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INFLUENCE OF GAMMA IRRADIATION ON PHENOLIC COMPOUNDS OF MINIMALLY PROCESSED BABY CARROTS

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ABSTRACT

Consumption of fresh fruits and vegetables provide several health benefits including risk reduction of oxidative stress-related diseases. These benefits have been associated with bioactive compounds, mainly phenolic compounds. Minimally processed products are a growing segment in food retail establishments due its practicality and convenience without significantly altering fresh-like characteristics. To extend the shelf life of these products, an application of ionizing radiation is an alternative, based on a physical and non-thermal method of preservation. The effect of irradiation on phenolic compounds of minimally processed baby carrots have not been reported in literature yet. The aim of this study was to evaluate the levels of phenolic compounds in baby carrots after the irradiation process. Samples of minimally processed baby carrots were purchased at a local supermarket and irradiated with doses of 0.5 and 1.0 kGy. Phenolic compounds were extracted from shredded carrots with MeOH and analyzed spectrophotometrically by the Folin Ciocalteau method using a gallic acid standard curve. The results showed that the phenolic contents decreased significantly ($p<0.05$) with increasing radiation dose. In non-irradiated baby carrots (control), the levels of phenolic compounds were about 330 µg eq. gallic acid/g, while irradiated samples with 0.5 kGy, showed an approximately 10% reduction when compared with the control. An irradiation dose of 1.0 kGy caused a loss of 20%. Although the radiation has affected the phenolic content, the process seems to be interesting by maintaining their fresh-like characteristics.

1. INTRODUCTION

In recent years, many studies have reported the importance and beneficial effects of bioactive compounds for human well being. The importance of phenolics as promoters of human health is well known and the main mechanism seems to be related with their antiradical scavenging activity [1] [2].

Epidemiological studies evidenced an inverse relationship between the consumption of fruits and vegetables *in nature* and the incidence of cardiovascular, degenerative and proliferative diseases. The beneficial effects have been partially attributed to the presence of bioactive compounds, mainly to the group of phenolic compounds and flavonoids [3] [4] [5] [6] [7].

Meanwhile preservation of nutritional characteristics of fresh vegetables depends on the type of processing techniques employed. It is known that the postharvest processes can affect some bioactive compounds properties, which demonstrates the importance to get a better understanding of how postharvest processes can affect the secondary metabolism of fresh vegetables and influence the synthesis of phytochemicals with nutraceutical activity [8] [9] [10].

An expanding segment of postharvest processing is the marketing of minimally processed vegetables. These products are manufactured by washing, sorting, peeling, slicing and packaging, with the objective to offer to consumers ready-to-eat products with fresh-like characteristics. Fresh food industries invest on this alternative food due to increasing demand by the consumers, seeking for healthful, fresh and convenient products. Carrots, particularly baby-carrots, fall in this category of foods, showing an increasing popularity [3] [11] [12] [13].

On the other hand, there is a concern about microbiological parameters on process. Many researchers have reported low-dose gamma irradiation as a potential tool to control the pathogenic bacteria and initial contamination level of minimally processed vegetables. The application of ionizing radiation is well established as a physical and non-thermal method of preservation (cold-pasteurization) of food at or near ambient temperatures. Gamma irradiation alone and in combination with refrigeration as a hurdle technology has been shown to prolong shelf life of fresh products without changing their nutritional and organoleptic quality. However the influence of gamma radiation on processed food properties needs to be elucidate [14] [15] [16] [17] [18].

Effects on phenolic compounds in carrots due to combination between minimally process technology and ionizing radiation have not been reported in literature yet. The aim of this study was conducted to investigate the effect of irradiation on the levels of phenolic compounds in minimally processed baby carrots.

2. MATERIALS AND METHODS

2.1. Minimally Processed Samples

Samples of minimally processed baby carrots were purchased at local supermarket in the city of São Paulo, Brazil. The material was available in plastic packages with 100 g, pre-peeled and washed, under refrigeration, with 19-day validity period. Carrots length was about 4 cm. All samples were kept at 4ºC before and after radiation and analyses were done immediately after purchase and concluded before expiration date.

2.2. Irradiation

The baby carrots were irradiated in a Multipurpose Cobalt-60 Irradiator Source (IPEN, São Paulo ï Brazil) and were divided in three treatments: control and doses of 0.5 kGy and 1.0 kGy. Gammachrome YR Bath 530 nm dosimeters were used for the measurement of radiation dose.

2.3. Extraction of Phenolic Compounds

Phenolic compounds were extracted, according to Surjadinata and Cisneros-Zevallos [2], from five grams of shredded carrots with 25 mL of MeOH using an UltraTurrax (IKA Labortechnik, Germany). Extracts were stored in covered plastic tubes overnight at 4 °C and then centrifuged at 30.000 g for 20 min to collect supernatant. The final volume was brought to 25 mL with MeOH and extracts were stored at -20ºC until analysis.

2.4. Determination of Phenolic Contents

The content of total phenolic compounds were determined in extracts according to the procedure described by Singleton et al. [19], with a slightly modification by replacing sodium carbonate by sodium hydroxide. Briefly, appropriate dilutions of extracts were oxidized with Folin Ciocalteau reagent and neutralized with 0.5 M NaOH. The absorbance of the resulting blue color was measured at 760 nm after 2 h using a Shimadzu UV-1650PC spectrophotometer. Total phenolics were quantified by using a gallic acid standard curve (1.5-11.25 µg mL^{-1}). Results were expressed in µg of gallic acid equivalents per g of carrot. Analyses were made in six replicates and results were expressed on dry basis.

2.5. Moisture

The moisture content was determined gravimetrically by drying a 5 g of shredded carrot in a vacuum oven at 70 °C until constant weight [20]. Determinations were carried out in triplicate.

2.6. Statistical Analysis

The results were evaluated with the analysis of variance (ANOVA) and signiýcant differences were identiýed by the Tukey test at 5% signiýcance using Statistica version 7.0.

3. RESULTS AND DISCUSSION

In non-irradiated baby carrots (control), the levels of phenolic compounds were about 330 µg eq. gallic acid/g on dry bases. Zhang and Hamauzu, Sun et al. and Mazzeo et al. observed previously that chlorogenic acid was the major hydroxycinnamic acid in carrot, representing from 42.2% to 61.8% of total phenolic compounds [21] [22] [23].

Reports in literature showed a wide range of amounts in carrots, varying between 159 and 1200 µg/g. Several factors such as seasonality, temperature, water availability, UV radiation, soil nutrients, pollution, and pathogen attack can affect the content of secondary metabolites in vegetables, such as phenolic compounds, which explain the large variation. Distinct extraction techniques with different solvents are an important point to influence the range founded, since there is not a standardized extraction [2] [24] [25] [26] [27].

Samples irradiated with 0.5 and 1 kGy showed mean values of 308 ± 8.3 and 266 ± 10.6 µg eq. gallic acid/g, respectively. The comparison of phenolics levels mean values among the control and delivered doses is shown in Fig. 1.

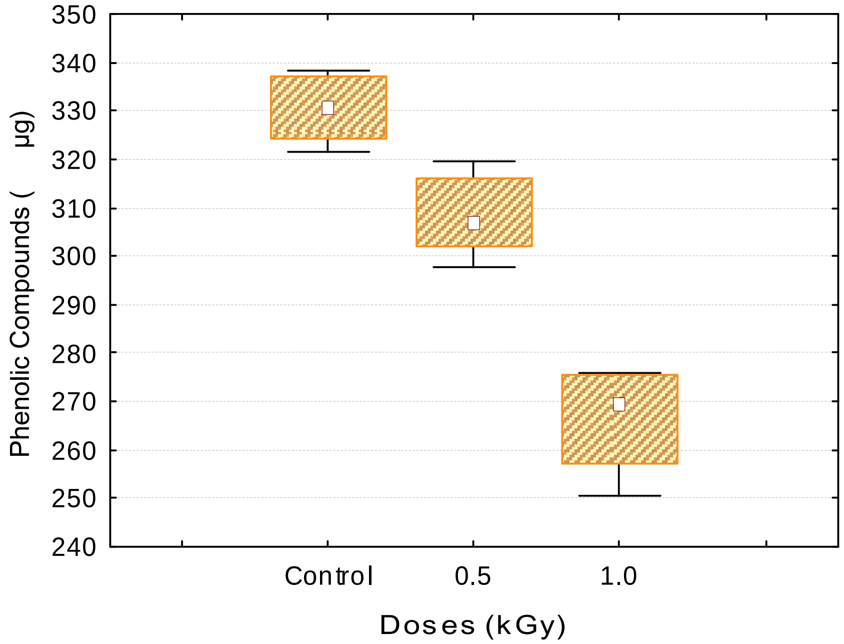

Figure 1: Levels of phenolic compounds in baby carrots before and after irradiation in dry weight. Box plot shows mean and standard deviation, expressed by error bars.

Evaluating the levels of phenolics, irradiated sample exposed to 0.5 kGy dose showed, an approximately, 10% reduction when compared to the control. An irradiation dose of 1.0 kGy caused a loss about 20% also compared with the sample without treatment.

Phenolic content significantly decreased ($p<0.05$) with increasing radiation dose. These results may indicate degradation or insolubilization of phenolic compounds when they are exposed to gamma irradiation. However, studies need to be conducted with more samples to confirm the results.

In contrast, an increase of the amounts of total phenolics due to irradiation has also been reported by many authors. Researches with *Nigella sativa* seeds, raspberries, apricots and soybeans demonstrated this behavior in the results. Harrison and Were [27] and Stajner et al. [28] suggested this increase in total phenolics may be due to the release of phenolic compounds from glycosidic components and degradation of larger phenolic compounds into smaller ones by gamma irradiation, with a consequent improvement in the extraction yield of the phenolic compounds [29] [30] [31] [32] [33] [34] [35].

Once the product is peeled and cutted, the protection of glycosidic wall is broken and bioactive compounds are released and susceptible to the influence of process treatments such as gamma irradiation. This can explain the increasing on natural foods and the decreasing on minimally processed foods.

3. CONCLUSIONS

Gamma irradiation, as a food processing method, affect phenolics content caused a decrease on the amounts, probably due to degradation or insolubilization. Although the radiation has affected the phenolics, the process might promote the consumption of ready-to-eat fresh foods, keeping fresh-like characteristics for longer.

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