GAMMA RADIATION EFFECTS ON FIGS READY-TO-EAT

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RESUMO

EFEITO DA RADIAÇÃO GAMA EM FIGOS MINIMAMENTE PROCESSADOS

O figo é uma fruta muito apreciada como sobremesa. A forma imatura pode ser utilizada como matéria-prima para produção de doce caseiro. O objetivo deste trabalho foi irradiar amostras de figos verdes minimamente processados, buscando o aumento da vida de prateleira do produto. As amostras foram processadas e embaladas em saco plástico, selados e armazenados a 8 ° C em BOD durante 7 dias. Posteriormente as amostras foram irradiadas com doses de: 0 (controle); 1,0 e 2,0 kGy, sob uma taxa de dose de 0,601kGy / h, em irradiador tipo Gammacell-220 e armazenados em BOD. Cada tratamento foi composto com 3 repetições com 10 frutos. As amostras foram avaliadas, imediatamente após a irradiação, para os parâmetros pH, sólidos solúveis, coloração da casca, cor da polpa, textura, clorofila A e B e carotenoides totais. Foi realizada análise estatística dos resultados e pelos resultados obtidos concluiu-se que não houve diferença significativa entre as amostras. Depois de quatro dias a irradiação todas as amostras foram descartadas.

Palavras-chave: alimentos minimamente processados, análise centesimal, irradiação de alimentos, Co^{60}.

ABSTRACT

Fig is very appreciated for dessert. The immature form can be used for make a sweet home-made. The aim of this work was irradiate samples of pre-ready green fig, seeking the increase of the useful shelf-life. The samples were processed and were wrapped in plastic, sealed and stored at 8°C in OBD 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 Gammacell-220 irradiator and stored OBD. Each treatment was consisted with 3 repetitions with 10 fruits. The samples were appraised, immediately after the irradiation, as for the parameters pH, soluble solids content, peel color, pulp color, texture, chlorophyll A, chlorophyll B and total carotenoids. The statistical analysis of the results was accomplished and by the results obtained was concluded that there was no significant difference between the samples. After four days the irradiation all samples went discarded.

Keywords: food ready-to-eat, centesimal analysis, food radiation, Co^{60}

INTRODUCTION

Ficus carica L., a deciduous tree belonging to the Moraceae family, is one of the earliest cultivated fruit trees and has more than 750 knowing species [1, 2, 3, 4].

The comercial fruit is an infructescenses constituted by a parenchymatous tissue and not formed by the ovary. The real fruit is a small achene that is formed by development of the ovary after fertilization and is not found under Brazilian conditions. The achenes have embryo surrounded the endosperm and the integument in pollinated flowers. The only cultivar planted in commercial scale in expressive Brazil is the "Roxo de Valinhos", introduced in the country at the beginning of the century XX by the Italian Lino Bussato in the municipality of Valinhos, SP. This cultivar has great economic value, is characterized by rusticity, vigor and productivity. It adapts well to the system drastic pruning, and produces fruit acceptable for consumption *in natura* (ripe), green (industry standard), swollen or ramie [3, 5]. When ripe the fruit has colored foreign dark purple-violet, reaching about 7.5cm long and weighing between 60 and 90g. Are considered large, pear shape and long have short stalk and inconvenience of having large and open ostiolo, which facilitates the penetration of fungi and insects. The pulp is pink-red color and displays cavity central. Ripe fig fruits are seen in many hollow ovarian [3].

Today, fig is an important crop worldwide for dry and fresh consumption [1].

On the basis of the Dietary Reference Intakes (DRI) data, published by the Food and Nutrition Board of the U.S. Institute of Medicine [6], and the nutrient composition of dried figs [1, 7], they can be demonstrated to be a superior source of minerals and vitamins, providing per 100 g serving the following: iron, 30%; calcium, 15.8%; potassium, 14%; thiamin (B1) 7.1%; and riboflavin (B2) 6.2%. Figs are sodium free as well as fat and cholesterol free [1, 8]. Fig fruits contain at least 17 types of amino acids, among which aspartic acid and glutamine are the highest ones [1, 8]. Dried figs also contain relatively high amounts of crude fibers (5.8%, w/w), higher than those of all other common fruits [1, 8]. More than 28% of the fiber is of the soluble type, which has been shown to aid in the control of blood sugar and blood cholesterol and in weight loss. Dried figs also contain one of the highest concentrations of polyphenols among the commonly consumed fruits and beverages [1, 7, 9].

Fig color varies from dark purple to green. Figs can be eaten whole and raw, but are often peeled; the flesh is eaten and the skin discarded. Although fig is one of the most abundant fruits in the Mediterranean diet, there is no information in recent scientific literature regarding its health-promoting potential. In a single paper, figs of an unknown variety were randomly picked at one time point and found to contain several carotenoids, including lutein, cryptoxanthin, lycopene, â-carotene, and R-carotene [1, 10], with lycopene being the most abundant carotenoid, followed by lutein and â-carotene.

The fig tree culture can be an important role in the economy of the rural properties with major social consequences, as the generation of jobs and improved quality of life, with appropriate soil-climate conditions [11].

One of the biggest barriers to the expansion of cultivation market in nature and high spoilage of fruit in the field is because the rains and in post-harvest is because of the decay and dehydration, requiring guaranteed market and trading quickly. The possibility of increase exports of ripe figs can be glimpsed. In recent years have been exported on average 705 tonnes [11, 12], produced in São Paulo, whose harvest extends November to April [11, 13]. In southern Brazil, due to rains during the harvest, we need technologies that ensure the production quality, so that the producer takes Export commitments [11].

The treatment of foodstuffs by g-irradiation is a fast, cheap and confident method for improving their hygienic quality thus extending their shelf life [14, 15, 16]. According to the global needs of the food security and the problems arising in the process of inadequate storage and processing, there was a growing search for new methods of food preservation. The irradiation of this material is available as a method of preservation, both the raw material in nature and as supportive of industrial processes [17](Villavicencio, 1998).

Irradiation is an excellent method of food conservation, as well as reinforces the action of other applied processes for the same purpose. Irradiation satisfies completely the objectives of giving food nutritional stability, sanitary conditions and along shelf life [18, 19](Harder et al., 2009; Embrarad, 2010).

Investigations demonstrated that macronutrients, such as proteins and carbohydrates are relatively stable at doses of up to 10kGy, and that, micronutrients, mainly vitamins can be sensitive to any method of food conservation. The sensitivity of various types of vitamins to irradiation and other methods for food conservation is variable; vitamins C and B1 (thiamin) are the most sensitive to irradiation. In general, the process of irradiation with acceptable dose cause little chemical changes in foods, whereas the food nutritional quality is no more affected than when it is treated with other conventional methods of preservation [17](Villavicencio, 1998).

On the other hand, this manipulation yields free radicals in foods, some of them recombining to give new species, which impact on the living organism was studied quite everywhere in the world with two WHO expert Committee ascertaining the wholesomeness of the treatment in 1980 and 1997 [16, 20, 21, 22]. Thus, the control on radiation procedure is important not only from a toxicological point of view but also for quality control of international trade and for consumer information [16].

Account of the questions placed above the aim of this study was to evaluate the changes caused by γ-irradiation in pre-ready green figs.

MATERIAL AND METHODS

The fruits were manually picked in a private property at a municipal district of Piracicaba/SP, and taken to the laboratory of Radiobiology and Environment, where were processing in the same day.

The samples were washed, made hygienic and submitted the cooking by a period of 15 minutes, after the cooking they were put in a drainer to expect cooling the fruits. After that process they were wrapped in plastic sack of 15x30cm and sealed in a manual sealing.

Irradiation was conducted in a Cobalt-60 type Gammacell-220, Nordion (CENA/USP) where the samples were irradiated with doses of: 0 (control); 1.0 and 2.0 kGy, at a rate of dose of 0.601kGy/h and stored by 24 hours to 8°C in OBD climate camera for 7 days for posterior analisis.

Each treatment was consisted with 3 repetitions with 8 fruits each. The samples were analyzed, for the for the parameters pH, soluble solids content, color peel, color pulp, texture, chlorophyll A, chlorophyll B and total carotenoids.

pH was determined using pHmeter MB-10, according to AOAC (2005) [23].

Soluble solids content

Estimated in refractometer RT-30ATC and expressed in Brix, according to AOAC (2005)[23].

Color peel and color pulp

The colorimeter MinoltaCR-200B was used, previously calibrated in white according to pre-determined standards, according to Bible and Singha (1997)[24]. Three values of chroma were evaluated: a*, b* and L. The value a* characterizes the color from the red (+a*) to the green (-a*); the value b* indicates the color from the yellow (+b*) to the blue (-b*). The value L determine the light ranging from white (L = 100) to black (L = 0). The chroma is the ratio between a* and b*, where the real color can be obtained [25]. Hue angle is the angle between a* and b*, indicating the color saturation of the analyzed object. To estimate chroma value, the following formula was adopted (1) and to estimate the hue angle, formula (2) [26].

$$C = \sqrt{a^2 + b^2} \qquad (1)$$

$$H^\circ = arctg = \frac{b^*}{a^*} \qquad (2)$$

Texture

This parameter was realized like according to methodology description by Souza and Ferraz (2009)[27].

Chlorophylls A and B

We used the method described by Arnon (1949)[28], which presents as the extractor to 80% acetone. Amount of 0.5 to 1 g of the peel, with a thickness of ± 1 mm distributed in the median equatorial region of the fruit was macerated and added 10 mL of extractor solution. The solution was at a dark bottle and cap for 12 hours in refrigerator, then was filtered on paper filter and held the reading to 645 and 663 nm in spectrophotometer. The values of absorbance were placed in Equations 3; 4 and 5:

Chlorophyll a = 12.7 x Abs (663) - 2.69 x Abs (645) (3)

Chlorophyll b = 22.9 x Abs (645) - 4.68 x Abs (663) (4)

Total chlorophyll = chlorophyll a + chlorophyll b (5)

The results were multiplied by the total dilution with the extractor.

Total carotenoids

To determine total carotenoids was used methodology descriptioned by Pinheiro-Sant'Ana et al. (1998)[29].

Statistical analyses

The experimental design was complete randomized with three replications. Results were analyzed (ANOVA) using the F-test, and mean comparisons were tested based on Tukey (P<0.05) using SAS (1996)[30].

RESULTS AND DISCUSSION

pH

The obtained variations of the pH of the irradiated pre-ready fig are given in Table1. There was a decrease in the value of the pH with increasing dose, which resulted in more acid product, despite a slight increase of the treatment with dose at 2.0kGy. In agreement with Basbayraktar et al. (2006)[31], that found the same decrease for pH value for irradiated carrots. However, Fan et al. (2005)[32] showed values of pH that do not have changed at irradiated sliced apple. Both at same doses like this study.

Table 1. Variation of pH and Brix of pre-ready green figs irradiated at 1.0 and 2.0kGy plus the control

Dose	*pH*	*Brix (°B)*
Control	4.820 ± 0.0$^{a(a, b)}$	2.0 ± 0.0$^{a(a, b)}$
1.0kGy	4.770 ± 0.0^{c}	2.0 ± 0.0^{a}
2.0kGy	4.810 ± 0.0^{b}	2.0 ± 0.0^{a}

a Mean ± standard deviation

b Means with different word(s) in the vertical significantly differ at the level of 5%

Soluble solids content

The obtained variations of Brix (Brix degrees) of the pre-ready green figs irradiated at doses of: 0(control); 1.0 and 2.0kGy are in Table1. The sample do not presented differences amount of soluble solids. This result is in agreement with D'innocenzo and Lajolo (2001)[33], which do not find significant difference between the differents radiation treatments at papaya fruit. To nectar fruits Harder et al (2009) and Spoto & Verruma-Benardi (2002)[19, 34] were verified statistical differences among the treatments, indicating that their radiation influenced this parameter, in kiwi nectar, at same doses of this study, and orange juice irradiated at several doses respectively.

Color analysis

According to Table 2, the treatment does not induce significant alterations in the color parameters. Chroma and hue angle are calculated datas.

There was not a linear decrease in the parameter L to the samples of the peel of the figs, but the treatments did not induce statistically significant differences between the samples. Kim et al. (2002)[35] found that Curcuma aromatica extracts got an improvement in color by gamma radiation.

Table 2. Median values of L, a*, b*, chroma and hue angle of pre-ready green figs irradiated – peel and pulp

Dose	Parameters				
	Peel				
	L	A	B	Chroma	H
Control	30.18 ± 1.0[ab(a, b)]	-0.57 ± 0.1[a]	12.51 ± 0.7[a]	14.39[(c)]	-1.04
1.0kGy	27.92 ± 1.5[b]	- 0.33 ± 1.7[a]	11.34 ± 2.9[a]	13.37	-1.50
2.0kGy	31.39 ± 0.7[a]	-0.31 ± 0.1[a]	13.14 ± 0.7[a]	13.72	-1.50
	Pulp				
Control	28.76 ± 4.7[a]	-2.63 ± 0.8[a]	9.02 ± 1.3[a]	14.24	1.22
1.0kGy	36.36 ± 9.6[a]	-1.62 ± 1.5[a]	11.34 ± 2.9[a]	11.66	1.31
2.0kGy	35.72 ± 6.3[a]	-3.75 ± 1.0[a]	11.16 ± 2.3[a]	9.45	1.21

a Mean ± standard deviation
b Means with different word(s) in the vertical significantly differ at the level of 5%
c Calculated values

Fan et al. (2005)[32] founded that Irradiation lowered the chroma values, suggesting that irradiated fruit were darker in surface color, according to that was founded at this study. But they founded that was promoted an internal injury expressed like a diffused browning. We founded a little darkening, but it was not significant statistically. Silva et al. (2008)[36] found a lightening in irradiated pineapple, but after 30 days, it started darkening.

According to Solomon et al. (2006)[1], differences in fig fruit color may result from differential expression of genes.

Texture

The texture analysis found significant statistical difference among the samples, show at Table 3.

Table 3. Median values of texture, chlorophyll (A, B and total), total carotenoids of pre-ready green figs irradiated

Dose	Texture	Chlorophyll A (μg/g)	Chlorophyll B (μg/g)	Total Chlorophyll (μg/g)	Total carotenoids
Control	0.10±0.07[b]	0.13±0.01[a]	0.04±0.03[ab]	0.17	0.14±0.01[a]
1.0kGy	0.27±0.15[ab]	0.13±0.02[a]	0.05±0.01[a]	0.18	0.14±0.02[a]
2.0kGy	0.40±0.00[a]	0.10±0.01[a]	0.03±0.00[b]	0.14	0.09±0.02[a]

a Mean ± standard deviation
b Means with different word(s) in the vertical significantly differ at the level of 5%

Doses increase as the texture turn mayor values.

It is agree with Silva et al. (2008)[36] that founded the same characteristics for texture of pineapple. According to Damayanti et al. (1992) and Susheela et al. (1997) too[37, 38].

Fan et al. (2005)[32] irradiating apple, concluded that the treatment is not interesting for this kind of fruit, a time that occur a degradation of the apple pectin and the fruit loss firmness.

Chlorophyll

The dates of chlorophyll are in Table 3 and there is a little difference between the treatments for chlorophyll B. Total chlorophyll is a calculated data.

Silva et al. (2008)[36] found modification at Chlorophyll content after 20 days storage.

Solomon et al. (2006)[1] found differences of Chlorophyll between the sample, working with different types of figs, because the diversity among the different cultivars only.

Total carotenoids

The obtained mean of pre-ready green fig with total carotenoids are in Table 3. And there are not statistical differences between the samples.

This study is not according to Pinheiro-Sant'Ana et al. (1998) [29], which working with carrots irradiated, found a loss of carotene about 14.4 to 39.9% of this compound.

Reyes and Cisneros-Zevallos (2007) [39], did not find any major changes with the carotenois, working with irradiated mango fruit, working about 3.1 kGy.

CONCLUSIONS

We conclude that the irradiation did not induce major significant alterations in the physiochemical of green figs ready-to-eat, with the exception for texture in all doses.

The analysis could not be finished because after four days the samples showed microbiological contamination.

So it is necessary others researches about this theme to have more information including time of sheflife.

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