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Gamma Radiation Effects in Jatoba Flour

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1. Introduction

According to [1] the neotropical canopy tree *Hymenaea courbaril* L. (*Caesalpiniaceae*) is commonly knowing as jatoba. This tree is a legume, from the same bean family, and has important characteristics that deserve attention from the scientific community [2]. The term jatoba refers to tree species of the genus *Hymenaea*, of the family Leguminosae, subfamily Caesalpinioideae [3]. Jatoba is also known by different names in various regions of the country, such as "jatai or jutaí", and it is a typical Brazilian "cerrado" legume.

Found in the Federal District, states of: Goiás, Minas Gerais, Mato Grosso, Bahia, Ceará, Piaui and Sao Paulo, it blooms from December to March and provides fruits from July to November.

The jatoba tree is a large tree that can be used for reforestation, because its wood has great commercial value, for the construction of furniture, its fruits have seeds, which are used in handicrafts and the pulp is extracted from flour [4].

The fruit and in all the plant has been reported to have natural antioxidant properties, and it has been used as anodyne, antiseptic, expectorant, laxative, purgative, sedative, stimulant, and tonic in folk medicine; its bark tea is recommended for diarrhea, dysentery and intestinal cramps exceptionally used by the empirical knowledge of a certain local population [5].

The initial researches using irradiated food treatment in Brazil were carried out during the 60's by the Center for Nuclear Energy in Agriculture (CENA / USP) in Piracicaba, SP state [6]. Treatment of food with ionizing radiation is already recognized as an efficient means of reducing contamination and associated medical problems, as irradiation provides for the elimination of pathogenic protozoa in fish, poultry, shellfish and red meat and eventually contaminates humans who feed on these products [7, 8].

Currently Resolution No. 21 of January 26, 2001, of the National Health Surveillance Agency (ANVISA), contains all the rules for the use of irradiation technology, which does not restrict which foods can be irradiated, provided that the maximum absorbed dose is lower than that capable of compromising the functional and sensory qualities of the food. As for the minimum dose, it was established that it would be sufficient to achieve the desired goal.

There are few studies that address the jatoba fruit, so the aim of this work was to irradiated the jatoba flour with increasing doses of Cobalt-60 gamma radiation to evaluated its behavior.

2. Methodology

The processing of jatoba fruits was carried out at Radiobiology and Environment Department, at Center for Nuclear Energy in Agriculture - CENA / USP, Piracicaba city, SP state and forwarded to its

laboratory. There, the they were sanitized and prepared to the extracted flour went through the sieving and drying process.
After flour preparation the samples were irradiated with doses of: 0 (control), 2.0; 4.0 and 6.0 kGy in a Gammacell-220 Cobalt-60 source at a dose rate of 0.34 kGy / hour. Installed at the Center for Nuclear Energy in Agriculture - CENA / USP, Piracicaba city, SP state.
After irradiation, physicochemical and colorimetric analyzes were performed.

Physicochemical analysis
Was evaluated the pH; Acidity; Carotenoid; Protein; Lipid; Umidade; Fiber soluble andFiber insoluble parameters, all of them according to the official methodology of AOAC [9].

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 [10]. 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 [11]:

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

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

To analyze the results, the Tukey test at 5% probability was used with the aid of the Statistical Analysis System computer program [12].

3. Results and Discussion

From the results of this Table 1 for the physicochemical analysis of jatoba flour we can observe that statistically did not present significant difference for all analyzed elements between the gamma radiation treatments and the control treatment.

Table 1 - The averages values of physicochemical analyze of irradiated jatoba flour with increasing doses of gamma radiation of Cobalt-60 are shown.

Doses (kGy)	pH	Acidity	Carotenoid	Protein	Lipid	Humidity	Soluble fiber	Insoluble fiber
0	5.57^{a}*	1.20^{a}	1.12^{a}	4.21^{a}	1.95^{a}	9.69^{a}	2.45^{a}	2.99^{a}
2	5.33^{a}	1.15^{a}	1.11^{a}	4.21^{a}	1.95^{a}	9.69^{a}	2.42^{a}	2.89^{a}
4	5.47^{a}	1.12^{a}	1.13^{a}	4.44^{a}	1.89^{a}	9.61^{a}	2.46^{a}	2.69^{a}
6	5.43^{a}	1.14^{a}	1.10^{a}	4.45^{a}	1.82^{a}	9.65^{a}	2.48^{a}	2.78^{a}

*Equal letters in the same column do not differ statistically at 5% significance level in Tukey test ($P<0.05$)

According to the results obtained by [13], it is possible to observe that jatoba flour has a large amount of antioxidant substances and phenolic compounds, justifying the stability of the material against ionizing radiation in addition to its photoprotective effect verified by the author.

From the results of this Table 2 for the colorimetric analysis of jatoba flour we can observe that statistically did not present significant difference for all analyzed elements between the gamma radiation treatments and the control treatment.

Table 2 - The averages values of colorimetric analyze of irradiated jatoba flour with increasing doses of gamma radiation of Cobalt-60 are shown.

kGy	L	a*	b*	Chroma	Hue angle
0	70.46[a*]	4.09[a]	30.34[a]	30.34[a]	1.42[a]
2	69.98[a]	3.89[a]	31.43[a]	32.03[a]	1.44[a]
4	70.37[a]	3.62[a]	31.20[a]	30.98[a]	1.45[a]
6	70.05[a]	3.67[a]	31.43[a]	31.64[a]	1.45[a]

*Equal letters in the same column do not differ statistically at 5% significance level in Tukey test ($P<0.05$)

From the data presented, it was evident that the doses used in the experiment did not cause changes in the color of the Jatobá flour, which was not expected, since in experiments with jatoba wood using non-ionizing radiation (UV), it showed effects of alteration of coloring making the wood darker [14].

In studies with stability of natural coloring compounds [15, 16] also observed a greater resistance of annatto and beetroot, against the application of ionizing radiation, confirming the results obtained in this experiment.

4. Conclusions

In the ecosystem of the "cerrado" vegetation the native fruit trees occupy a prominent place and their fruits are already being marketed and with great popular acceptance. These fruits are tasty and have high levels of sugars, proteins, vitamins and minerals and can be consumed in nature or in the form of juices, liqueurs, ice cream, jellies, etc. Among them is the jatoba of the species *Hymeneae courbaril* L. As an arboreal species of the Leguminosae family, it originates from the Brazilian jatoba its fruits are used in the food industry and the leaves and seeds in the pharmaceutical and cosmetic industry. The objective of the work was to irradiate the jatoba flour with increasing doses of Cobalt gamma radiation. The processing of the fruits of jatoba was carried out with equipment of easy acquisition; the extracted flour went through the process of sieving and drying. After preparation of the flour the samples were irradiated with doses of: 0 (control), 2.0; 4.0 and 6.0 kGy in a Gammacell-220 Cobalt-60 source, at a dose rate of 0.34 kGy / hour. Installed at the Center for Nuclear Energy in Agriculture - CENA / USP., Piracicaba, SP., Brazil. After irradiation the physical-chemical analyzes were performed: pH, acidity, carotenoid, protein, lipid, moisture, soluble fiber, insoluble fiber and colorimetric. To analyze the results, the Tukey test was used at the 5% probability level. The results obtained from the physicochemical and colorimetric analyzes were concluded that there was no significant difference between the gamma radiation treatments and the control. Therefore the irradiation process can be used to improve the quality of jatoba flour.

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