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Effect of Ionizing Radiation on Starch Films Incorporated with Hibiscus or Turmeric Extracts

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1. Introduction

Starch, globally ubiquitous, affordable, and environmentally benign. is an excellent material for sustainable and environmentally food packaging materials applications given its ability to form thermoplastic films. Numerous factors, including starch source, extraction method, film formulation, and processing methods impact the ultimate material properties. In recent years efforts are being made toward the development of functional films containing antioxidant or antibacterial agents. Hibiscus sabdariffa, known as roselle, is an edible plant used for making wine, juice, jam, syrup, pudding, cakes, ice cream or tea. Roselle flower and calyces are also known for its antiseptic, diuretic, antioxidant and antimutagenic properties The dried flowers of this plant contain gossipetine and hibiscin (anthocyanins); the petals yield glucoside hibiscritin (flavanol); and the calyces are rich in riboflavin, ascorbic acid, niacin, carotene, calcium and iron [1]. Turmeric is a spice cultivated from the rhizomes of Curcuma longa (known everywhere as “curcuma”) which is a member of Zingiberaceae family. It is very popular worldwide as a spice, food preservative, and coloring material. The most important component of turmeric is curcumin, a biologically active polyphenolic compound [2]. Curcuma has been used in traditional medicine and many scientific studies have been proven its many bioactivities. Radiation technology can be applied for the production of biodegradable packaging for the food Industry. The objective of this work was to assess the effect of electron beam irradiation on some important mechanical barrier and properties of films made of a natural polymer, potato starch, and additives such as hibiscus or turmeric or curcuma natural extracts.

2. Methodology

Materials were obtained from the local food market. Potato starch trade mark Yoki. Hibiscus and turmeric powders obtained in bulk at All reagents used were of analytical standard. The hibiscus and turmeric samples were obtained as powder in bulk from *Empresa Zona Cerealista Ltda*.

The water was treated in a Milli-Q purification system (TGI Pure Water Systems). The process of film preparation (casting) was carried out by homogenizing in aqueous solution 5% of starch (w/v), 3% of glycerol (w/v), 0.5% of propionate of calcium under constant stirring until starch gelatinization.

For the preparation of bioactive films, the same formulation was prepared with the addition of 1% and 2% of the extracts. Hydrogels formed were kept at room temperature for 1h. Then, 80g were poured into acrylic plates and these were subjected to drying in a chamber with air circulation under controlled temperature re (25°C) and relative humidity (50%), for a period of 72 h.

Film irradiation was carried out using a Dynamitron II electron accelerator, Radiation Dynamics Inc. The samples were irradiated at room temperature with doses of 5, 10, 20 and 40 kGy, dose per pass 5kGy, energy 0.550 MeV, beam current 3.21mA, dose rate 22.38 kGy/s. For each treatment, a non-irradiated sample was maintained as a reference (0kGy). After irradiation, the samples were placed in desiccators and stored until analysis. The doses chosen were based on preliminary analyzes. Dosimetry was performed using alanine pellet dosimeters calibrated according to the international standard ISO/ASTM l5160.

The analyzes of the mechanical properties of the films were carried out on a TX Plus Texture Analyzer, using the "Texture Exponent 32" program (Stable Micro Systems, Surrey, UK, England). For the breaking strength test, the equipment was connected to a 50 kg load cell; the software used was Exponent and the accessories attached to carry out the experiments were a film support (HDP/FSR) and a 5 mm diameter stainless steel spherical probe (P/5S). Tests were carried out at a constant speed of 0.5 mm s-1 and a distance of 15 mm. For each test, 10 specimens of 30 mm2 were used for all doses studied.

The determination of the water-soluble fraction of the films was carried out according to the methodology in which a sample of known initial dry mass was immersed in 50 mL of distilled water at 25°C for 24 hours. Afterwards, the insoluble films were dried in an oven at 105C for 24 hours to determine the final dry mass of the sample. The water-soluble fraction was calculated according to equation:

$$WSC\ (\%) = \frac{(mi - mf)}{mi}\ x100$$

Where: WSC=Water solubility in (%); mf= final mass of the sample and mi=initial mass.

The oxygen permeability rates (TP'O2) were determined by the coulometric method, according to the procedure described in the ASTM-F 1927 standard, in OXTRAN equipment, model 2/22, from MOCON, operating with pure oxygen as the permeant gas. The tests were carried out at 23 °C and 50% RH. The effective permeation area of each specimen was $50cm^2$. The results obtained were corrected for a 1atm oxygen partial pressure gradient between the two surfaces of the film. This gradient corresponds to the driving force for oxygen permeation through the film. The doses of the films analyzed were 0 and 40 kGy. From the oxygen permeability rate, the oxygen permeability coefficient (PO2) was calculated, as follows:

$$PO_2 = \frac{TP'O_2xe}{p}$$

where:

PO_2 = oxygen permeability coefficient (mL (CNTP). µm. $m^{-2}.day^{-1}.atm^{-1}$)

$TP'O_2$ = oxygen permeability rate (mL(CNTP). $m^{-2}.day^{-1}$)

e= average thickness of the test piece (µm)

p= partial pressure of oxygen in the permeant gas chamber of the diffusion cell, since the partial pressure of O_2 in the carrier gas chamber ($N_2 + H_2$) is considered zero.

3. Results and Discussion

The potato starch with hibiscus films were, in general, malleable, with good appearance, absence of fractures and colorful. Despite the coloring, the films were transparent, indicating that this material did not completely block the passage of light. It was also observed that irradiation changed the color of the films.

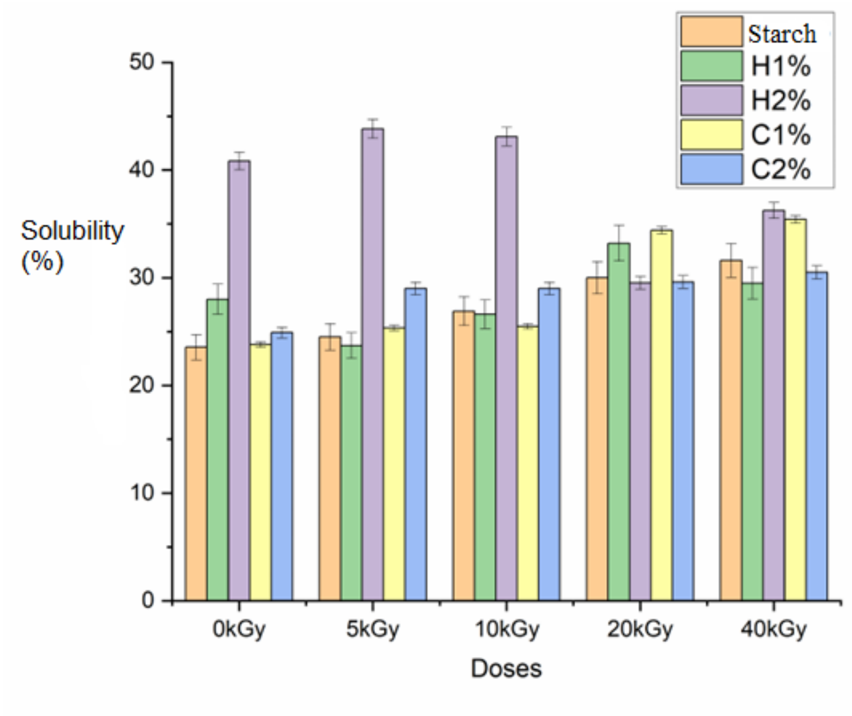

Figure 1: Water solubility of starch films pristine (S) and added of 0, 1 and 2% hibiscus or curcuma extracts irradiated with 0 and 40 kGy

Water solubility data of starch films (S) and added with hibiscus and curcuma extracts are displayed in Fig 1. In Fig. 2 are the oxygen permeability coefficients and Fig 3 shown the mechanical properties of the same samples.

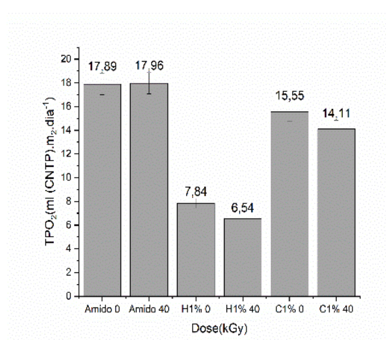

Figure 2. Oxygen permeability coefficients of starch (S) films and S added with 1% hibiscus or 1% curcuma irradiated with 0 and 40 kGy.

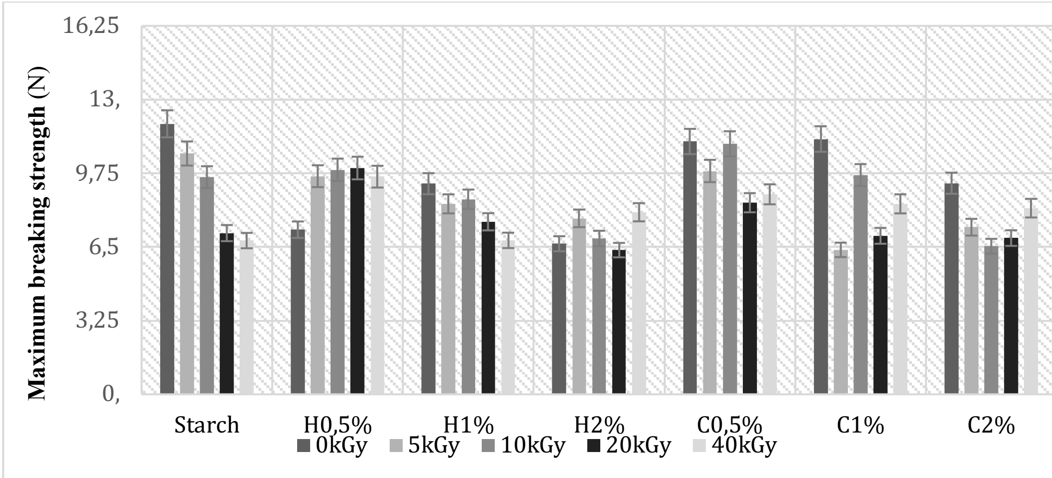

Figure 3. Maximum breaking strength of pristine starch films (S) and added of 1% and 2% hibiscus extracts, and 1% and 2% curcuma extracts irradiated with 0-40kGy

4. Conclusions

With increasing irradiation dose, the resistance to perforation of the prepared films tends to decrease. For water absorption, the samples showed different behavior depending of the dose applied. Moisture and solubility varied slightly ($p<0.05$) between non-irradiated and irradiated samples. Hibiscus and turmeric incorporated starch films [3] can be included in the novel applications for food packaging.

Acknowledgements

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