DEVELOPMENT OF A BIODEGRADABLE FILM USING AGRO-INDUSTRIAL BY-PRODUCTS – PINE NUT FAILURE (*Araucaria augustifolia*) AND RICE HUSK (*Oryza sativa*)

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ABSTRACT

Growing awareness of the escalating accumulation of plastic packaging in the environment has spurred research towards organic packaging solutions. This study aimed to develop a smart film by valorizing agribusiness by-products, specifically rice husks (Oryza sativa) and pine nuts (Araucaria angustifolia). Seven films were fabricated using the casting methodology, employing edible raw materials and varying concentrations of aqueous extracts from rice husks and pine nuts. The concentrations of phenolic compounds in both the film and the extracts were quantified, and the film's properties were evaluated. It was applied as an interlayer on mozzarella cheese, followed by analyses. The optimal film demonstrated temperature resistance, heat-sealing capability, and an intelligent color-changing feature in solutions with varying pH levels. It also exhibited antioxidant properties. Its application preserved the food's characteristics, akin to the commercial sample. The results suggest replacing synthetic materials with the developed bioplastic.

Keywords: Film. Smart biopolymer. Circular bioeconomy. Rice husk. Pine nut failure.

1 INTRODUCTION

Conscientious and appropriate use of packaging ensures the safety and quality of food and drink, protecting against biological, chemical, physical, and mechanical damage during transportation and storage.[1] In this way, the unfavorable ecological impact caused by synthetic polymers can be considerably reduced by using biodegradable polymers. Considering this, rice husks and pine nut failure have the potential to be used as raw biomaterial for food packaging.[2] Additionally, there has been limited academic research on pine nuts and their derivatives. This approach believes in minimizing plastic use and valorized by-products with significant potential for developing environmentally friendly materials. The Fig. 1 illustrates this study.

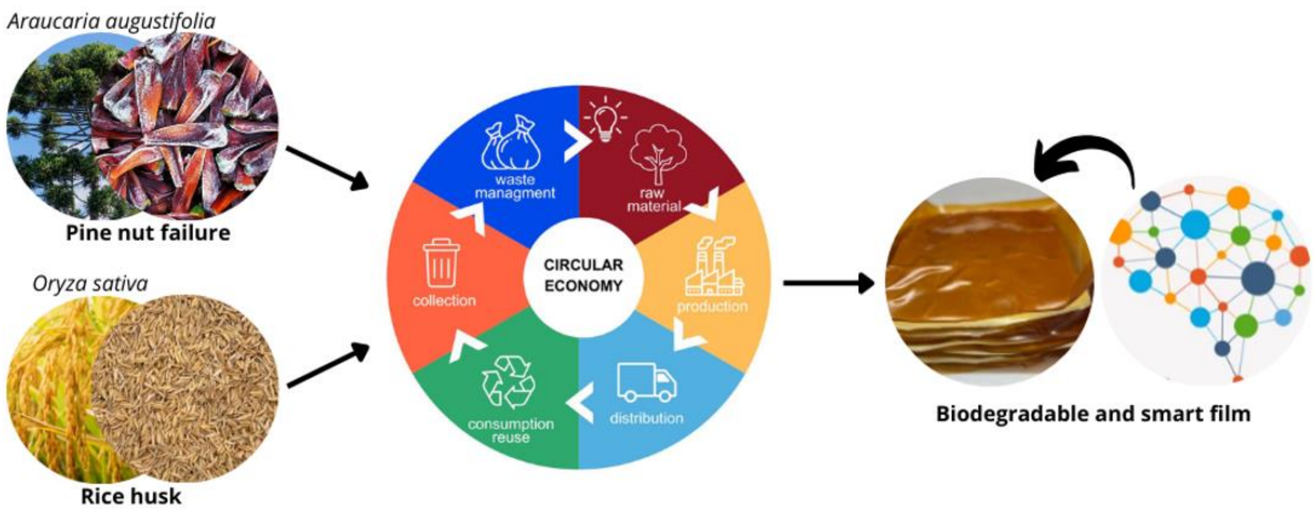

Figure 1 Demonstration of circular economy[3] film production

2 MATERIAL & METHODS

The rice husk and pine nut extracts were produced using waste from local industries and previously processed to obtain properly sterilized components. The films were produced by adding corn starch, glycerol, carboxymethylcellulose, distilled water, and the extracts. A pine nut extract was prepared using a modified 1:10 ratio method[4] and the same ratio as rice husk extract,[5] and to form the casting method was applied. Color in different pHs and luminosity analyses were carried out to characterize the films.[6] In addition to the antioxidant potential through the measurement of polyphenols, as well morphology, and water solubility.[7] Finally, was made a biodegradable estimation of the film.[8]

3 RESULTS & DISCUSSION

In characterizing the change in color at different pHs, at acidic values (pH=3) it was light yellow. And dark orange at high values (pH =12). The absorption behavior was evaluated between 500 and 800 nm, as can be seen in Fig. 2. The difference in the behavior of the spectrum proves that the extract changes under different pH conditions.[9]

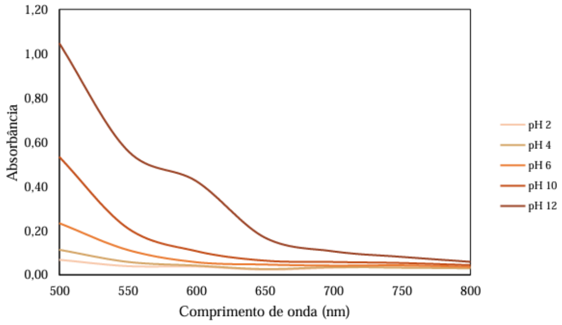

Figure 2 Absorbance spectra of the pine nut failure extract as an indicator at different pH's

The pine nut failure extract showed 18.45 ± 1.16mg GAE.g-1. According to studies carried out on pine nut cooking water, the number of phenolic compounds in the 15, 30, and 45 minutes conditions is 0.12 ± 0.22mg GAE.g-1, 0.17 ± 0.01mg GAE.g-1 and 0.36 ± 0.07mg GAE.g-1, respectively.[10] The rice extract showed 0.75 ± 0.00mg GAE.g-1, which represents a low value for antioxidant potential. According to these results, the pine nut failure extract showed a high value of phenolic compounds, which implies a potential for antioxidant activity in films.[11]

Figure 3 shows the morphology of the film, which is a rough surface without pores or cracks. However, the white dots represent starch that has not been completely solubilized.

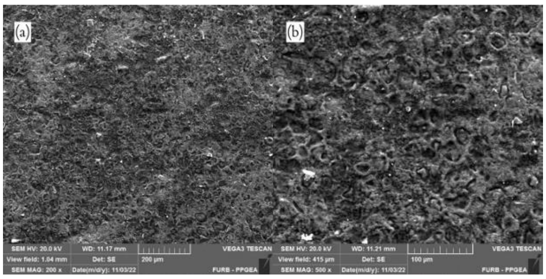

Figure 3 Micrographs of the film surface

The biodegradation analysis of the developed film was conducted qualitatively, with the process documented through photographic records. In a 12 cm x 12 cm sample (Figure 4), the biodegradation process was observed over 12 days. By day 5, the sample had lost all rigidity and structure, with only a few fragments remaining and parts of the film completely degraded. By day 12, the degradation process was fully completed.

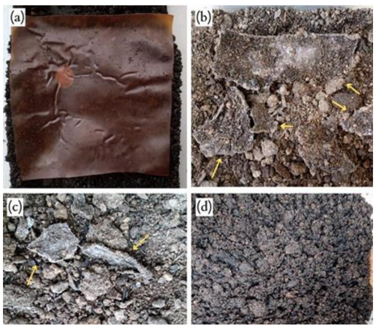

Figure 4 Biodegradability of the film (12cm x 12cm) on days (a) zero, (b) 5, (c) 10 and (d) 12.

Upon analyzing the film samples, can be concluded the correlation between opacity and transparency to luminosity. Specifically, the film shows a luminosity value (L* 71.23±0.50), indicating reduced light transmission. These findings denote that higher extract concentration resulted in films with reduced light transmission and increased opacity, enhancing its suitability for food contact applications.[12]

The samples showed high water solubility and significant differences between the values ($p < 0.05$), with the highest value being 55.41±3.41% (Treatment 4). In terms of biodegradable packaging, high solubility is desired. Nevertheless, for protection to be achieved, the food needs to have low water solubility so that shelf life extends, thus avoiding degradation of the packaging.[13] Biodegradable films with low solubility are more versatile when applied to foods with high moisture content, as they will not solubilize or suffer damage due to the high concentration of water present in the food.[14]

4 CONCLUSION

This work developed an intelligent film with antioxidant and intelligent properties using by-products from the agricultural industry (rice husks and pine failure). This approach emphasizes the circular bioeconomy, sustainability, and recent trends toward more environmentally conscious food consumption patterns. All the ingredients used to develop this biopolymer are edible, imparting this characteristic to the developed material. The film developed exhibited adequate coloration changes visible to the human eye. This behavior is due to the pine nut extract changing color at different pH levels, imparting an intelligent property to the film. Additionally, the extracts contained satisfactory concentrations of phenolic compounds, providing the biofilm with antioxidant potential. Structurally, the film is flexible, and biodegradable within 12 days. Furthermore, the packaging has potential for various other applications, such as in plastic film and as a quality indicator through color change. The results indicate the potential for substituting oil-based materials with the innovative bioplastic developed in this study. This bioplastic is not only intelligent but also biodegradable and edible.

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