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Gamma Radiation Effects in Precooked Figs

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1. Introduction

Ficus carica L. is a deciduous tree belonging to the Moraceae family, is one of the first cultivated fruit trees and has more than 750 known species. The only cultivar planted on a commercial scale in Brazil is "Roxo de Valinhos", introduced in the country at the beginning of the 20th century by the Italian Lino Bussato in the municipality of Valinhos/SP. This cultivar has a great economic value, is characterized by rusticity, vigor and productivity. It adapts well to the drastic pruning system, and produces fruits that are acceptable for consumption in natura (ripe), green (industry standard), swelling or ramie [1, 2]. When ripe, the fruit has a dark purple-violet color, reaching about 7.5 centimeters in length and weighing between 60 and 90g. They are considered large, pear-shaped, have a short peduncle and an open ostiole, which facilitates the penetration of fungi and insects. The pulp is pink or red and has a central cavity. The nutritional composition of dried figs [3, 4] which can be a superior source of minerals and vitamins, each 100g contains: 30% iron, 15.8% calcium, 14% potassium; 7.1% thiamine (B1) and 6.2% riboflavin (B2). Figs are sodium free as well as fat and cholesterol free [4, 5]. Dried figs also contain relatively high amounts of raw fiber (5.8%, w/w), higher than all other fruits [3, 4]. More than 28% of the fiber is of the soluble type, which has been shown to help control blood glucose and cholesterol and help with weight loss.

Gamma radiation treatment is a quick, inexpensive, and reliable method of preservation to improve the hygienic quality of food, thus extending its shelf life [6, 7, 8]. Irradiation, in addition to being an excellent method of food preservation, completely satisfies the objectives regarding nutritional food stability, sanitary conditions and long-term shelf life [9]. The objective of this work was to evaluate the changes caused by gamma radiation in precooked green figs.

2. Methodology

The fruits were manually harvested on a private property in Piracicaba/SP, and taken to the Radiobiology and Environment laboratory at Radiobiology and Environment Department, at Center for Nuclear Energy in Agriculture - CENA / USP, Piracicaba city, SP state. The samples were washed, sanitized and subjected to cooking for 15 minutes, then placed in a colander to wait for the fruits to cool. After this process, they were packed in 15x30cm polyethylene bags and sealed with manual sealing. Irradiation was carried out in cobalt-60 type Gammacell-220, Nordion (CENA/USP), the doses applied were: 0 (control), 1.0 and 2.0 kGy, at a dose rate of 0.601kGy/h and stored up to 24 hours in the climatic chamber at 8ºC, for 7 days, for further analysis. Each treatment consisted of 3 repetitions with 8 fruits each. Analyzes of pH, soluble solids content, skin color, pulp color, texture, chlorophyll a, b chlorophyll and total carotenoids were performed [10].

Color analysis

The parameters were analyzed for color L, a *, b * values, Chroma and Hue-Angle. We used a colorimeter Minolta CR-200 b previously calibrated in white [11]. The values were measured in a *, b * and L * characterizes where the colors red (+a *) to green (-a *) b *, yellow (+b *) to blue (-b *) and white L (L = 100) to black (L = 0).

It was determined the values of Chroma (Eq. 1) and Hue-Angle (Eq. 2) by the values obtained by a *, b * and L, as the following formulas [12]:

$$C = \sqrt{\left(a^2 + b^2\right)} \quad (1)$$

$$H^o = \text{arctg } b^*/a^* \quad (2)$$

To analyze the results, the Tukey test at 5% probability was used with the aid of the Statistical Analysis System computer program [13].

3. Results and Discussion

The variations in pH obtained from the precooked irradiated fig are given in Table 1. There was a decrease in the pH value with increasing dose, which resulted in a more acidic product, despite a slight increase in the treatment with a dose of 2.0 kGy, being in agreement with [14, 15].

Table 1 - pH and soluble solid variation of irradiated precooked green figs.

Dose	pH	Soluble Solids (oBrix)
Control	4.820 ± 0.0[*a**]	2.0 ± 0.0[a]
1.0kGy	4.770 ± 0.0[c]	2.0 ± 0.0[a]
2.0kGy	4.810 ± 0.0[b]	2.0 ± 0.0[a]

* Mean ± standard deviation.

** Means followed by the same letter in column do not differ by Tukey test (P <0.05).

Soluble solids content (ºBrix) of precooked green figs irradiated in doses: 0 (control); 1.0 and 2.0 kGy are in Table 1. The samples did not show significant differences between them. This result is in agreement with [16], who found no significant difference between the different treatments in irradiated papaya. [17, 18], verified statistical differences between treatments with the same doses, indicating that radiation influenced this parameter in kiwi nectar and orange juice irradiated in various doses.

According to Tables 2 and 3, there were no significant changes between treatments regarding the color parameter. Chroma and hue angle data were calculated. There was no linear reduction in the L parameter for the fig peel samples, therefore, it also did not show statistically significant differences between the samples. [18, 19] concluded that aromatic curcuma extracts showed better color after gamma radiation.

Table 2 - Mean values of l, a*, b*, chroma and hue angle of the skin of irradiated precooked green figs.

Dose	Parameters				
	L	a*	b*	Chroma	H
Control	30.1833 ± 1.0[*ab**]	-0.5733 ± 0.1[a]	12.5067 ± 0.7[a]	14,38923	-1,03872
1.0kGy	27.917 ± 1.5[b]	- 0.327 ± 1.7[a]	11.340 ± 2.9[a]	13,37308	-1,50045
2.0kGy	31.393 ± 0.7[a]	-0.305 ± 0.1[a]	13.143 ± 0.7[a]	13,72021	-1,50442

* Mean ± standard deviation.

** Means followed by the same letter in column do not differ by Tukey test (P <0.05).

Table 3 - Mean values of L, a*, b*, chroma and hue angle of irradiated precooked green figs pulp

Dose	Parameters				
	L	A	B	Chroma	H
Control	28.757 ± 4.7[*a**]	-2.627 ± 0.8[a]	9.017 ± 1.3[a]	14,23713	1,217945
1.0kGy	36.363 ± 9.6[a]	-1.623 ± 1.5[a]	11.340 ± 2.9[a]	11,65796	1,308757
2.0kGy	35.720 ± 6.3[a]	-3.750 ± 1.0[a]	11.157 ± 2.3[a]	9,448735	1,212893

* Mean ± standard deviation.

** Means followed by the same letter in column do not differ by Tukey test (P <0.05).

According to [15, 20] who stated that the irradiation lowered the chroma values, stating that the irradiated fruits had a darker color on the surface, according to what was found in the present study. However, [15] described that an internal injury expressed as a widespread darkening may have been caused, but this was not statistically significant. [18, 21] found a low value in irradiated pineapples, although after 30 days, browning started. According to [4], fig color differences may result from the expression of differential genes.

Texture analysis showed a statistically significant difference between samples (Table 4). The texture proportionally increased the doses. In agreement with [18], who studied the same texture characteristics of pineapple. According to [21, 22] and also [15, 20] irradiating apples, they concluded that the treatment is not interesting for this type of fruit, a as there is a degradation of the pectin of the apple and loss of firmness of the fruit.

Table 4 - Mean values of texture, chlorophyll (a, b and total), total carotenoids of irradiated precooked green figs

Dose	Texture	Chlorophyll A (µg/g)	Chlorophyll B (µg/g)	Chlorophyll Total (µg/g)	Total Carotenoids
Control	0,10000 ± 0.07[*b**]	0,12837 ± 0.01[a]	0,043267 ± 0.003[ab]	0,171637	0,14107 ± 0.01[a]
1.0kGy	0,26667 ± 0.15[ab]	0,13103 ± 0.02[a]	0,04773 ± 0.01[a]	0,17876	0,13593 ± 0.02[a]
2.0kGy	0,40000 ± 0.00[a]	0,10093 ± 0.01[a]	0,034700 ± 0.00[b]	0,13563	0,09417± 0.02[a]

* Mean ± standard deviation.

** Means followed by the same letter in column do not differ by Tukey test (P <0.05).

Chlorophyll results are in Table 4, and there is a small difference between treatments for chlorophyll b. Total chlorophyll is a calculation of data. [18] found changes in chlorophyll content after 20 days of storage. [4] found differences between the chlorophyll sample, working with different types of figs, because the diversity only between different cultivars. The averages obtained for total carotenoids of the pre-cooked green fig are shown in Table 4, there is no statistical difference between the samples, these results are not in agreement with those of [22, 23].

4. Conclusions

Fig (Ficus carica) is the fruit of the fig tree, original of Mediterranean, has fleshy and succulent pulp, besides being sweetened slightly. It is very appreciated for dessert. The immature form (green) can be used for make a sweet home-made. The objective of this work was to evaluate the changes caused by the irradiation gamma in pré-cooked green figs.. The samples were washed, made hygienic and submitted the cooking by a period of 15 minutes, after the cooking they were put in an drainer to expect cooling the fruits and after that process they were wrapped in plastic sack of 15x30cm and sealed in a manual sealing and stored at 8oC in a OBD

camera for 7 days. Later samples were irradiated with doses of: 0 (control); 1.0 and 2.0 kGy, under a rate of dose of 0.601kGy/h, in a Gammacell-220 irradiator and stored by 24 hours to 8oC in OBD. Each treatment was consisted with 3 repetitions with 10 fruits each. The samples were appraised, immediately after the irradiation, as for the parameters pH, soluble solids content, color peel, color pulp, texture, chlorophyll A, chlorophyll B and total carotenoids. The statistical analysis of the results was accomplished, through outline entirely randomized by test F for variance analysis and when significant compared by Tuckey test. By the obtained results was concluded that there was not significant difference between the treatments and the control. After four days the samples presented microbiological contamination, they went discarded.

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