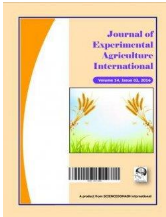

Journal of Experimental Agriculture International

20(6): 1-7, 2018; Article no.JEAI.38521
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Ultraviolet-C Radiation on *Psidium cattleyanum* L. Conservation and Its Influence on Physico-chemical Fruits Characteristics

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Authors' contributions

This work was carried out in collaboration between all authors. Author TFA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. All other authors contributed equally in data collection, manage the study analyses and discussion. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2018/38521
Editor(s):
(1) Claude Bakoume, Professor, Institute of Agricultural Research for Development, Cameroon.
Reviewers:
(1) Perihan Guler, Kırıkkale University, Turkey.
(2) Mohini Chetan Kuchekar, Pune university, India.
(3) Ojo Omolara Comfort, University of Lagos, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/23380

Original Research Article

Received 30th November 2017
Accepted 15th February 2018
Published 28th February 2018

ABSTRACT

Aims: The present study aimed to evaluate UV-C radiation influence on physicochemical and phytochemical characteristics of yellow cherry guava fruits.
Study Design: The staining data obtained were submitted to analysis of variance (ANOVA), being the results compared with each other by the test of Tukey *(P = .05)*. The other data were submitted to the ANOVA *(P = .05)*, and when there was a significant difference, the means were compared by the Hartley Test *(P = .05)*.
Place and Duration of Study: The study was developed in March 2017 at Palma Agricultural Center and Post-Harvest and Fruit Quality Laboratory at LabAagro, at Federal University of Pelotas (UFPel).
Methodology: *Psidium cattleyanum* fruits near the maturity point were harvested in the orchard. The fruits were divided into a completely randomized design, with four treatments, which had four

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replicates composed of fifteen samples each. Evaluations and UV-C radiation were performed at intervals of four days from zero to 12 d, being two minutes the exposure time of the fruits to UV-C radiation in each application, fruits were stored in a cold chamber at 4°C temperature and relative humidity of 85-90%. The variables analyzed were skin colour, fruit length, fruit diameter, soluble solids (SS), initial fruit weight, final fruit weight, mass loss, hydrogen ionic potential (pH) and titratable total acidity.

Results: UV-C radiation usage did not significantly interfere with the physicochemical characteristics of the evaluated yellow cherry guava fruits.

Conclusion: The use of UV-C radiation associated with cold-chamber storage maintained fruit quality for a period significantly longer compared to storage at room temperature.

Keywords: Yellow cherry guava; native fruits; post-harvest; UV-C; cold storage.

1. INTRODUCTION

The yellow cherry guava (*Psidium cattleyanum* L.) is a fruit that arouses the pharmaceutical industry interest and also of the nutritional area due to its rich composition, as evidenced by studies about its numerous health benefits. It has a high content of vitamin C and has an exotic flavor, reminiscent of guava, being well accepted by consumers [1]. However, among the factors that hinder *in natura*l fruits commercialization of this species is the reduced shelf life, because under room temperature the fruit's durability is one to two days (d) [2].

In spite of having a large occurrence in Rio Grande do Sul state, the yellow cherry guava is little explored commercially, being more restricted to domestic orchards. The high fruits perishability limits their cultivation, besides the scarce literature, requiring more precise studies on the subject [3]. Certain fruit damages, such as browning and rot appearance are associated with water content and intense fruit metabolism [3]. In order to produce yellow cherry guava commercial, crops it is necessary to develop marketing strategies to increase fruit production and consumption [4].

Alternative studies to increase fruits and vegetables shelf life has intensified greatly in recent years. A method that is gaining prominence nowadays is the use of ultraviolet C (UV-C) radiation, as it acts by inactivating microorganisms [5] without altering the irradiated food flavor, besides its application does not leave toxic residues.

The use of UV-C associated with other techniques, such as refrigerated storage, reduces pathogens incidence in plant tissue. Therefore, it minimizes mainly the rot risks, allowing the fruits to maintain their sensorial and nutritional attributes for a longer period of time [6]. The main limitation of this method in post-harvest is related to the low feed penetration index [7]. Thus, the disinfection is only superficial, indicating, therefore, its application as a phytosanitary control measure.

Refrigeration is the most effective method in post-harvest conservation as it works by reducing fruits respiration process. Consequently, it slows down the metabolic rate and senescence events, such as the ethylene production and the water loss, which occur in a reduced form. Thus, fruits and vegetables that are stored in a refrigerated environment and with adequate humidity control maintain the post-harvest quality for a longer period [8,9]. However, regardless of the post-harvest method used, the initial fruit quality will not improve. This technology efficiency is directly linked to the fruit management during the plant cycle, harvesting techniques and its management after harvested [8].

The objective of the present work was to evaluate the influence of UV-C radiation on the fruits physicochemical characteristics harvested near the maturation point.

2. MATERIALS AND METHODS

The present experiment was developed at the Laboratory of Fruit Quality of LabAgro / FAEM of the Federal University of Pelotas - UFPel. Yellow chery guava near the maturation point was collected in the orchard at Palma Agricultural Center, in March 2017. The fruits were selected, excluding those with mechanical damage or pest attack, and stored in plastic trays inside an ultraviolet radiator equiped with Phillips® brand UV-C lamps, 30 W of power. Fruits exposure time to the radiation was for two minutes in each application, resulting in an intensity of

2.17 kJ m^{-2}. In this way, fruits were irradiated on all faces, and after application, they were taken to the cold room and kept at 4°C temperature and 85-90% relative humidity.

The experimental design was completely randomized, and consisted of four treatments with four replicates, each repetition composed of 15 fruits.

UV-C applications, as well as fruit quality assessments, were performed in stages at four days intervals until completion of 12 d of storage. In the first step, on the harvest day, Treatment 1 (control) consisted of fruits evaluated immediately after harvest and not irradiated. The other treatments received the UV-C application and were taken to the cold room at 4°C. In the second stage, at four days of storage, Treatment 2 was evaluated, and the other Treatments (T3 and T4) received UV-C application, returning to storage. In the third stage, at eight days after harvest, T3 was evaluated and T4 received another application, returning to the chamber and being evaluated only when it completed 12 days of storage. Thus, T1 did not receive UV-C radiation; T2 was stored for four days and irradiated only once; T3 was stored for eight days and irradiated twice and T4 was stored for 12 d, receiving three UV-C applications.

The analyzed variables were:

Fruit skin color: A measurement performed with a Minolta CR-300 colorimeter, equiped with light source D65, at two surface locations in all fruits of each repetition, with readings of the L* coordinates indicating luminosity (from black to white), a* (indicates change from green to red) and b* (indicates blue to yellow variation). With a* and b* values, the hue angle (°h) was calculated, which defines the colour tone and the chroma, as well as the colour intensity;

Fruit length: Variable measured with aid of graduated ruler, measuring externally each fruit in vertical, obtained result was expressed in centimeter (cm);

Fruit diameter: Variable measured horizontally in the fruit in the median region, obtained with the aid of a digital caliper, obtained result was expressed in cm;

Soluble solids (SS): Variable obtained with a digital refractometer brand Atago, measure expressed in ºBrix of juice;

Mass Loss: Variable obtained considering the initial and final weight of each sample, result expressed in percentage (%);

Hydrogen ionic potential (pH): A variable obtained with a pH meter brand Quimis®, according to the methodology described by IAL [10];

Titratable total acidity: Variable obtained by titration with 0.1 N sodium hydroxide (NaOH), where 1 mL of fruit juice was diluted in 90 mL of distilled water, titrating with the hydroxide to the point of (pH 7.9-8.2). The result is expressed in g of citric acid per 100 g of fruit pulp.

Data were submitted to analysis of variance (ANOVA). The Hartley test was applied at 5% probability to test the data normality. When a treatment effect was detected, treatments mean values for the variable considered were compared by the Tukey test at 5% probability.

3. RESULTS AND DISCUSSION

According to the ANOVA result (Table 1), treatments showed a significant difference for mass loss (ML) only. Therefore, there was no need to apply the Tukey test to compare means in the other variables.

Table 2 shows the mean values of physical characteristics of the fruits, resulting from the treatment applied.

Table 1. Analysis of variance (ANOVA) and coefficient of variation (CV) of the variables analyzed

	D (cm)	L (cm)	ML (%)	SS (g citric acid 100 g-1 of pulp)	TA (%)	pH
F	0.580	0.550	8.240	0.880	2.010	3.220
P > F	0.640	0.655	0.003	0.478	0.166	0.061
CV (%)	6.129	5.119	57.936	10.202	10.732	3.089

Table 2. Variables: Diameter (D), length (L) and mass loss (ML) of yellow cherry guava fruits submitted to different number of UV-C radiation and to different number of days of storage in a cold room at 4°C

Treat.	D (cm)	L (cm)	ML (%)
T1 31/03 (control)	39,32 ^{ns}	41,85 ^{ns}	0,00 ^{c}
T2 04/04	37,54 ^{ns}	41,28 ^{ns}	5,75 ^{b}
T3 08/04	39,57 ^{ns}	42,09 ^{ns}	16,21 ^{a}
T4 12/04	38,81 ^{ns}	40,32 ^{ns}	10,96 ^{ab}

Means accompanied by the same lowercase letter do not differ from each other according to Hartley test at 5% probability

There was no significant difference between treatments for fruit diameter and length. Regarding mass loss (%), T2 (fruits stored for four days after irradiation) presented lower value for this parameter, disregarding T1 (not irradiated and not stored fruits), since its evaluation occurred immediately after the harvest. Evangelista [11], studying the influence of UV-C radiation on *Plinia cauliflora* cultivar 'Sabará', observed that mass loss occurred in all treatments, including those not irradiated fruits. T3 had the highest value of mass loss, more than 16%.

This process is related to cell water content decrease that occurs by the transpiration process. Mota et al. [12] stated that water loss during this metabolic event was common in ripening plants. As a result of this change, the fruit loses turgidity, causing visual depreciation and, consequently, a reduction of its commercial value [8].

T4 had lower mass loss than T3, but did not differ statistically from T2 and T3. Sanches et al. [13] studying the relationship between UV-C irradiation time and storage day, observed that the losses were about 5% at the end of nine-day-experiment, whereas fruits of the control treatment, without UV-C application, lost more than 9%. Table 3 shows the fruits chemical characteristics values.

These parameters' stability can be related to the low storage temperature, according to Benato [14], this is the method considered more effective in maintaining fruits quality. In horticultural products, events such as respiration, transpiration, as well as ethylene biosynthesis and senescence are reduced when they are stored at 4°C [15]. Therefore, the reserves consumption is also lower, which justifies the subtle change in acid content, soluble solids and pH.

The results obtained for the chemical variables that did not show a significant difference were encouraging, since storage conditions aimed to allow maintaining fruit characteristics for a longer period than usual. According to Caldeira et al. [16] and Bezerra et al. [17] soluble solids, acidity and pH vary according to the genetic material, soil and local climatic conditions, as well as plant production cycle. The contents found are in accordance with those described by Rombaldi et al. [18] in a research that evaluated the genotype and harvest season influence on the phytochemical composition of red and yellow cherry guava fruits. In this study, the slightly higher values are justified by the fact that some fruits that composed the samples may have been harvested over mature, since they were chosen at random and the collected time coincided with the end of the production period.

Physical-chemical characteristics, in general, should not be significantly affected by UV-C radiation, since it acts superficially and does not penetrate the food. It is possible that UV-C radiation in plants could activate their defence mechanisms and induce the carotenoids metabolism [19], which according to Erkan et al. [20], are pigments that characterize the maturation process. Alothman et al. [21] and Shen et al. [22] stated that the increase in antioxidant activity caused by UV-C radiation had an influence on fruit senescence reduction.

Mean diameter was not affected significantly, remaining stable because of the relatively short storage period throughout the storage period. Table 4 presents the results of luminosity (L*), hue angle (°h) and Chroma (C*).

Evaluations regarding the skin colour indicated that the fruits initially had a lighter and brighter coloration compared to the values obtained in the final analyses. This assumption is taken from the luminosity (L*) values, however, throughout the storage, this variable did not present significant differences.

Table 3. Mean values of soluble solids (SS), titratable acidity (TA) and hydrogenation potential (pH) in yellow cherry guava fruits submitted to different number of UV-C radiation and to different number of days of storage in a cold room at 4°C

Treat.	SS (°Brix)	TA (g citric acid 100 g^{-1} of pulp)	pH
T1 31/03 (control)	14,1 ^{ns}	0,75224 ^{ns}	3,7 ^{ns}
T2 04/04	15,1 ^{ns}	0,81626 ^{ns}	3,72 ^{ns}
T3 08/04	15,8 ^{ns}	0,89628 ^{ns}	3,5 ^{ns}
T4 12/04	14,9 ^{ns}	0,78425 ^{ns}	3,62 ^{ns}

^{ns} *Non-significant mean values according to Hartley test at 5% probability*

Table 4. Luminosity (L*), hue angle (°h) and Croma (C*) resulting from the respective treatments

	Initial values			Final values		
	L*	Hue (°h)	C*	L*	Hue (°h)	C*
T1 (control)	62,81 ^{ns}	97,38 ^{ns}	41,47 ^{ns}	62,81 ^{ns}	97,38 ^{ns}	41,47 ^{ns}
T2	62,1 ^{ns}	98,71 ^{ns}	41,85 ^{ns}	59,59 ^{ns}	96,06 ^{ns}	44,47 ^{ns}
T3	62,95 ^{ns}	98,89 ^{ns}	43,10 ^{ns}	57,66 ^{ns}	92,90 ^{ns}	43,19 ^{ns}
T4	63,38 ^{ns}	97,01 ^{ns}	43,72 ^{ns}	59,9 ^{ns}	94,80 ^{ns}	45,46 ^{ns}

^{ns} *Means do not differ statistically from each other based on Tukey Test (P = .05)*

The values obtained through the hue (°h) angle showed that all fruits presented a yellow peel coloration without resulting in statistically significant differences. However, the final values showed a sharper staining compared to the initial values. In a study that subjected yellow cherry guava fruits to UV-C radiation for three and six minutes, respectively, Sanches et al. [13] observed that the yellow coloration of the fruits remained stable during the 12 d of storage, without presenting significant differences between the treatments; the authors attributed the carotenoid contents stability to fruit exposure to UV-C.

Chromaticity, or chroma (C*), expresses colour purity and homogeneity. Higher values indicate more homogeneous staining [23,24]. The results obtained indicate that all treatments in the present study did not present significant differences regarding the skin coloration homogeneity.

Further studies are needed to investigate whether fruits irradiation with UV-C had a significant influence on carotenoid content. In a study carried out with tomatoes submitted to UV-C radiation for two and three minutes, and stored for 21 d, Campos and Vietes [25] observed that they obtained higher carotenoid contents, differing from the control treatment.

4. CONCLUSION

UV-C radiation, along with refrigerated storage did not interfere with soluble solids content, pH, acidity and colour attributes of yellow cherry guava fruits. Therefore, refrigerated storage was efficient in maintaining postharvest quality of yellow cherry guava fruits during 12 D.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Silva EF, Araújo RL, Martins CSR, Martins LSS, Veasey EA. Diversity and genetic structure of natural populations of araçá (*Psidium guineense* SW.). Revista Caatinga. 2016; 29(1):37-44.
2. Vanin CR. Araçá amarelo: atividade antioxidante, composição nutricional e aplicação em barra de cereais. Dissertação de Mestrado em Tecnologia de Alimentos. Universidade Tecnológica Federal do Paraná. 2015;117. Portuguese.
3. Paglarini CS, Silva FS, Porto AG, Zela SP, Leite ALMP, Furtado GF. Efeito das condições de desidratação osmótica na qualidade de passas de araçá-pêra. Revista Brasileira de Tecnologia Agroindustrial. 2015;9(2):1945-1961. Portuguese.
4. Camelatto TS, Mello-Farias P, Malgarim MB, Maia LC. Obtenção de seleções de araçazeiro amarelo oriundos de progênies de plantas do sul do Rio Grande do Sul. Tese de Doutorado. Programa de Pós-

Graduação em Agronomia – Área de Concentração em Fruticultura de Clima Temperado. Universidade Federal de Pelotas. 2017;107. Portuguese.

5. Almeida RR, Campos JA. Conservação pós-colheita e avaliação da qualidade da pinha tratado com radiação UV-C e atmosfera modificada. Anais do Congresso de Ensino, Pesquisa e Extensão da UEG (CEPE) Inovação, Inclusão Social e Direitos. 2016;3. Portuguese. (Accessed 18 April 2017) Available:http://www.anais.ueg.br/index.php/cepe/article/view/8005/5490
6. Stevens C, Khan VA, Wilson CL. The effect of fruit orientation of postharvest commodities following low dose ultraviolet light-C treatment on host induced resistance to decay. Crop Protection. 2005;24(8):756-759.
7. Guedes A Maciel M, Novello D, Mendes GM, Cristianini M. Tecnologia ultravioleta para preservação de alimentos. Boletim do Centro de Pesquisa de Processamento de Alimentos. 2009;27(1):59–70. Portuguese. (Accessed 23 June 2017) Available:http://ojs.c3sl.ufpr.br/ojs2/index.php/alimentos/article/viewArticle/14953
8. Chitarra MIF and Chitarra AB. Pós-colheita de frutas e hortaliças: fisiologia e manuseio. 2ª Ed. Lavras: FAEPE; 2005. Portuguese.
9. EMBRAPA. Colheita e beneficiamento de frutas e hortaliças. Embrapa Instrumentação Agropecuária. 2008:144. Portuguese. (Accessed 01 September 2017) Available:http://poscolheita.cnpdia.embrapa.br/documents/36843/1212205/colheita_e_beneficiamento_de_frutas_e_horalicas/efb05ffb-595e-4ec9-acfb-2375ca43e017
10. Instituto Adolfo Lutz (IAL). Normas Analíticas do Instituto Adolfo Lutz. Métodos químicos e físicos para análise de alimentos – versão eletrônica. 2008; 4:1020. Portuguese. (Accessed 01 September 2017) Available:http://www.ial.sp.gov.br/resources/editorinplace/ial/2016_3_19/analisedealimentosial_2008.pdf
11. Evangelista ZR. Radiação UV-C e cloreto de cálcio na qualidade pós-colheita de jabuticaba Sabará. Dissertação de Mestrado em Engenharia Agrícola. Universidade Federal de Goiás. 2015;81. Portuguese.
12. Mota WF, Salomão LCC, Pereira MCT, Cecon PR. Influência do tratamento pós-colheita com cálcio na conservação de jabuticabas. Revista Brasileira de Fruticultura. 2002;24(1):49-52. Portuguese.
13. Sanches AG, Costa JM, Silva MB, Moreira EGS, Santana PJA, Cordeiro CAM. Aspectos qualitativos e amadurecimento do araçá amarelo tratado com radiação UV-C. Nativa Pesquisas Agrárias e Ambientais. 2017;5(5):303-310. Portuguese. Available:http://dx.doi.org/10.5935/2318-7670.v05n05a01
14. Benato EA, Sigris JMM, Hanashiro MM, Magalhães MJM, Binotti CS. Avaliação de fungicidas e produtos alternativos no controle de podridões pós-colheita em maracujá amarelo. Summa Phytopathologica. 2002;28(4):299-304. Portuguese.
15. Hardenburg RE, Watada AE, Wang CY. The commercial storage of fruits, vegetables, and florist, and nursery stocks. United States Department of Agriculture (USDA). Agricultural Research Service. 1986;130.
16. Caldeira SD, Hiane PA, Ramos MIL, Ramos Filho MM. Caracterização físico-química do araçá (*Psidium guineense* SW.) e do tarumã (*Vitex cymosa* Bert.) do estado de Mato Grosso do Sul. Boletim do Centro de Pesquisa de Processamento de Alimentos. 2004;22(1):145-154. Portuguese. (Accessed 23 June 2017) Available:https://www.researchgate.net/profile/Priscila_Hiane/publication/273346987_CARACTERIZACAO_FISICO-QUIMICA_DO_ARACA_Psidium_guineense_SW_E_DO_TARUMA_Vitex_cymosa_Bert_DO_ESTADO_DE_MATO_GROSSO_DO_SUL/links/5877721a08ae329d6227f241/CARACTERIZACAO-FISICO-QUIMICA-DO-ARACA-Psidium-guineense-SW-E-DO-TARUMA-Vitex-cymosa-Bert-DO-ESTADO-DE-MATO-GROSSO-DO-SUL.pdf
17. Bezerra JEF, Lederman IE, Silva Junior JF, Proença CEB. Araçá. In: Vieira R F, Agostini-Costa TS, Silva DB, Sano SM, Ferreira FR. Frutas nativas da região centro-oeste do Brasil. Embrapa Recursos Genéticos e Biotecnologia. 2006;41-62. Portuguese.

18. Rombaldi CV, Teixeira AM, Chaves FC, Franzon RC. Influence of genotype and harvest season on the phytochemical composition of araçá (*Psidium cattleianum* Sabine) fruit. International Journal of Food and Nutritional Science. 2016;3(4):1-7.
19. Liu C, Jahangir MM, Ying T. Alleviation of chilling injury in postharvest tomato fruit by preconditioning with ultraviolet irradiation. Journal of the Science of Food and Agriculture. 2012;92(15):3016-3022. DOI: 10.1002/jsfa.5717
20. Erkan M, Wang SY, Wang CY. Effect of UV treatment on antioxidant capacity, antioxidant enzyme and decay in strawberries fruit. Postharvest Biology and Technology. 2008;48(2):163-171. DOI: 10.1016/j.postharvbio.2007.09.028
21. Alothman M, Bhat R, Karim AA. UV radiation-induced changes of antioxidant capacity of fresh-cut tropical fruits. Innovative Food Science and Emerging Technologies. 2009;10(4):512-516. DOI: 10.1016/j.ifset.2009.03.004
22. Shen Y, Sun Y, Quiao L, Chen J, Liu D, Ye X. Effect of UV-C treatments on phenolic compounds and antioxidant capacity of minimally processed Satsuma mandarin during refrigerated storage. Postharvest Biology and Technology. 2013;76:50-57. Available:https://doi.org/10.1016/j.postharvbio.2012.09.006
23. Fernandes APS, Costa JB, Soares DSB, Moura CJ, Souza ARM. Aplicação de filmes biodegradáveis produzidos a partir de concentrado protéico de soro de leite irradiado. Pesquisa Agropecuária Tropical. 2015;45(2):192-199. Portuguese.
24. Marques LOD, Moreno MB, Lima AYB, Farias PCM, Malgarim MB, Veiga OJ et. al. Caracterização do fruto de três diferentes grupos de bananas (*Musa* spp.) consumidas no estado do Rio Grande do Sul. Revista Iberoamericana de Tecnología Postcosecha. 2017;18(1):17-22. Portuguese.
25. Campos AJ, Vietes RL. Ultravioleta (UVC) na conservação da qualidade de tomate 'Pitenza'. Revista Eletrônica de Agronomia. 2009;16(2):20-26. Portuguese.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23380