

Original Research Article

Ultraviolet-C Radiation on *Psidium cattleianum* L. Conservation and its Influence on Physico-Chemical Fruits Characteristics

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 **F Test 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 cattleianum* 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 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 color, 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 physico-chemical 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 **higher 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 cattleianum* 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** 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

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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. MATERIAL 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 were 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 equipped 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 was** evaluated **immediately after harvest** and **it was** 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, equipped 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**) were 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 centimeters (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 °Brix 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]; **Titrateable 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. The variables that presented significant difference between treatments had their means** compared by the Tukey test at 5% probability.

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3. RESULTS AND DISCUSSION

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

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 shows the mean values of physical characteristics averages evaluated inof the fruits, according resulting from to the applied treatment applied.

Table 2. Obtained Means for the variables :variables: Diameter (D), length (L) and mass loss (ML) of in yellow cherry guava fruits submitted to different number of UV-C radiation and to different number of days of storage ed in a cold room at 4 °C. UFPel, 2017.

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 in the column do not differ from each other according to by the Hartley test at the 5% probability level.

^{ns} Non-significant means by the F-test (P = .05).

There was no significant difference between treatments for fruit diameter and length. Regarding mass loss (%), T2 treatment (fruits stored for four days after irradiation) presented lower value for this parameter, disregarding T1 (not irradiated and not stored fruits) treatment, 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 occurred in all treatments, including those not irradiated fruits, without radiation application. T3 had the highest value of mass loss, higher more than 16%.

This process is related to cell water content decrease that occurs by the transpiration process. Mota and co-workers et al., [12] stated that water loss during this metabolic event wasis 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 and co-workers 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-s experiment, whereas fruits of the control treatment, without UV-C application, lost more than 9%. Table 3 shows the fruits chemical characteristics values.

Table 3. Mean values obtained forof 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 stored in a cold room. UFPel, 2017.

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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 by the F-test (P = .05).

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, this method is applied [15]. Therefore, the reserves consumption is also lower, which justifies the subtle change in acid content, soluble solids and pH.

The obtained results obtained for the chemical variables that did not show a significant difference were already expected, since the storage conditions aimed to would allow maintaining fruit characteristics them to be maintained for a longer period than usual. According to Caldeira and colleagues et al., [16] and Bezerra and co-workers 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 and co-workers 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 defense mechanisms and induce the carotenoids metabolism [19], which according to Erkan and co-workers et al., [20], are pigments that characterize the maturation process. Alotman and colleagues et al., [21] and Shen and co-workers et al., [22] stated that the increase in antioxidant activity caused by UV-C radiation had an influence on fruit senescence reduction.

Because it was a relatively short period, the 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*).

Table 4. Obtained values for Luminosity (L*), hue angle (°h) and Chroma (C*) according to results from the respective treatments. UFPEI, 2017.

	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 by the Tukey Test (P = .05).

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

The obtained values obtained through the hue ($^{\circ}h$) 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 and co-workers 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.

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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.

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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 averages for carotenoid contents, differing from the control treatment.

4. CONCLUSION

UV-C radiation, along with refrigerated storage usage did not interfere in with soluble solids content, pH, acidity and colorcolouring attributes of yellow cherry guava fruits. Therefore, Refrigerated storage was efficient to in maintaining physico-chemical characteristics and postharvest quality of yellow cherry guava fruits during 12 during 12 d of storage period.

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