2026 International Nuclear Atlantic Conference – INAC 2026
Escola de Guerra Naval, Rio de Janeiro, RJ, August 24 - 28, 2026

Starch hibiscus films prepared by extrusion and submitted to electron beam irradiation

B. S. Teixeira[1] and N. L. del Mastro[2]

[1]*brunasaporito@hotmail.com, IPEN/CNEN - Avenida Professor Lineu Prestes, 2242 - Cidade Universitária, São Paulo - SP, CEP 05508-000, Brazil*
[2]*nelida@usp.br, IPEN/CNEN - Avenida Professor Lineu Prestes, 2242 - Cidade Universitária, São Paulo - SP, CEP 05508-000, Brazil*

1. Introduction

Starch is a promising forming film material for food packaging, owing to its biodegradable nature and edible film formulation properties, as well as its wide availability, high nutritional value, low cost, biocompatibility, edibility and functional properties [1,2]. Hibiscus (*Hibiscus sabdariffa)* is rich in numerous bioactive compounds, such as dietary fiber, organic acids, flavonoids, polyphenolic pigments, thiamine, riboflavin, ascorbic acid and beta-carotene [3]. The main challenge with natural antioxidants, such as those extracted from hibiscus, is their inherent instability. In the present article, starch hibiscus films were prepared by extrusion [4], added of 1% and 2% of nanoparticles of hibiscus followed by electron beam irradiation [5]. Visual, thickness, humidity and water absorption properties of the films were analyzed.

2. Methodology

The potato starch films were prepared as described by Teixeira [4] including nanoparticles preparation. The proportions prepared for the development of extruded starch films with hibiscus particles, it is presented in Table I.

Table I: Development of starch films by extrusion (%)

Films	Starch	Glycerol	water	Calcium propionate	Encapsulated hibiscus particle**
F1	64	20	15	1	-
F2	63	20	15	1	1
F3	62	20	15	1	2

**Encapsulated hibiscus particle (active ingredient 1%, maltodextrin 30%, ratio 1:20)

Extrusion was processed in a twin-screw extruder (screw diameter of 16 mm and L/D ratio of 40) (Process 11, ThermoElectron-Germany). The potato starch-based films were irradiated using a Dynamitron II electron accelerator, Radiation Dynamics Inc. Parameters of electron beam irradiation (EBI) are displayed at Table I. Samples were irradiated at room temperature with doses of 5, 10, 20, and 40 kGy; visual, thickness, humidity and water absorption properties of the films were analyzed.

Table II: Electron beam irradiation parameters

Sample	Total Dose (kGy)	Dose for pass(kGy)	Energy (MeV)	Beam current (mA)	Dose rate ($kGy.s^{-1}$)
Film	40	5	0.550	3.21	22.38

3. Results and Discussion

Several factors affect film thickness, including its preparation method, raw material, and its properties, such as density, viscosity, surface tension, and the presence of nanoparticles. Typically, films have a thickness of 0.25–0.36 mm depending on their application. Photographs of films prepared by extrusion is presented in Figure 1 and thickness, humidity and water absorption properties are displayed in Table II. Present results on thickness are in agreement with other authors as the incorporation of active agents generally increases film thickness, which has been attributed to the increase in total solids content in the system (LEE et al., 2019).

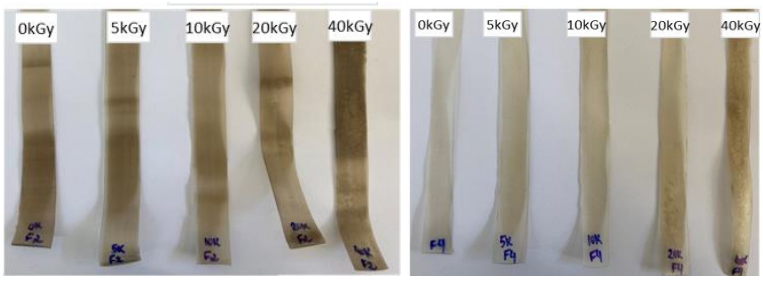


Figure 1: Starch films with added hibiscus nanoparticles (1% left and 2% right) prepared by extrusion and irradiated.

Table III: Physicochemical properties of starch films, and films with added hibiscus nanoparticles (1 and 2%) extruded and irradiated with different doses.

Starch	0kGy	5kGy	10kGy	20kGy	40kGy
Thickness (mm)					
F1	0.27±0.01^{b}	0.27±0.01^{b}	0.28±0.01^{b}	0.3±0.01^{a}	0.32±0.01^{a}
F2	0.36±0.02^{b}	0.34±0.01^{c}	0.32±0.01^{d}	0.39±0.02^{a}	0.4±0.02^{a}
F3	0.36±0.03^{a}	0.38±0.02^{a}	0.36±0.01^{b}	0.35±0.02^{b}	0.36±0.02^{b}
Humidity (%)					
F1	19.5±0.1^{a}	8.3±0.2^{d}	11.8±0.1^{c}	25±0.1^{e}	17.3±0.1^{b}
F2	15.8±0.1^{c}	7.2±0.1^{d}	18.2±0.4^{b}	19.5±0.5^{a}	18.5±0.1^{b}
F3	16±0.1^{c}	17.2±0.3^{b}	14.7±0.1^{d}	20±0.1^{a}	20±0.1^{a}
Water absorption (%)					
F1	54.4±0.1^{a}	55.1±0.1^{a}	60.6±0.2^{b}	50±0.3^{c}	43.7±0.5^{d}
F2	65.2±0.1^{a}	63.2±0.4^{b}	53.5±0.1^{c}	55±0.3^{d}	54.5±0.1^{d}
F3	46±0.5^{a}	58.7±0.1^{b}	48.5±0.3^{c}	50±0.1^{d}	37.7±1^{e}

Mean ± standard deviation in the same row with different lowercase letters are significantly different ($p<0.05$) according to Tukey's test. F1=Starch film; F2=Starch film with the addition of 1% encapsulated hibiscus nanoparticles; F3=Starch film with the addition of 2% encapsulated hibiscus particles.

4. Conclusions

Edible films made of starch enhanced with natural antioxidants are a very promising materials for food packaging and contribute to green and sustainable food packaging technologies [6]. These edible films can lead to retention of food moisture retention, preserving the freshness of the product by maintaining color, brightness, and reducing water loss. Ionizing irradiation has proven to be a versatile and effective method for modifying polysaccharides. Additionally, the inclusion of antioxidant agents in the formulation of films help of mitigate some undesirable impact of EBI.

Acknowledgements

This work was performed using the facilities of the CETER, IPEN/CNEN.

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