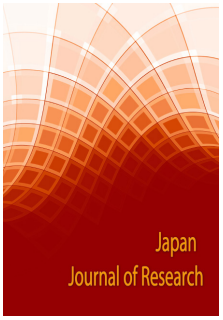
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Opinion Article



The Effects of Pitaya de Mayo (*Stenocereus pruinosus*) Gamma Irradiation on Its Chemical and Sensory Parameters

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Abstract

According to the FDA, regulations for horticultural produce exportation, at least to the United States of America, involve irradiation as a quarantine treatment against insects. In addition, this agency demands that the effects of this treatment on chemical and sensory parameters be published to ensure their quality, safety, and consumer acceptance. In this study, we present results of the irradiation of pitaya de mayo (Stenocereus pruinosus) "Jarro" (with orange pulp) and red-pulp varieties with ɣ rays at 150 and 350 grey and we determined that there is a variety effect on chemical and sensory parameters. The 150 Gy dose was shown to be the best treatment for red pulp pitaya since it preserved its color, sweetness, and overall natural appearance, compared with the 350 Gy dose.

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Keywords

Pitaya de Mayo, Cactaceae, Irradiation, export regulations, quarantine treatments.

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Introduction

Invasive pests frequently restrict the international marketing of horticultural produce for sale as fresh produce. Quarantine treatments indicated by the international authorities, especially the FDA, require the disinfestation of produce that is prone to harboring insects to places where they do not exist, and they are often the simplest approach to overcome regulatory barriers to gaining or maintaining access to international markets] [1].

Irradiation has been shown to be an excellent quarantine treatment as an alternative to ethylene dibromide and ethyl bromide fumigation treatments, which were very effective but caused considerable harm to the atmosphere and human health. Therefore, they have recently been removed from the world market (2015), because, along with the halogenated hydrocarbons, they act as catalysts of a reaction that destroys the ozone layer, and after that, their end products recombine, become active again, and persist for several years.

Irradiation treatments have generally been approved to eliminate fruit flies from the genus Tephritid (150 grey [Gy]), and 450 Gy for all insects, so this technology may be used to prevent the invasion of any pest without having to interrupt trade in produce [2-4]. New approaches to food irradiation involve the limited penetration of low-energy electrons, whereas high-energy electrons penetrate the whole food.

Irradiation consists of the use of ionized radiation (also known as ionizing energy), and it comes from cobalt-60 or cesium-137, which come from machines that produce controlled amounts of gamma rays (high-speed electron rays produced by electron accelerators), all of which possess more energy than light, microwaves, and short radio waves, but at energy levels lower than the threshold to induce radioactivity. For this reason, this process does not turn food radioactive.

In previous studies [5], results indicated there was no irradiation effect on "Jarro" pitaya's chemical and sensory parameters. We have seen in other types of studies that there is a variety effect on some features such as the inability of "Jarro" to be thermally processed (according to results in pilot-plant assays), or the positive response of red pulp varieties to edible films compared with red pulp varieties [6]. Therefore, in this study we wanted to determine whether there was any variety effect on chemical and sensory parameters in irradiated red-pulp pitayas.

Objective

To determine whether there is a variety effect on chemical and sensory parameters in red-pulp pitaya varieties irradiated with ɣ rays compared with pitaya "Jarro".

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Method

Origin And Fruit Handling

We collected the red pulp varieties of pitaya de mayo from the "El Pitayo" orchard in the community of San Juan Joluxtla, Municipio de Cosoltepec, State of Oaxaca, 18° 9' 44" N 97° 44' 43." W.

We collected ripe fruits, according to the producers' usual practices. We transported them in standard cardboard boxes maintaining the cold chain as consistently as possible at 10±1°C to the Nuclear Research National Institute (ININ), at Salazar, State of Mexico. We exposed a group of fruits to an irradiation dosage of 150 Gy, and another group of fruits to 350 Gy, in consultation with the Radio-Biology Department researchers to approximate conditions at the commercial irradiator in Matehuala, San Luis Potosí (BENEBION).

Back at the Universidad Autónoma Metropolitana – Iztapalapa Postharvest Physiology of Fruits and Vegetables laboratory, we analyzed both control and irradiated fruits for physical and chemical parameters (color, °Brix, pH, titratable acidity), and sensory parameters in the laboratory designated for those studies.

Color

We determined this parameter on both the fruit skin and mesocarp by means of Munsell tables. Afterwards, we converted the values obtained to the Hunter Lab values; we determined total soluble solids by means of an ATAGO® PAL-1 manual refractometer; results are reported as °Brix. We determined pH with a Conductronic 108, 8283 series potentiometer, and titratable acidity with NaOH 0.1N and the potentiometer until a pH of 8.5 was reached. Results are reported in milliequivalents of acids per 100 ml of juice (meq/100 ml), with all measurements performed in triplicate.

Sensory Evaluation

We asked 102 consumers between 20 and 65 years old to evaluate their general level of liking by means of a 7-point hedonic scale, where 1 = I absolutely dislike it, 7 = I really like it very much. On the other hand, we used the CATA (check all that apply) method, which consists in asking the consumers to mark all the attributes present in the sample. The features used in this study were floral aroma, brightness, red and yellow colors, fiber, whether it melts in the mouth, floury, juicy, opaque, acid residual sensation, bitter flavor, and metallic flavor. This test, combined with the level of liking, allows us to identify features that increase or decrease liking when they are present or absent. This analytical method is known as "penalty analysis". We finally implemented the "Just About Right" (JAR) penalty analysis method which allows us to identify attributes that reduce liking when they are present to a greater or lesser extent.

Statistical Analysis

We used the XLSTAT (version 2019.2.2, Addisoft, Boston, MA, USA) software for data analysis with a = 0.05. We analyzed physical and chemical parameters by means of an ANOVA and a Tukey test to evaluate whether there was any difference between experimental groups. The sensory test design was developed with the Fizz (3.9.3 Bio-systems, Countemon, France) software.

Results

Table 1 shows the color test results; we did not find significant differences in skin or pulp color perception among the experimental treatments] ($p>0.05$). However, The skin color of pitayas treated with 350 Gy showed significantly lower a* and b* coordinate values than that of control pitayas.] These results indicate an attenuation of red and yellow on the surface of the pitayas' skin]. On the other hand, pulp treated with 150 Gy showed a significant decrease in the a* coordinate ($p<0.05$) compared with the control group of pitayas. These changes might be due to irradiation-induced photo-oxidation of betalains, which results in alterations in the a* and b* coordinates, possibly in addition to pulp oxidative stress or enzyme activity that specifically affected betalains, the compounds responsible for the stability of the red color [7].

Table 2 summarizes the effects of irradiation on the physical and chemical parameters of pitayas. Soluble solids (°Brix) and titratable acidity did not differ significantly among treatments ($p>0.05$), whereas pH decreased significantly as the irradiation dose increased. Thus, irradiation affected potential acidity without altering sugar content or free organic acid levels. pH decreases with no changes in titratable acidity or °Brix may be

Table 1. *Effects of irradiation treatments on pitayas' skin and pulp color parameters (L*, a*, and b*).*

Treatments	L*skin	a*skin	b*skin	L*pulp	a*pulp	b*pulp
Control	36.25±4.41^{a}	47.65±2.55^{a}	18.65±1.30^{a}	41.2±0.00^{a}	50.50±0.00^{a}	20.10±0.00^{a}
150 Gy	41.2±0.00^{a}	50.5±0.00^{a}	20.1±0.00^{a}	41.45±9.12^{a}	32.50±18.52^{b}	13.85±8.54^{a}
350 Gy	36.25±4.40^{a}	31.15±17.31^{b}	12.2±7.07^{b}	46.4±4.65^{a}	47.50±5.10^{ab}	19.85±3.18^{a}

Values are expressed as mean ± standard deviation. a , b Means in the same column with different letters are significantly different ($p < 0.05$).

Table 2. *The effects of irradiation treatments on pitayas' physical and chemical parameters.*

Treatments	°Brix	pH	Titratable Acidity
Control	13.05±0.04^{a}	5.85±0.13^{a}	0.0070±0.0027^{a}
150 Gy	11.50±1.34^{a}	5.325±0.60^{ab}	0.0095±0.0049^{a}
350 Gy	12.00±1.79^{a}	5.075±0.38^{b}	0.0090±0.0054^{a}

Values are expressed as mean ± standard deviation. a , b Means in the same column with different letters are significantly different ($p < 0.05$).

due to the treatments that caused them to release hydrogen ions in the tissues. This process decreased the environment acidity without altering total sugar or the overall organic acid levels.

Sensory evaluation data exhibited no significant difference in liking ($p>0.05$), with scores near 5, corresponding to "like slightly."

CATA Correspondence Analysis

Correspondence analysis of the CATA data explained 100% of the total variation (Fig. 1). The resulting map showed a clear separation among treatments.

- **Control:** Strongly associated with the descriptors "fibrous," "opaque," and "red color."
- **150 Gy:** Positioned on the negative side of Dimension 1 and characterized by a bright appearance, floral aroma, and juiciness.
- **350 Gy:** Also positioned on the negative side of Dimension 1 and associated with a floury texture and an "easy to dissolve in the mouth" perception.

The observed changes may be due to the effects of irradiation on the fruit. On the one hand, a dose of 150 Gy] probably altered the cellular membrane's permeability, promoting the release of surface water and secondary volatiles, resulting in greater brightness, juiciness, and floral aroma, whereas the 350 Gy treatment] induced the oxidative degradation of pigments in the samples, which we observed in the determination of color parameters (Table 1).

Penalty Analysis Results

Figure 2 presents the results of the CATA penalty analysis (left; Fig. 2a) and the JAR penalty analysis (right; Fig. 2b).

Positive drivers of liking (Fig. 2a): Red color, brightness, juiciness, and floral aroma positively influenced overall consumer liking, indicating that these attributes are important determinants of pitaya acceptability and preference.

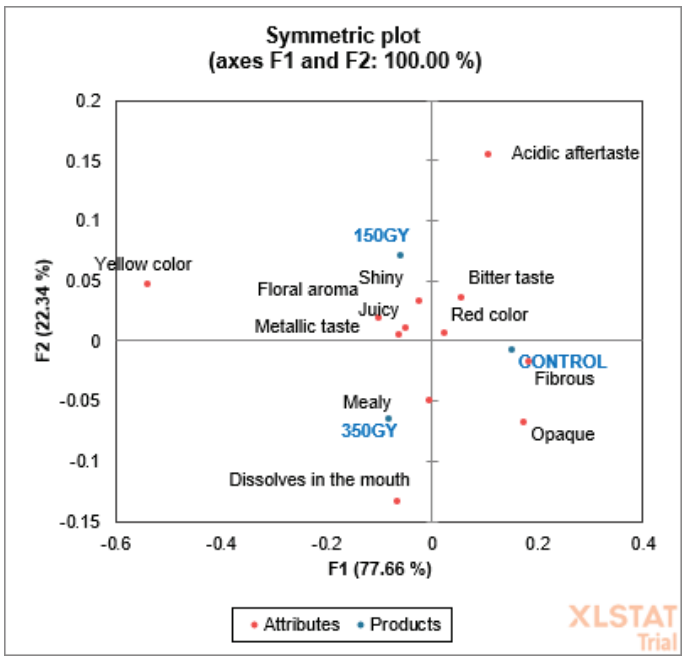


Figure 1. *Correspondence analysis showing the association between samples and sensory attributes*

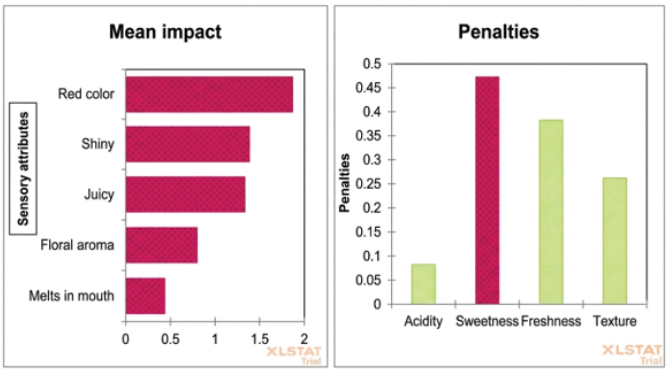


Figure 2*. Penalty analysis of the CATA tests (left) and JAR analysis (right).*

Negative drivers of liking (Fig. 2b): The JAR analysis identified attributes whose perceived intensity was lower than expected and therefore reduced acceptability. Sweetness was the only attribute that produced a significant penalty, indicating that insufficient sweetness caused a marked decline in overall consumer liking.

Conclusions

The application of irradiation showed a direct relationship between the physical and chemical parameters of red-pulp pitaya and consumer preference], positioning the 150 Gy dose as the best treatment, in contrast to the higher dose, which caused red pulp pitaya to lose color, probably due to pigment degradation and texture softening. The moderate 150 Gy dose preserved the original fruit appearance and was perceived as brighter and juicier. It was also perceived as brighter and juicier, with a pleasant floral aroma.

On the other hand, the stability of soluble solids after irradiation allowed sweetness to remain intact. This was fundamental, because penalty analysis (JAR) showed that lack of sweetness is the only factor that causes consumers' rejection. Therefore, the 150 Gy treatment is the ideal choice because it enhances the attributes preferred by consumers, without losing the sweet flavor or the natural appearance of red-pulp pitaya.

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