VALORIZATION OF AN AGRO-INDUSTRY BYPRODUCT TO OBTAIN DIETARY FIBER AND ITS USE IN EDIBLE PACKAGING

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ABSTRACT

Soy agro-industrial byproducts present a notable environmental and economic concern, yet they offer a promising solution for sustainable packaging. Rich in prebiotic fibers, these byproducts can be transformed into edible films that carry probiotic microorganisms to prolong the shelf life of perishable products. The current study successfully extracted soy fiber (RSF) with a 5.31% yield via acid hydrolysis, producing films with an average thickness of 0.05 ± 0.005 mm and water vapor permeability of 2×10^{-11} g/(m×Pa×s). These metrics are comparable to those of commercial CMC films and superior to starch alternatives. The films boast over 70% UV protection and enhanced opacity, making them well-suited for safeguarding UV-sensitive goods during industrial shipping, though their opacity is less ideal for retail packaging where product visibility is crucial. Despite slower solubility compared to β-glucan, RSF films match the biodegradability of Inulin and Pectin films and hold up in humid conditions. Significantly, they fully biodegrade in soil within seven days, confirming their potential as eco-friendly packaging that can significantly reduce the impact of soy byproducts.

Keywords: Byproduct. Casting. Pectin. Inulin. Beta-glucan.

1 INTRODUCTION

The agro-industrial sector plays a critical role in the global economy, with an annual yield of approximately 7.26 gigatonnes. In Brazil, this sector contributes about 25.5% of the nation's GDP, a substantial share of which is attributed to grain production, such as soybeans[1], generating around 1.4 billion tonnes of byproducts yearly[2]. These byproducts, rich in prebiotic dietary fibers, not only further human health but also have a range of applications, most notably in the production of edible films. As integral components of the polymer matrix, they fulfill a dual purpose: reinforcing the structural integrity of edible films and acting as functional foods that bolster human health and probiotic viability.

Edible films are emerging as an eco-friendly alternative to conventional plastics. They are crafted using innovative methods that polymerize plant-derived biomass, offering protection from environmental factors and extending the shelf life of perishable goods, notably fruits and vegetables. Furthermore, these films are not only gentle on the environment but also capable of carrying probiotics, leading to the creation of symbiotic films. This promising development in food technology not only advances sustainable practices but also supports the well-being of consumers[3].

2 MATERIAL & METHODS

The extraction of soybean residue fiber (SRF) was conducted utilizing a modified procedure based on the protocol established by Chen *et* al.[4]. The raw soybean residue was sourced from the Mercado Municipal in Poços de Caldas. The efficiency of fiber extraction was quantified through the yield, defined as the weight percent of the extracted fiber relative to the initial mass of the soybean byproduct.

The casting technique was employed for the synthesis of edible films, following a method adapted from Abedi-Firoozjah *et* al[5]. The materials used included fibers: Pectin (Adicel), Inulin (SweetMix), β-Glucan (Nutramax), and RSF. Glycerol (Synth) served as the plasticizing agent, and carboxymethyl cellulose (CMC) from Sigma was used as the polymeric base.

This study utilized adapted methods from Abedi-Firoozjah *et* al.[5] for most analyses, while water vapor permeability (WVP) was assessed as per Ekrami *et* al.[6] 's technique. Film thickness was gauged at four points with a micrometer caliper. Optical properties were analyzed by spectrophotometry, measuring opacity via absorbance at 550 nm against film thickness. WVP was determined through controlled observation of mass changes over 24 hours, calculating the Water Vapor Transmission Rate (WVTR). Water Solubility (WS) involved drying, immersing, agitating, and re-drying. Films' biodegradability was evaluated by environmental exposure and degradation monitoring.

3 RESULTS & DISCUSSION

The hydrolysis of fiber by assimilating acid hydrolysis at high temperatures (121 ºC, 1.15 bar) resulted in a yield of 5.31%. Control fibers were used for comparison, and the resultant soluble fiber (RSF) exhibited a significantly more pronounced coloration, as demonstrated in Figure 1 (A-D).

Figure 1 Films obtained by the casting method: a) Pectin b) Inulin, c) β-Glucan and d) RSF

The thickness and water vapor permeability of the films were not significantly different, with an average thickness of 0.05±0.005 mm. The permeability of a pure CMC film is approximately 2×10^{-11} g/(m×Pa×s)[7], and the addition of 20% fibers did not significantly affect this property. In comparison to starch films, CMC films offer significantly superior barrier properties, which is beneficial as it leads to less water absorption in the foods they wrap[8].The RSF's transmittance was significantly different from the other fibers as shown in Figure 2, blocking more than 70% of UV rays, suggesting its potential use in preserving foods and products sensitive to this type of radiation, a property not observed in the other fibers. On the other hand, the opacity of the fibers was measured at 1.24±0.26 for Pectin, 0.54±0.14 for Inulin, 0.89±0.02 for β-Glucan, and 2.22±0.42 for RSF. These results demonstrate that the application of RSF can alter the visibility of products to the end consumer, however, this does not affect the potential use of this fiber in the storage and transportation of foods. The RSF film exhibited significantly lower solubility (71.96±3.2%) compared to the β-glucan film (80.38±0.8%), while being similar to the Inulin and Pectin films (63.5±2.1%). This indicates good biodegradability in water while also showing resistance to degradation in environments with moderate relative humidity. Biodegradability was not altered for any of the films, with all being degraded in soil within a maximum of 7 days, thereby reinforcing their sustainability and reducing the environmental.

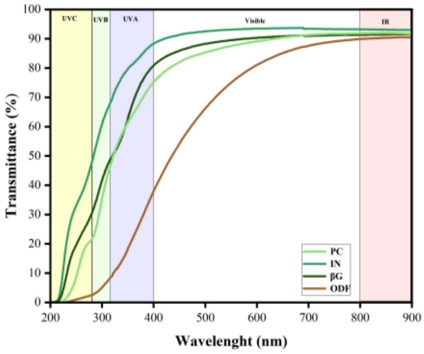

Figure 2 Transmittance profiles for different films.

4 CONCLUSION

This study successfully developed sustainable edible films from agro-industrial byproducts, demonstrating their potential as an eco-friendly alternative to conventional plastics. The optimized extraction process yielded fibers that contributed to the uniform physical properties and enhanced optical features of the films, including increased opacity and UV protection. The rapid biodegradation of these films highlights their environmental benefits. These findings pave the way for advancing the application of biodegradable packaging solutions in the industry.

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