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EFFECTS OF IONIZING RADIATION ON THE PHYSICOCHEMICAL PROPERTIES OF RED WINE CABERNET SAUVIGNON.

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ABSTRACT

Oenology has as its main purpose the continuous improvement of wine quality without jeopardizing its proprieties, and the intent is to make these improvements using innovative new technologies. The objective of the present work is to assess the effect of ionizing radiation on the physicochemical properties of Cabernet Sauvignon that may lead to changes in wine quality, aging process and other related characteristics.

The samples used for this process were irradiated using an Argonaut reactor powered at 340 Watts and with a thermal neutron fluency of 10^9 $n.cm^{-2}.s^{-1}$. For irradiation experiments, the samples were put into the reactor chamber until the reactor reached criticality and for an additional 30 minutes while receiving radiation.

The analyzed data included density, alcoholic, ashes and spectrophotometric measurements of absorbance at wavelengths of 420, 520 and 620 nm. Increased absorbance values at 420 nm indicate an increase in tannin composition of the wine and therefore a higher level of oxidation. Intriguingly, a rise in absorbance was also observed at 520 nm for the same test samples; which is inconsistent with published data on irradiated cachaça that showed that anthocyanin levels dropped at 520 nm after irradiation.

In summary, for measurements made at a fluency of 109 $n/cm^2.s$ for 30 min, the effects were minimal, which requires a higher dose to have better effects. Future studies should evaluating dosing effects of irradiation on improving the quality of the Cabernet Sauvignon.

1. INTRODUCTION

Wine results from a change of vegetable matter by microorganisms. More specifically, this alcoholic beverage is obtained by fermentation of ripe grape. The process of wine production and aging is notably biochemical phenomenon. Its quality and proprieties vary according to several factors, such as the fermentation system, reactions that occur during aging, environmental factors, among others. These definitions allow us to understand the extreme complexity of its chemical proprieties, and also featuring the food value that wine has. Inorganic compounds of the grape and the wine also have a significant influence on their quality. [1][3][15]

Wine has the ability to improve in quality as it ages, which differs from most types of food. Typically, the low pH in wine (such as Pinot Noir strain) is more likely to age quicker. For red wines, such as Cabernet Sauvignon strain used in this study, the possibility of aging is due to the presence of aromatic compounds (phenolic compounds) in its composition. Changes like wine flavor, color, aroma and palate, occur through complex chemical reactions involving acids, phenolic compounds (e.g. tannins) and sugars of a wine, this aging generates modifications that can make the wine enjoyable to the person who appreciate it. [6]
One of the most commonly used methods for the natural wine aging is accomplished under oxygen. Thus seeking to restrict the maximum dissolution of oxygen. Some of the more modern artificial aging processes, however, use irradiation. There are several reasons for using this type of method in wines, among them are: changes in the sensory proprieties of it, sterilizing the juice of the grape and the main, the acceleration of aging. [2][13]

The human being has a long history of attempts to accelerate the natural aging process through artificial means. The current oenology is becoming increasingly advanced as regards to the use of modern technology. Even with the large amount of research related to food irradiation, are not very familiar with the effects of irradiation on fermented beverages like wine. [6]

Oenology has as its main purpose the continuous improvement of wine quality without jeopardizing its proprieties, and the intent is to make these improvements using innovative new technologies. The red wine Cabernet Sauvignon was selected for analysis in this study for having one of the highest consumption rates in Brazil. In addition, the variable phenolic composition of this wine allowed us to ascertain changes in flavor quality.

2. THEORY

The experimental part was performed at the Instituto de Engenharia Nuclear (IEN), supported by the Instituto de Radioproteção e Dosimetria (IRD), both located in Rio de Janeiro. The laboratories involved were Reator Argonauta (IEN), where sample irradiation took place and the Laboratório de Nêutrons (LN / IRD) where the physicochemical properties of the red wine were analyzed.

2.1. Wine Samples

The red wine Cabernet Sauvignon was selected for analysis in this study for having one of the highest consumption rates in Brazil. In addition, the variable phenolic composition of this wine allowed us to ascertain changes in flavor quality. The following samples were acquired: T1 (Brazilian, 2011; Alcohol 12.5% vol.), T2 (Chilean, 2011, 12.5% vol alcohol) and T3 (Argentine, 2012, 13.2% vol. alcohol).

2.2. Irradiation

The samples used for this process were irradiated using an Argonaut reactor powered at 340 Watts and with a thermal neutron fluence of 109 $n/cm^2.s$. For the irradiation experiments, the samples were placed into the reactor chamber until the reactor reached criticality and left in the reaction for an additional 30 minutes while receiving radiation. This process was repeated for each sample (i.e., T-1, T-2 and T-3).

2.3. Physical and Chemical Analysis

The samples were analyzed by spectrophotometry, ashes, density and alcohol% vol. content. Such experiments may lead to possible changes in the wines properties by the irradiation process.
The samples were divided in two categories: "control" and "irradiated". Each of the three wine samples were scanned between 400 and 650 nm, so that it can remove data at 420 nm, 520 nm, and 620 nm wavelengh that relate to wine shade and color.

The percent alcoholic content and density were obtained using a digital Mettler Toledo densimeter - Densito PX 3.

Ash content was determined using an automatic muffle, Jung, where the wine was warmed in samples of 10 µL, and the temperature raised exponentially up to 450 °C for 30 min. Afterwards, the samples were removed from the muffle and placed in a desiccator for 1h so that their masses can be measured.

3. RESULTS AND DISCUSSION

3.1. Indexes at 420, 520 and 620 nm.

The high absorbance at 520 nm (red) indicates a high level of anthocyanin, characteristic of young red wines, as wine loses absorption as it ages at the mentioned wavelength and gains absorption at 420 nm (yellow) caused by an increase in the content of tannins and in the oxidation level of the wine. The values found in these two wavelengths are indicative of the level of aging of a wine. The older the wine is, the closer to 1 its tone value is. There is also a significant absorbance at 620 nm in young red wines at high pH values, due to their purplish color.

As shown in Table 1, each wine sample (i.e., T-1, T-2, T-3) revealed different absorbance values. The highest absorbance values at 420, 520 and 620 nm wavelengh were obtained for the Brazilian wine (T-1), indicating a greater presence of phenolic compounds responsible for wine coloring. In contrast, the Argentine wine (T-2) showed the lowest values, indicating poor yield of phenolic compounds in the wine. It was also possible to observe a predominant absorbance at 520 nm (red), demonstrating the young age of all the wine sample tested in the study.

Irradiation of wine samples T-2 and T-3 resulted in an increase in absorbance levels at 420, 520 and 620 nm. However, in wine sample T-1, which had the highest combined absorbance values in control, there was a decrease in these absorbance values after irradiation, as shown in Table 1.

3.2. Tone / Color / Matiz.

According to the spectrophotometric analysis, it is possible to set or determine the tone of the wine, which is obtained by the rate equation: T = Abs at 420 nm / Abs at 520 nm, and corresponds to the level of evolution of color from red to orange. [26]

This rate decreased by the irradiation process in wines T-1 and T3, and increased in T-2 as seen in Table 1. However, despite the increase in values at 420 and 450 nm for wine T-3, its tone practically did not change with irradiation.

Table 1: Spectrophotometric analysis results.

	Abs at 420 nm	Abs at 520 nm	Abs at 620 nm	Color Intensity	Tone
Control T-1	0.7324	0.8822	0.2012	1.8159	0.8302
Irradiated T-1	0.7175	0.8650	0.2013	1.7838	0.8295
Change (%)	- 2.0402	- 1.9533	0.0442	- 1.7671	- 0.0886
Control T-2	0.6231	0.7457	0.1767	1.5455	0.8355
Irradiated T-2	0.6304	0.7543	0.1787	1.5635	0.8357
Change (%)	1.1734	1.1554	1.1316	1.1599	0.0178
Control T-3	0.4497	0.5424	0.1241	1.1162	0.8292
Irradiated T-3	0.4540	0.5510	0.1245	1.1294	0.8238
Change (%)	0.9370	1.5906	0.3264	1.1867	- 0.6433

3.3. Alcohol Contente, Density and Ashes.

Samples analyzes showed a reduction of 0.1% in alcohol vol. (Table 2) in all irradiated wine samples, when compared to control. The variation in wine density between irradiated and control samples was very small as seen in Table 2, but it increased in all irradiated wine samples.

Table 2: Classic Analysis Results.

	Alcohol %vol	Density (g/cm^3)	Ashes (mg)
Control T-1	2.2	0.9944	0.941
Irradiated T-1	2.1	0.9948	0.907
Change (%)	- 4.5455	0.0402	- 3.6132
Control T-2	3.3	0.9926	0.345
Irradiated T-2	3.2	0.9928	0.338
Change (%)	- 3.0303	0.0201	- 2.0290
Control T-3	3.0	0.9932	0.557
Irradiated T-3	2.9	0.9934	0.550
Change (%)	- 3.3333	0.0201	- 1.2567

4. CONCLUSIONS

Concerning the irradiated samples, the parameters previously studied suffered some change, samples T-2 and T-3 had positive changes in their absorbance values in spectrophotometric readings at wavelength 420 nm, indicating a higher presence of tannin in the wine and, consequently, a higher level of oxidation. However, there was also an increase in wavelength values at 520 nm for the same samples, which is in contrast to irradiation studies of cachaça in the literature, where a reduction in the amounts of anthocyanins is also seen, but absorbance reduction was noted at 520 nm. This result reflects an increase in the color intensity of the wine when irradiated, since the Intensity of Color is the sum of the absorbance at the wavelengths

420, 520 and 620 nm. In the case of sample T-1, decreased levels were observed in all wavelengths except at 620 nm, leading to a decrease in intensity of Color and Shade.

Classic analysis tests of the irradiated wine samples set as: density, alcoholic and ash contents were found to be reduced by irradiation as compared to control.

In summary, the results indicated that the irradiation dose used in the study did not considerably affect the analyzed wine samples. Future studies should evaluate dosing effects of irradiation on wine samples. Understanding how changes in wine characteristics and quality can occur will help us develop methods to preserve the quality of the Cabernet Sauvignon.

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