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POLYLACTIDE FILMS WITH INCREASED OPTICAL BARRIER PROPERTIES THROUGH THE USE OF BIXIN

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Introduction

The use of carotenoids as yellow-red colorants for polymeric materials represents a sustainable way of obtaining colored packaging. The introduction of bixin, a carotenoid that exists in abundance in annatto seeds, could be used to increase the optical barrier properties of poly(lactide) (PLA) films, turning the biodegradable polymer more suitable to protect light-sensitive products. However, the use of additives in polymeric matrixes could interfere in their thermal and oxygen barrier properties, where an increase on the latter is highly desirable to food packaging materials. The present study aimed to develop PLA films with increased optical barrier properties through the use of different concentrations of bixin. Considering that besides light, the contact with oxygen plays an important role on the shelf-life of perishable goods, the films barrier to oxygen was evaluated, as well as their thermal properties.

Materials and Methods

PLA “PLE 001” was purchased from NaturePlast. Bixin was extracted from annatto seeds (*Bixa orellana*) with dichloromethane¹. PLA films were produced by solvent-casting technique dissolving PLA in dichloromethane, where bixin was added to PLA solutions to produce films with different concentrations of the carotenoid (w/w): 0%; 0.01%; 0.05%; 0.10%; 1.0%. PLA/bixin solutions were poured into Teflon plates and dried at ambient temperature for 48 hours. Subsequently, films were peeled and thermo-compressed (160 °C, 6 min) to remove the residual solvent. The optical barrier properties of the films were measured by placing films in a quartz test cell, scanning the samples from 200 to 800 nm, using a UV-Vis spectrophotometer (Jasco V-750, Japan). An empty test cell was used as reference, and results were expressed as percentage transmittance. The oxygen permeability of films was determined using a manometric method on a GDP-C permeameter (Brugger, Germany) working at 25 °C. The permeability (P) was calculated by multiplying the measured oxygen transmission rate by the sample thickness (measured with a micrometer on 9 points). The diffusion (D) and sorption (S) coefficients were calculated with the help of the time-lag (t_{lag}) method². The analysis of crystallinity degree (χ) and glass transition temperature (T_g) of the films were carried out by means of a Q100 DSC (TA Instruments), in triplicate.

Results and Discussion

As expected, the presence of bixin reduced the light transmission of PLA films: the higher the concentration of bixin, the higher the films’ barrier to ultraviolet (200–300 nm) and visible light (300–800 nm) (Figure 1). The reduction of light transmittance is due to the presence of conjugated double bonds in bixin molecular structure, which serve as chromophore moieties and are responsible for its light absorption capacity. The colored films are shown in Figure 2.

The presence of bixin did not affect the oxygen solubility, diffusivity and permeability of the films, neither their thermal properties, given by T_g and crystallinity degree (χ) (Table 1).

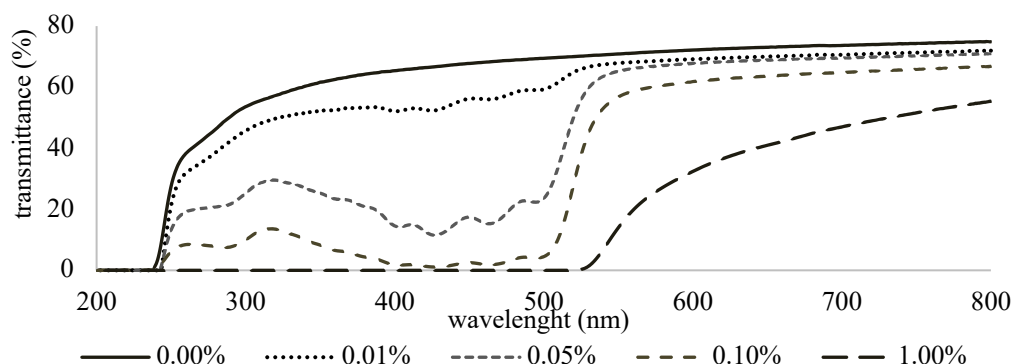


Figure 1. Light transmittance (%) through PLA films with different concentrations of bixin (0 – 1%)

The presence of bixin in the PLA matrix can therefore be expected not to introduce changes in the mechanical behavior of PLA packaging materials. However, the change in the UV light transmittance helps efficiently to protect oxidation sensitive foods against degradation³.

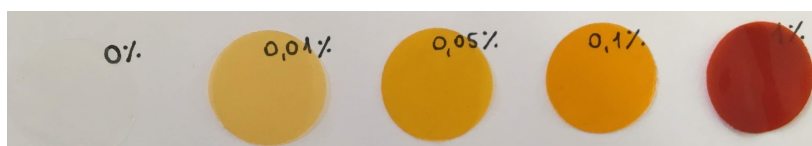


Figure 2. Colored PLA films produced with different concentrations of bixin (0 – 1%)

Table 1 – Oxygen barrier and thermal properties of PLA films produced with bixin.

Bixin (%)	P.10 ¹⁸ [m ³ m m ⁻² Pa ⁻¹ s ⁻¹]	D.10 ¹² [m ² s ⁻¹]	S.10 ⁶ [m ³ m ⁻³ Pa ⁻¹]	Tg (°C)	χ (%)
0.00	3.31	3.3	1.0	50.5 ± 0.7	0.8 ± 0.1
0.01	4.14	3.5	1.2	49.8 ± 1.9	1.5 ± 0.2
0.05	3.04	2.8	1.1	50.4 ± 1.7	1.0 ± 0.4
0.10	3.59	3.2	1.1	50.3 ± 0.1	1.3 ± 0.2
1.00	3.32	2.9	1.2	49.3 ± 2.3	1.3 ± 0.0

Conclusion

Bixin was shown to effectively increase the UV and visible light barrier of PLA films, where the presence of 1% of the carotenoid resulted in films with nearly zero UV light transmittance. Considering light is a powerful lipid-oxidizing agent in food systems and bixin present a notable antioxidant activity, the produced films are currently being explored as an antioxidant packaging material. Although improvements on oxygen barrier properties are still required, the presence of bixin is expected to retard oxidation reactions in sunflower oil.

References.

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