Processing zucchini (Cucurbita pepo L.) with low UV-C radiation

PORTELA, Mauro[1]; SILVA, Cristina L.M.[2];BRANDÃO, Teresa R.S.[2]; GONÇALVES, Elsa M.[3]; ABREU, M.[3]; OLIVEIRA, Antonio J.[4], Gaspar, Nelma P.[1] VIEIRA, Margarida C.[1]

[1] Escola Superior de Tecnologia Universidade do Algarve, Campus da Penha, 8005-139 Faro.
[2] Escola Superior de Biotecnologia Universidade Católica Portuguesa, R. Dr. António Bernardino de Almeida, 4200-072 Porto.
[3] Departamento das Indústrias Alimentares Instituto Nacional de Engenharia, Tecnologia e Inovação, Estrada do Paço do Lumiar, 1600-038 Lisboa.
[4] Friopesca Refrigeração de Aveiro, S.A. Av. Pedro Álvares Cabral Apart.9, 3834-908 Gafanha da Nazaré.

INTRODUCTION

Food Safety has become an important issue among food companies these days and a definite requisite for consumers especially in an efficiently controlled food safety farm-to-fork concept. Documented cases of various foodborne illness associated with fresh produce have increased substantially in recent years and major outbreaks have been linked to contamination by common foodborne pathogens such as *Salmonella*, *Listeria monocytogenes*, *Shigella spp.*, *Escherichia coli* and *Enterococcus faecalis*.

Although current techniques in processing fresh vegetables have improved the overall quality and extended shelf life there is a need for novel preservation practices for fresh processed vegetables quality attributes during all the distribution chain (Allende et al, 2003*)*.

Ultraviolet radiation, UV-C, (200-280 nm) is sometimes called the germicidal range due to being lethal to most microorganisms. Numerous studies have demonstrated the effectiveness of low UV-C radiation from germicidal lamps in reducing deterioration of produce by reducing microbial spoilage and putrefaction on onions (Lu *et al*, 1987), carrots (Mercier and Arul, 1993), tomatoes (Liu *et al*, 1993), red apples (Yaun, *et al*, 2004), strawberries (Marquenie et al., 2002), table grapes (Nigro *et al*, 1998) and lettuce (Allende *et al*, 2003).

UV-C radiation may be used in many ways in a food processing plant, namely for disinfection of contact surfaces, rinsing water or air in a preparation area. The equipment is relatively inexpensive, but operation is subject to certain safety precautions. (Bintsis *et al*, 2000). High intensity UV-C lamps have become widely available and their destruction potential for surface bacteria on foods has been enhanced by concentrated peak radiation at 253.7 nm, a significant germicidal point of the electromagnetic spectrum.

UV-C involves direct alteration of microbial DNA due to its UV light absorption, causing cross-linking between neighbouring pyrimidine nucleoside bases (thymine and cytosine) in the same DNA strand. Due to the mutated base, formation of the hydrogen bonds to the purine bases on the opposite strand is impaired. DNA transcription and replication is thereby blocked, compromising cellular functions and eventually leading to cell death. The amount of cross-linking is proportional to the amount of UV exposure. The level of mutations that can be reversed depends on the ability of target microorganisms to repair the photochemical damage to DNA (photoreactivation). Once exceeded the threshold of cross-linking, cell death occurs (Miller *et al*, 1999).

The overall objective of this study was to analyze the bactericidal effects of UV-C light at 253.7 nm on zucchini and to evaluate its future potential as a microbiological hurdle on fresh and processed cucurbitaceous vegetables.

Keywords: UV-C radiation; photoreactivation; microbial inactivation; zucchini

MATERIAL AND METHODS

Sample preparation

Fresh zucchini (Cucurbita pepo L.) where purchased daily from local suppliers. To study surface contamination of the product, both conical tips of the vegetable were discarded and samples were cut in triangular prisms of approximately 10 grams, from the surface inwards.

UV-C treatment

The UV-C disinfection chamber consisted of rectangular box with four TUV TL mini 8W lamps (Philips) were suspended horizontally on the inside (Fig.1 and Fig.2). Samples were placed on an acrylic tray at 30 cm from the UV-C lamps to simulate a processing line. To avoid temperature increases, a fan was placed on the top section of the chamber, above the lamp bank. Samples of zucchini were processed for various exposure times and different energy discharges of UV-C radiation.

The different UV-C treatments performed in the present study are further described in Fig.3, along with the respective microbiological enumerations performed for each type of sample.

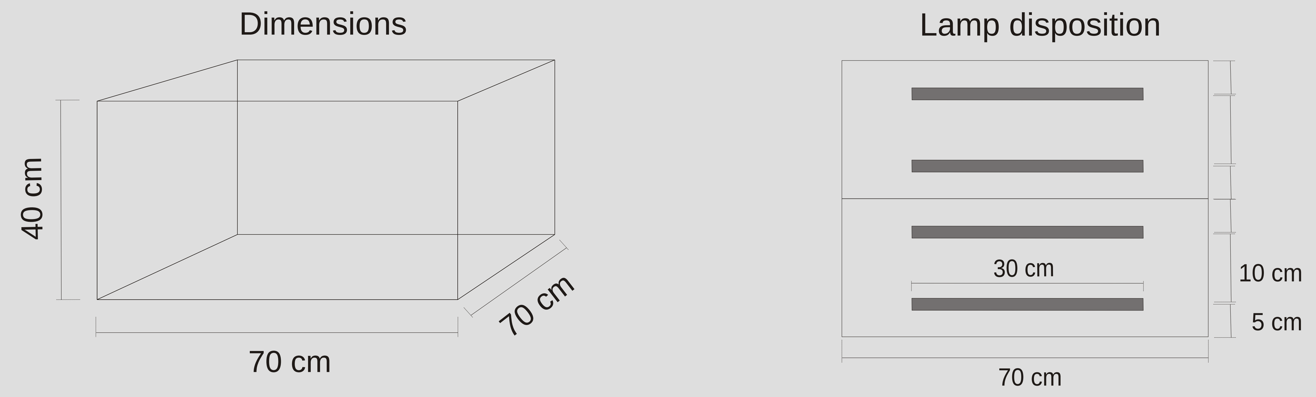

Fig. 1 – UV-C disinfection chamber dimensions and lamp disposition

Fig. 2 – UV-C disinfection chamber

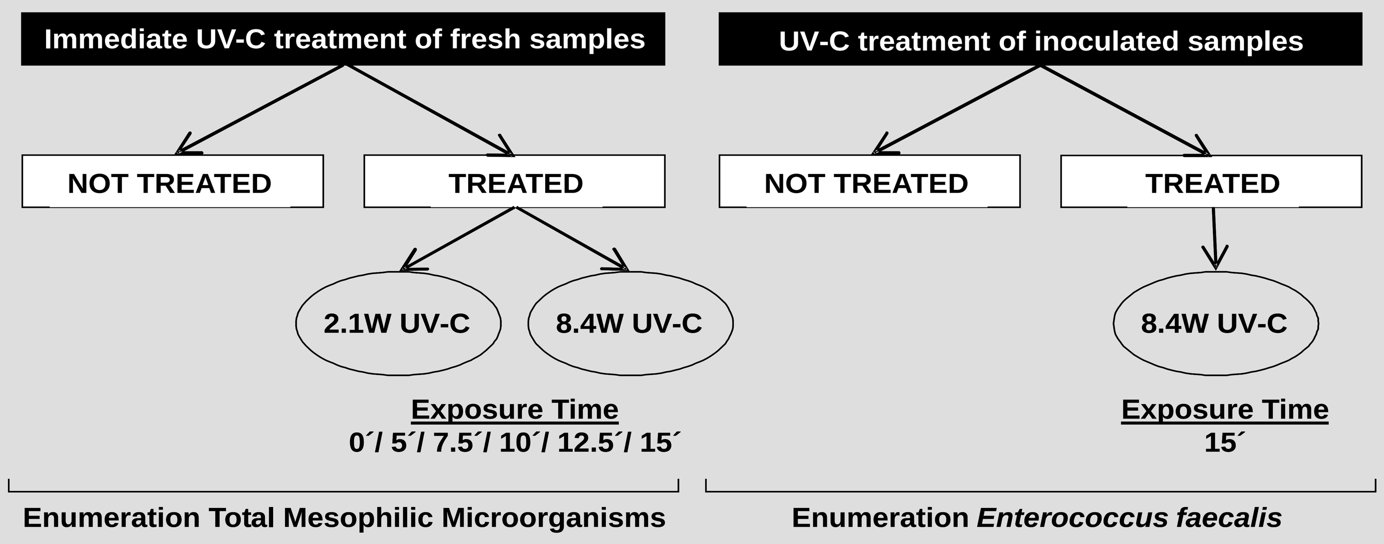

Fig. 3 – Overall combinations of radiation doses and exposure times studied

RESULTS AND DISCUSSION

Mesophilic microorganisms

Total populations of mesophilic microorganisms present in samples were generally reduced by UV-C exposure especially at stronger doses of UV-C radiation and maximum exposure times. However, effects of ultraviolet exposure did not have a linear evolution with respect to exposure time, especially between 7.5 and 12.5 min (Fig. 4).

Microbial populations present showed significant resistance to lower doses of UV-C radiation, and only above 10 min of exposure time did enumerated colonies start to diminish. Nevertheless, after 12.5 min results were not conclusive between tests. This type of behaviour may support the prediction that at certain levels of UV-C exposure, surviving or injured bacteria may have the ability to resist ultraviolet light and repair damaged DNA by photoreactivation.

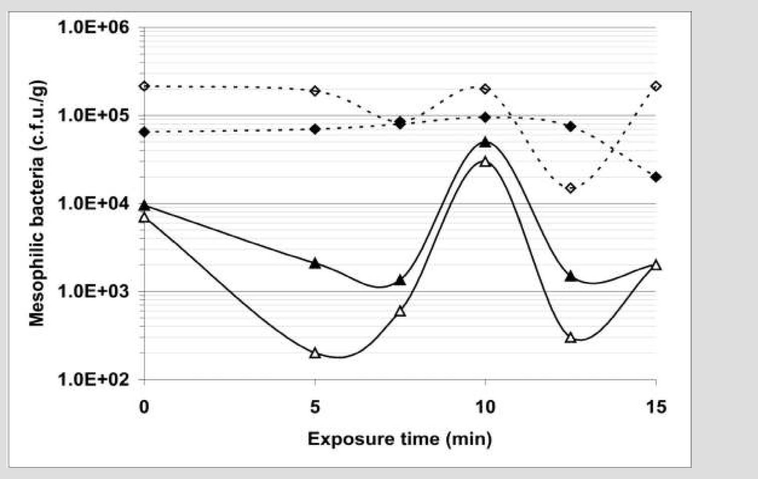

Fig. 4 – Mean counts of total mesophilic aerobic on freshly cut zucchini samples at different UV-C treatments: continuous lines 2.1 W UV-C; dashed lines -- 8.4 W UV-C

Enterococcus faecalis ATCC 29212

Artificially contaminated samples of whole Cucurbita pepo vegetables showed objective evidence of UV-C lethality with regard to *E. Faecalis*. The data collected from microbiological enumeration showed that approximately 2 logarithmic reductions of this target microorganism were achieved (Fig. 5).

Despite no outputs regarding photoreactivation ability during the 15 minute period of exposure, these results are positive with regard to two aspects: 1) as far as we know, no previous studies of UV-C inactivation had clearly focused on *E. faecalis*; 2) *E. faecalis*, normally an indicator of faecal contamination and considered in past years as the main target microorganism during the design of UV disinfection processes for natural mineral water (Urakami et al, 1997) may be of importance with regard to the design of UV disinfection processes for fresh produce.

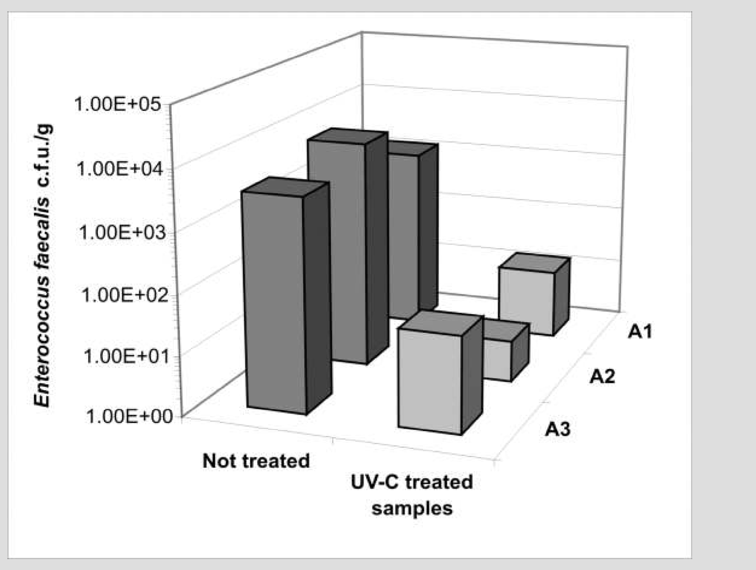

Fig. 5 – Mean microbial counts of E. faecalis achieved with whole zucchini after artificial contamination: no treatment grey bares; treated with 8.4 W UV-C for 15 min light-grey bares

CONCLUSIONS

In most samples analyzed, UV-C exposure significantly reduced microbial activity. It was also evidenced that the number of microorganisms with photoreactive ability may decrease substantially with prolonged exposure times (as observed by short tailing at the end of inactivation graphs) although further studies are necessary on this issue.

Our present findings reveal that due to dispersed results obtained when assaying total populations of mesophilic microorganisms, and considering that effects of UV-C light may vary somewhat between different microorganisms, the present work may serve as evidence that indicator microrganisms and pathogens alike should be individually studied in relation to UV-C inactivation. Microbial reduction can also be correlated with precise UV-C radiation doses (mW/cm2) in order to confirm results attained in the present work.

Another issue was enhanced in this study, photoreactivation should definitely be taken into consideration to a large extent during the design of the UV-C disinfection process, especially at low radiation doses and short exposure times.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support through Programa Operacional Agricultura e Desenvolvimento Rural Projecto AGRO nº822 (Novas Tecnologias de Processamento de Hortofrutículas Congelados EMERCON).

REFERENCES

- ALLENDE, A.; ARTéS, F. 2003. UV-C radiation as a novel technique for keeping quality of fresh processed 'Lollo Rosso' lettuce. *Food Research International*, 36, 739746.
- BINTSIS, T.; LITOPOULOU-TZANETAKI, E.; ROBINSON, R. K. 2000. Existing and potential applications of ultraviolet light in the food industry - a critical review. *Journal of the Science of Food and Agriculture*, 80, 637645.
- LIU, J.; STEVENS, C.; KHAN, V. A.; LU, J. Y.; WILSON, C. L.; ADEYEYE, O.; KABWE, M. K.; PUSEY, P. L.; CHALUTZ, E.; SULTANA, T.; DROBY, S. 1993. Application of ultraviolet-C light on storage rots and ripening of tomatoes. *Journal of Food Protection*, 56(10), 868872.
- LU, J. Y.; STEVENS, C.; YAKABU, P.; LORETAN, P. A.; EAKIN, D. 1987. Gamma, electron beam and ultraviolet radiation on control of storage rots and quality of Walla Walla onions. *Journal of Food Processing and Preservation*, 12, 5362.
- MARQUENIE, D.; MICHIELS, C. W.; GEERAERD, A. H.; SCHENK, A.; SOONTJENS, C.; VAN IMPE, J. F.; NICOLAï, B. M. 2002. Using survival analysis to investigate the effect of UV-C and heat treatment on storage rot of strawberry and sweet cherry. *International Journal of Food Microbiology*, 73, 187196.
- MERCIER, J.; ARUL, J.; JULIEN, C. 1994. Effect of food preparation on the isocoumarin, 6-methoxymellein, content of UV-treated carrots. *Food Research International*, 27: 401404.
- MILLER, R.; JEFFREY, W.; MITCHELL, D.; ELASRI, M. 1999. Bacterial responses to ultraviolet light. *American Society of Microbiology*, 65(8), 535541.
- NIGRO, F.; IPPOLITO, A.; LIMA, G. 1998. Use of UV-C light to reduce Botrytis storage rot of table grapes. *Postharvest Biology and Technology*, 13, 171181.
- URAKAMI I.; YOSHIKAWA M.; UDAGAWA J.; SUGAHARA T. 1997. Ultraviolet light disinfection of natural mineral water. *Journal Antibact Antifung Agents Japan*, 25, 697-701.
- YAUN, B. R.; SUMNER, S. S.; EIFERT, J. D.; MARCY, J. E. 2004. Inhibition of pathogens on fresh produce by ultraviolet energy. *International Journal of Food Microbiology*, 90, 18.