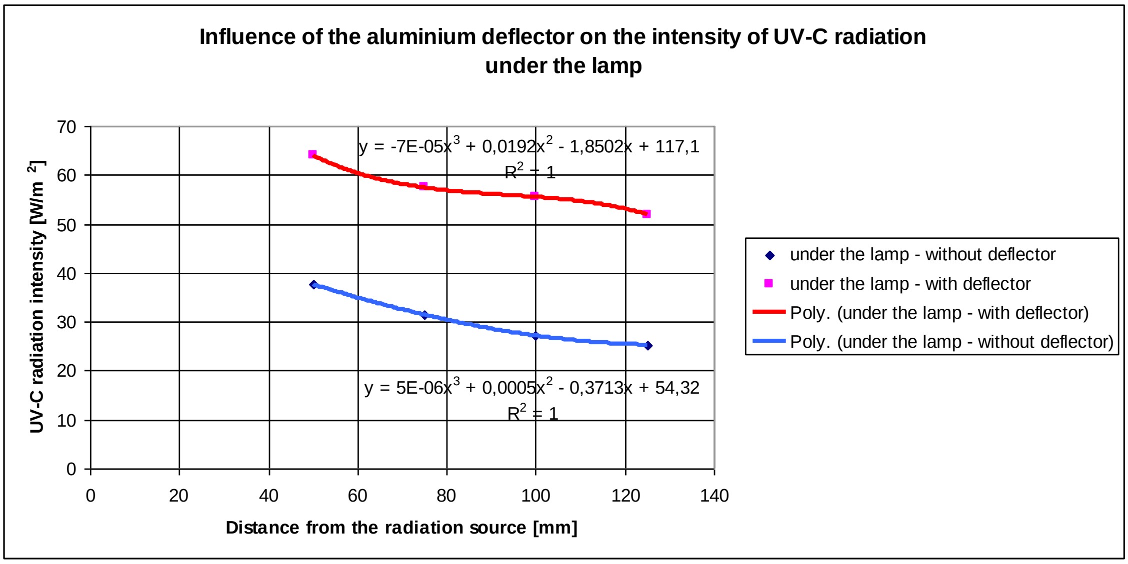

Fig. 3 - Influence of the deflector on the intensity of UV-C radiation under the lamp

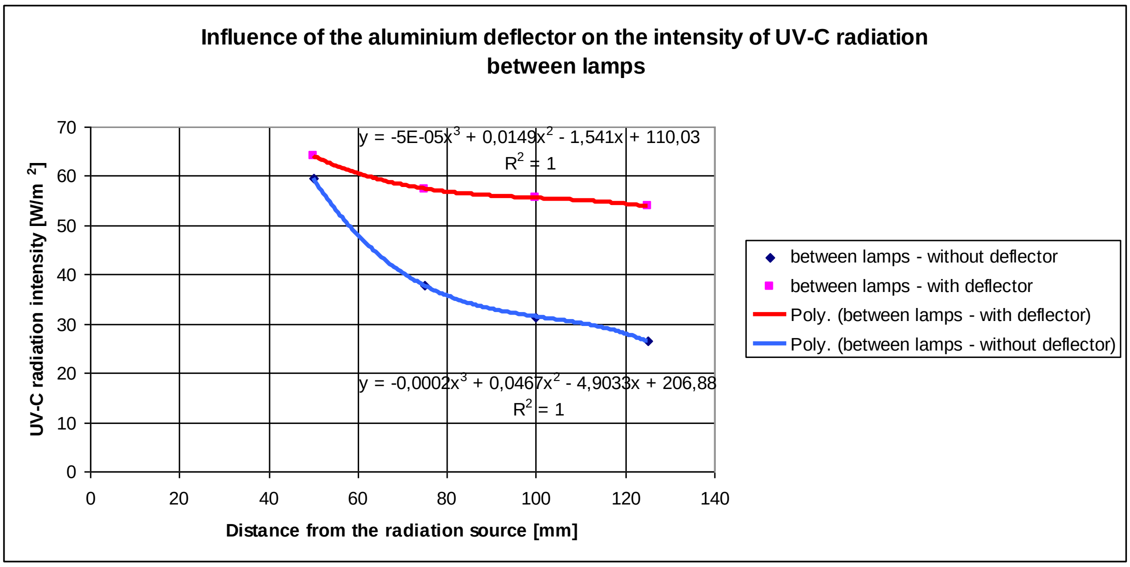

Fig. 4 - Influence of the deflector on the intensity of UV-C radiation between lamps

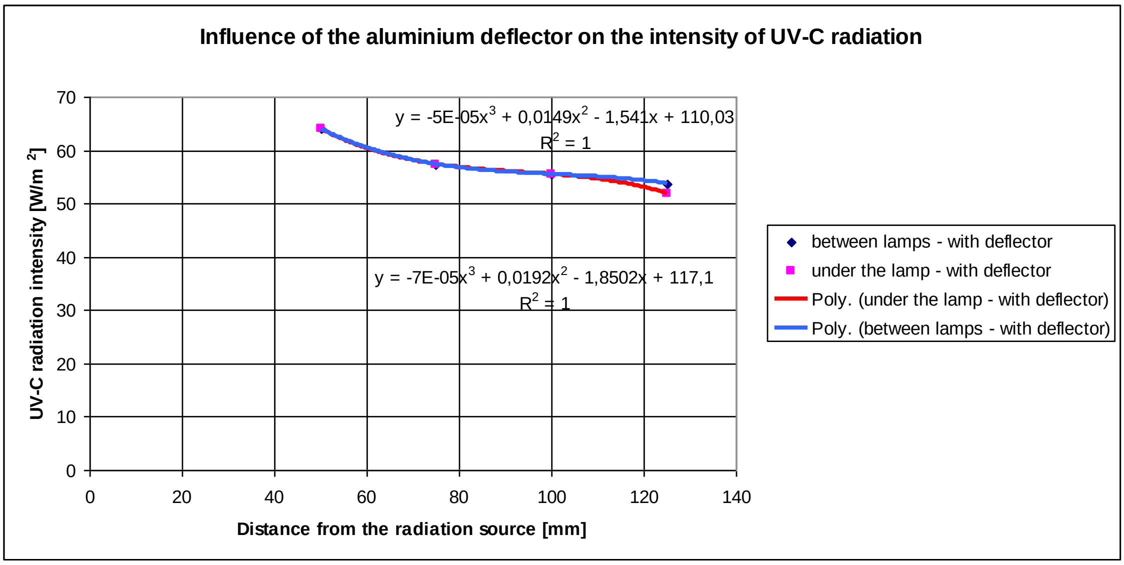

Fig. 5 - Influence of the deflector on the intensity of UV-C radiation

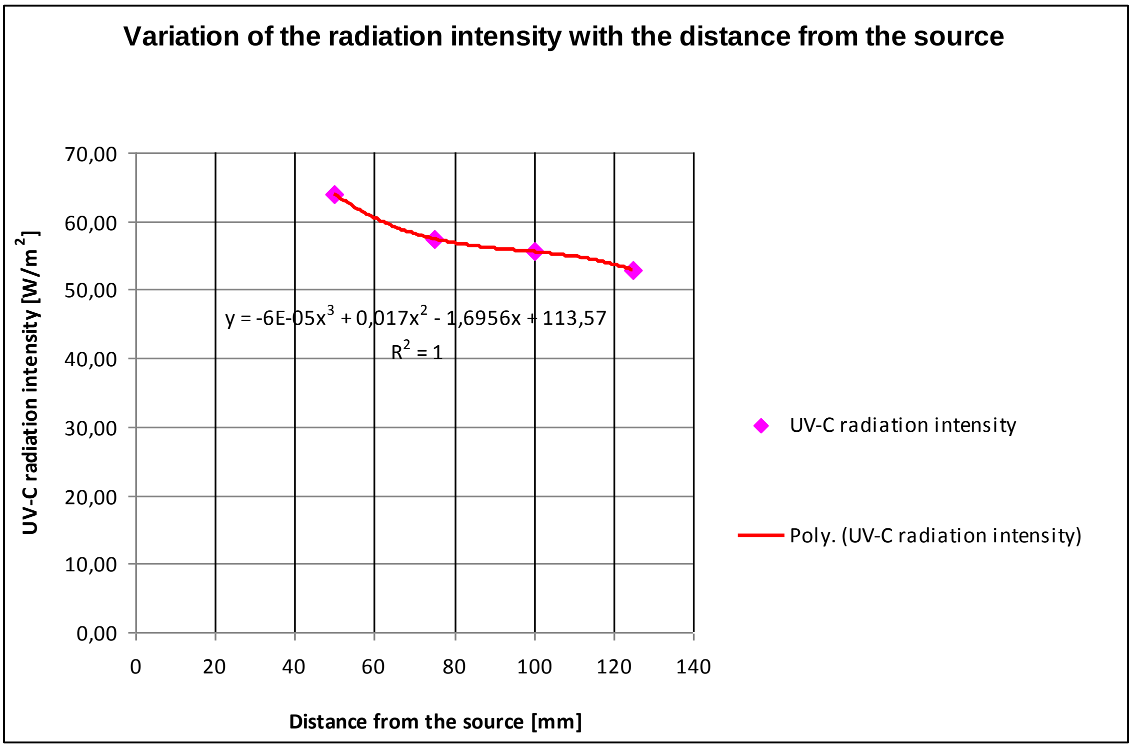

Fig. 6 - Variation of the radiation intensity with the distance from the source

Linear regression performed using Excel, allowed the identification of a third degree polynomial function, which estimates the variation of the radiation intensity depending on the distance from the source, with a maximum coefficient of determination.

Figure 7 shows the variation of minimum and maximum dose of UV-C radiation with the distance from the source of radiation.

Regresia liniara realizata cu ajutorul programului Excel, a permis identificarea unei functii polinomiale de gradul 3 care estimeaza variatia intensitatii radiatiei in functie de distanta fata de sursa, cu un coeficient de determinare maxim.

In figura 7 se prezinta variatia dozei minime si maxime de radiatie UV-C cu distanta fata de sursa de radiatie.

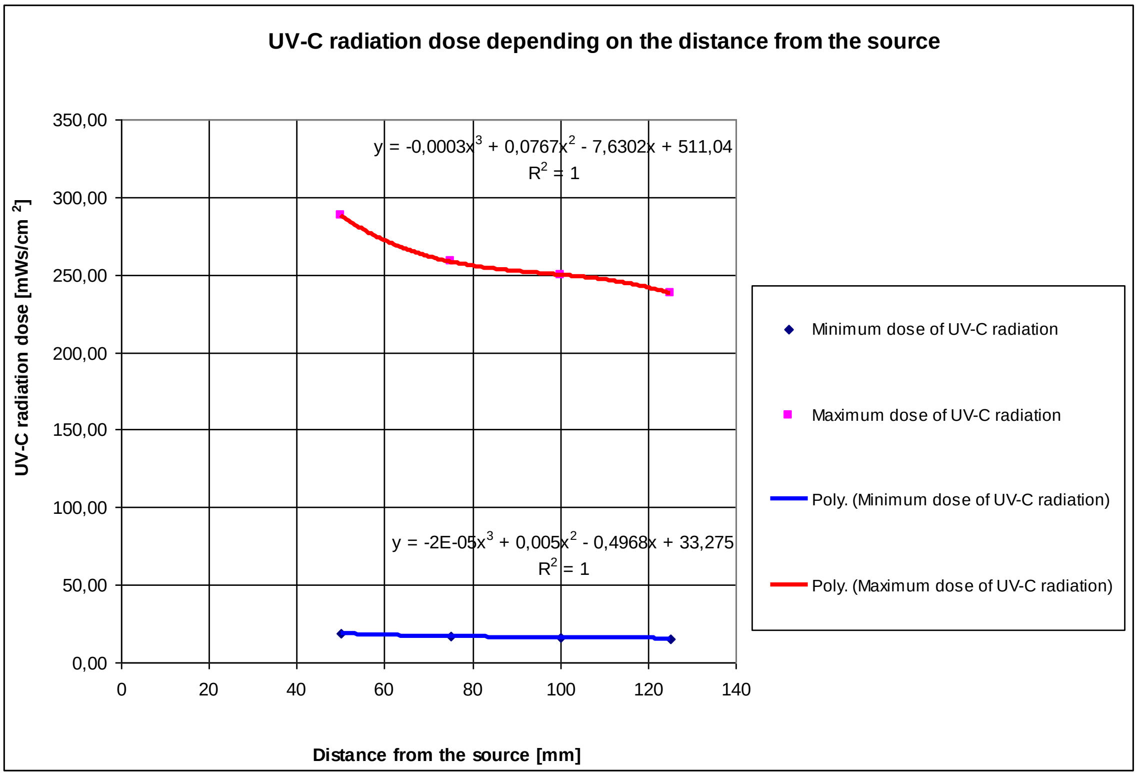

Fig. 7 - Variation of minimum and maximum dose of UV-C radiation with the distance from the source

Also, using linear regression was identified a third degree polynomial function, which estimates the variation of UV-C radiation dose depending on the distance from the source, with a maximum coefficient of determination.

Some aspects during the determination of the energy indices and qualitative indices of the decontamination installation, are shown in figures 8 and 9.

De asemenea, cu ajutorul regresiei liniare s-a identificat o functie polinomiala de gradul 3 care sa estimeze variatia dozei de radiatie UV-C in functie de distanta fata de sursa, cu un coeficient de determinare maxim.

Cateva aspecte din timpul determinarii indicilor energetici si indicilor calitativi ai instalatiei de decontaminare, sunt prezentate in figurile 8 si 9.

Fig. 8 - The determination of the energy indices of the decontamination installation

Fig. 9 - The determination of the qualitative indices of the decontamination installation

CONCLUSIONS

Analyzing the data obtained, regarding the use of aluminium deflector for the UV-C lamps, it is found that its use increases the radiation intensity by 70 % - 105 % under the lamp and by 8 % - 103 % between lamps. Also it conducts to the obtaining of a homogenous distribution of UV-C radiation on the working width of the installation, with a variation index of the intensity between 0.01 % and 2.45 %.

Following the analysis of the obtained experimental data and the data contained in table 1, regarding the UV-C radiation doses recommended for the destruction of the most common potentially pathogenic microorganisms existing on the exterior surfaces of the horticultural products, it is found that the experimented decontamination installation has the capability to achieve quality indices superior to the recommendations in table 1. However, although the installation is able to provide radiation doses higher than those shown in table 1, the product subjected to decontamination receives only half the dose, relative to its entire surface. This statement was set forth taking into account the simplifying assumption that, at a certain moment in time, only the upper half of the product will be exposed to UV-C radiation, the other half being shadowed. Considering this hypothesis, the installation still achieves a destruction rate of 90% of the most resistant pathogens presented in table 1, even in a single pass, adjusted at 125 mm distance from the radiation source, without having to repeat the exposure to UV-C radiation. For a destruction rate of 99 %, the installation is able to provide the necessary radiation doses for almost all the pathogens in the table 1, except for *Rhizopus nigricans* which needs a higher dose. The next phase of the research will be directed towards the measurement of the microbial count existing on the exterior surfaces of horticultural products.

Given the results obtained, the use of UV-C ultraviolet non ionizing radiation may be a viable solution as post harvest treatment method, in order to decrease the microbiological load from the exterior surfaces of horticultural products.

CONCLUZII

Analizand datele obtinute, in ceea ce priveste utilizarea deflectorului de aluminiu pentru lampile UV-C, s-a constatat faptul ca utilizarea acestuia creste intensitatea radiatiei cu 70 % - 105 % sub lampa si cu 8% - 103 % intre lampi. De asemenea, conduce la obtinerea unei distributii omogene a radiatiei UV-C pe latimea de lucru a instalatiei, cu un indice de variatie a intensitatii cuprins intre 0,01% si 2,45%.

In urma analizei datelor experimentale obtinute si a datelor continute in tabelul 1, in ceea ce priveste dozele de radiatie UV-C recomandate pentru distrugerea celor mai frecvente microorganisme potential patogene existente pe suprafetele exterioare ale produselor horticole, s-a constatat ca instalatia de decontaminare experimentata are capabilitatea de a atinge indici de calitate superiori recomandarilor din tabelul 1. Totusi, desi instalatia poate furniza dose de radiatie mai mari decat cele prezentate in tabelul 1, produsul supus decontaminarii receptioneaza numai jumatate de doza, raportat la intreaga sa suprafata. Aceasta afirmatie a fost enuntata luand in considerare ipoteza simplificativa conform careia la un anumit moment de timp, numai jumatatea superioara a produsului va fi expusa la radiatia UV-C, cealalta jumatate fiind umbrita. Luand in considerare aceasta ipoteza, instalatia inca poate atinge o rata de distrugere de 90 % a celor mai rezistenti agenti patogeni prezentati in tabelul 1, chiar dintr-o singura trecere, reglata la o distanta de 125 mm fata de sursa de radiatie, fara a fi nevoie sa se repete expunerea la radiatia UV-C. Pentru o rata de distrugere de 99 %, instalatia poate furniza dozele necesare pentru aproape toti agentii patogeni din tabelul 1, cu exceptia *Rhizopus nigricans* care necesita doze mai ridicate. Urmatoarea etapa a cercetarii va fi directionata catre determinarea numarului de microorganisme existente pe suprafetele exterioare ale produselor horticole.

Avand in vedere rezultatele obtinute, utilizarea radiatiei ultraviolete neionizante UV-C poate fi o solutie viabila ca si metoda de tratare post recoltare, in scopul micsorarii incarcaturii microbiene de pe suprafetele exterioare ale produselor horticole.

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