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ASPECT OF SUCROSE AND ITS MONOMERS FROM SUGARCANE JUICE SUBMITTED TO DIFFERENT DOSES OF COBALT-60 IRADDIATION

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ABSTRACT

The sugarcane is an important source of sucrose, which has been for years an essential source of energy, even for consumption as food or to produce liquid fuels. During the manufacturing process of crystal sugar, one of the main concerns is to avoid the inversion of sucrose to glucose and fructose, which could decrease the efficiency of crystal's production. The increase of sugar production and the growing interest of foreign market have encouraged the development of numerous investigative studying, searching for alternative technologies and a better efficiency of process of current clarifying, sulphitation, producing a whiter sugar in a process named "sulfur free" with effectiveness production of crystal sucrose. In acid conditions or extended exposure to high temperatures, inversion reaction can occur, resulting in the formation of reducing sugars – i.e. mainly glucose and fructose - which affect the sucrose crystallization process. This study aimed to evaluate the impact of gamma irradiation (Co-60) on the rate of reducing sugars and also totals reducing sugars (i.e., sucrose, glucose and fructose) into sugarcane juice before and after treatment with different doses: 5, 10 and 20 kGy. Some parameters were evaluated, such as: Brix, pH, reducing sugar and total reducing sugar, and from the results it was observed that parameters such as Brix and pH did not have a significant variation between the control and irradiated samples, varying from 13.2 Brix (Control) to 13.0 Brix (20 kGy) and 5.26 (10KGy) to 5.36 (20 kGy), respectively. For the analysis of reducing sugar, the contents varying from 29±0.87 to 43±1.43 $mg.mL^{-1}$ with the largest rise occurred in the sample irradiated at 20 kGy. For analysis of total reducing sugar, the results ranged from 12.02±0.46% in control sample to 11.93±0.21% in the sample which received the highest radiation dose, 20 kGy. Against these results, we could conclude that the impact of gamma radiation emitted to dose rate of 3.88 KGy/h by Cobalt-60, to those doses analyzed, were not sufficient to modify the sugars profiles found in sugarcane juice, indicating viability to use of gamma irradiation technology on sugar and energy industry, either as an alternative to the clarification (for pigment degradation) in crystal sugar or sterilization process of sugarcane juice.

Keywords: sugarcane, gamma radiation, sucrose, reducing

1. INTRODUCTION

The sugarcane (*Saccharum* spp.) is one of the largest and an oldest agricultural crop explored in Brazil and has been of great socio-economic importance [1]. Since 70th, agricultural crops went through a transformation, leaving to be just for food sector to belong as well to the energetic sector, producing fuel, and having a positive effect at the competitiveness of the system generating [2].

However, the increase of percentage of exports takes to a higher demand for sugar quality [3], which have encouraged the development of numerous investigative works, searching for alternative technologies and more efficient process of clarifying, sulfitation, producing a whiter crystal sugar, and a sugar free of sulfur residues (TRS; reduced total sulfides) in an efficiency process to produce crystals of sucrose.

The sucrose is the most important component in the processing of sugarcane, resulting in a crystal form, being susceptible to reactions as the decomposition in acidic and basic, through effect of temperature and enzymes [4]. In acidic medium sucrose suffers inverse reaction, resulting on reducing sugars (glucose and fructose) and, the rate of sucrose inversion at some pH, is favored by high temperatures, long exposure times and low concentrations sucrose in solution [5,6].

Therefore, the degradation of sucrose forming reducing sugars cause negatively influences in the processing of sugarcane juice due to the effects of its decomposition products which form highly complexes and colored compounds, colloidal condensation, substances melassigenics and aspartic acid, who result in a negative interference in the final morphology of sucrose crystals [7, 8]. It can result in losses on the recovery crystal sucrose, resulting in increased intensity of the color of the broth [9].

In order to incorporate new technologies to achieve higher levels of quality and efficiency required by the world market for products derived from sugarcane is that the sulfitation alternative processes have been discussed in several scientific papers and patent applications by INPI, where there are several proposals such as the use of membranes, enzymes or calcium bicarbonate, who may be alternatives to the conventional process of clarification of sugarcane juice. Therefore, this study aims to evaluate the behavior of sugars in the juice of sugarcane treated using the oxidation process with gamma-radiation.

2. MATERIAL AND METHODS

2.1 Sugarcane juice samples

The sugarcane cv. SP 81-3250 used in this study was obtained from the Experimental Station farm of the Escola Superior de Agricultura "Luiz de Queiroz"/University of São Paulo at Piracicaba/SP, in the 2009/10 harvest. The juice was obtained by mill and silfted through filter with 0.394" in diameter. The experiments and analysis were conducted using analytical grade reagents for the spectrophotometric analysis.

2.2 Sugarcane Composition

Samples of sugarcane juice before and after treatments of clarification were analyzed for the following parameters: a) total soluble solids (Brix), according to methodology [10]. b) To determine the pH of the juice it was sampling method used in direct reading digital potentiometer, recommended by [11]. c) To determine the total reducing sugar it was performed the inversion of sucrose by acid hydrolysis using 25 mL of the sample and completing the final volume to 100 mL of distilled water. The diluted solution was heated to 65-70 °C, which received the addition of 5 mL of hydrochloric acid (Merck, São Paulo/SP) and remained in a water bath. After 5 min, the system is cooled to room temperature and received 8 mL of 30% sodium hydroxide, until there is a change in pH. The solution is transferred to a 100 mL volumetric flask, completing the volume with distilled water. The sample containing only sugars found is diluted 1:4 and thereafter should be determined the dilution necessary. For this determination it is mixed with 5 mL of solution A and 5 mL of solution B of reactive Fehling, adding 50 mL of distilled water and bringing to the boil. It was used the sample containing reducing sugars such as titrating agent and the appearance of red precipitate as an indicator of the turning point. d) For quantification of reducing sugars calorimetric method was used in 3.5-dinitrosalicilic (DNS), that was used 0.5 mL in the analysis of samples, diluted with 250 mL of water and subsequently adding 0.5 mL of sample to 1.5 mL of DNS reagent, leading to heating, for 5minutes absortivity and analyzing the compound formed in 540 nm. The standard curve for quantification was determined previously according to [12].

2.3 Gamma-radiation procedures

The gamma-radiation was realized at the Center for Radiation Technology, IPEN using an irradiator Gammacell 220 (AECL, Canada), which uses cobalt-60 source placed in pencil. The samples were in a sealed polyethylene bottles, with approximately 500 mL capacity, and they were irradiated at doses of 5, 10 and 20 kGy at a rate of dose of 3.88 kGy/h. Each treatment was analyzed with three repetitions and the samples were analyzed according to the parameters Brix, pH, reducing sugars and total reducing sugars.

3. RESULTS AND DISCUTION

The soluble solids (Brix) for the control and irradiated samples with gamma radiation have shown in Table 1. Brix values ranged from 13. 2 of the control sample to 13.0 from the sample irradiated with 20 kGy from cobalt-60 source.

Table 1. Average values of soluble solids (Brix) for samples of sugarcane juice control and irradiated in cobalt-60 source. The values represent the average of triplicates±standard deviation. CV = 0,00.

Samples/Treatments	Brix	pH
Control (0 kGy)	13.2 ±0	5.3 ±0
5 kGy	13.2 ±0	5.3 ±0
10 kGy	13.1 ±0	5.26 ±0
20 kGy	13.0 ±0	5.37 ±0

The samples irradiated in source of cobalt-60 when compared to the sample control showed low levels of their variation for soluble solids. According to studies realized by Podadera [13] showed that sugar solutions treated with radiation increase their degree of Brix, which may indicate that sugar molecules present in solution receive the energy from radiation and may suffer losses, generating molecules with less molecular mass, such as acids, which cause an increasing of the concentration of soluble solids. But it was not observed in this study a rise of Brix rate of irradiated solutions when compared to control.

For pH analysis, the results did not have a significant change, as shown in Table 1. The fact that the pH of sugar cane juice did not decrease significantly can be shown as a positive factor, once in medium acid it can occur an inversion of sucrose to glucose and fructose, present in the juice of sugar cane, chaining together a series of dehydration reactions that can result in the formation of colored compounds, unwanted [14].

The levels of glucose and fructose (reducing sugars) are shown in Figure 1, were calculated from the equation derived from a standard curve performed with standard solution of glucose; for the control and irradiated samples of cobalt-60 source. The values ranged between 29 and 43 $mg.mL^{-1}$. Since the reducing sugar content of the sugarcane juice varied in relation to control samples, with the application of irradiation. In the samples irradiated with gamma radiation the largest increase occurred in the sample of 20 kGy that have 43 $mg.mL^{-1}$.

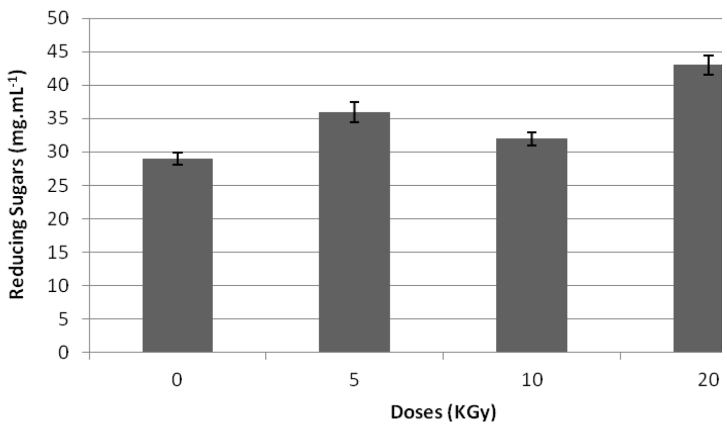

Figure 1. Values of reducing sugars (glucose and fructose) for samples of sugarcane control and irradiated in cobalto-60 source. The values represent the average of triplicates ± standard deviation. CV = 3.42.

For reducing sugar content of sugarcane that directly affect the purity, which can reflect negatively on the recovery of the sugar factory as well as result in reactions that can increase the color of the sugar and therefore detract from its quality [15]. Aside from that during the production of sugar, candy may be formed from condensation and degradation reactions of glucose and fructose catalyzed by acid or base [16]. Studies realized showed that increasing the radiation dose it raises either radical formation, which will interact with sugar molecules, forming larger amount of compounds with acidic character. Even that the pH may decrease as the irradiation dose increases since the radiation interacting with the molecules of sucrose, glucose and fructose breaks these molecules with the formation of acids [17]. According to Payne [18] colored compounds resulting from the reaction between reducing sugars and amino acids, the decomposition of sugars and many reactions like condensation.

The analysis of reducing sugars represented in Figure 2 showed an increase in the concentration of glucose and fructose in the samples that received the higher doses of irradiation. The values of total reducing sugars ranged from 12.02 to 11.93%. Through analysis of the determination of reducing sugars and total reducing sugars is possible to obtain the sucrose content of sugarcane juice.

The levels of reducing sugars and total carbohydrates present in sugarcane juice showed no significant difference between the fresh and processed product, agreeing with the results of Alcarde *et. al* [19], who observed stability in the total concentration of sugars in broth of sugarcane that was subject to radiation doses of 10 kGy. In addition, Van Zeller *et al.* [20] studying the conservation of syrup of sugarcane by the use of gamma radiation, does not check ram significant changes in the levels of glucose, fructose and sucrose, in this syrup, when irradiated with doses up to 40 kGy besides Watanabe and Sato [21] observed stability in the concentration of total sugars, present in broth and syrup of sugarcane that were subjected to gamma radiation at doses of 30 and 40 kGy, respectively.

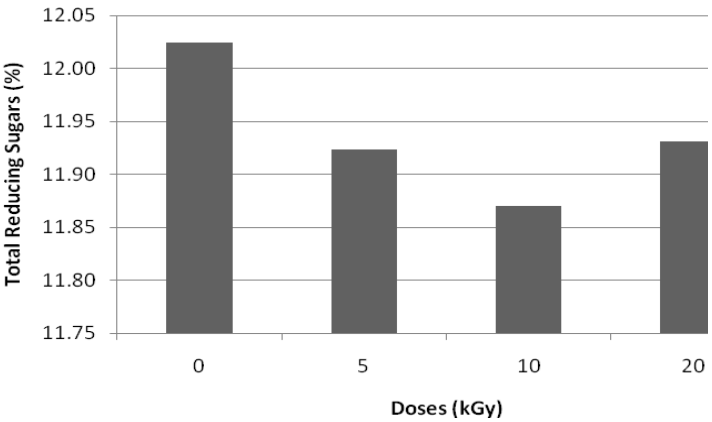

Figure 2. Values of total reducing sugars (glucose and fructose) in percentage for samples of sugarcane juice control and irradiated in coblato-60 source. The values represent the average of triplicates ± standard deviation. CV = 2.03.

4. CONCLUSIONS

Thus, it can be concluded that the impact of gamma radiation emitted to dose rate of 3.88 KGy/h by Cobalt-60, to those doses analyzed, were not sufficient to modify the sugars aspects present in sugarcane juice, a factor that indicate as viable use of gamma irradiation technology on sugar and energy industry, either as an alternative to the clarification (for pigment degradation) in crystal sugar or sterilization process of sugarcane juice.

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