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► To cite this version:

Liana Stoll, Alessandro de Oliveira Rios, Sandra Domenek. Polylactide films produced with bixin and ATBC: effect of thermal treatment on bixin stability and migration kinetic. Matbim 2019, May 2019, Milan, Italy. 2019. hal-03906626

HAL Id: hal-03906626 https://hal.science/hal-03906626

Submitted on 19 Dec 2022

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POLYLACTIDE FILMS PRODUCED WITH BIXIN AND ATBC: EFFECT OF THERMAL TREATMENT ON BIXIN STABILITY AND MIGRATION KINETIC

Liana Stoll, Alessandro de Oliveira Rios; <u>Sandra Domenek</u>

1. Introduction

The incorporation of antioxidants into a polymeric structure to produce antioxidant active materials is an alternative way to extend the shelflife of fatty food products. Even tough polylactide (PLA) present satisfactory mechanical properties, it requires improvements to be used as an antioxidant material for food packaging.

Bixin, a carotenoid with hydrophobic character, presents coloring and antioxidant properties and hence is a potential antioxidant additive for PLA. Considering bixin thermal low stability, films produced with bixin and the plasticizer acetyl tributyl citrate (ATBC) were produced by different thermal processes. The effect of thermal treatments over films color changes and bixin stability was evaluated, also as its effect on bixin's kinetic of migration.

2. Materials and Methods

Bixin was extracted from annatto seeds (*Bixa orellana*) with dichloromethane. Polylactide (NaturePlast PLE 001) was used to develop the active films, where two formulations (F-without plasticizer; A-with plasticizer) were produced by different methods. Formulations and methods are shown below.

The effect of the thermal treatments over films **color stability** was evaluated using a Konica Minolta colorimeter through L*(luminosity), a* (red-green), and b* (yellow-blue) parameters. The total color differences (ΔE) caused by thermal processes when compared to casting films was calculated using the following equation

Table 1. PLA films formulations and method of obtention								
	Bixin (%)	ATBC (%)	Film Processing Method					
F_cast	0.1	0	casting					
A_cast	0.1	13	casting					
F_TP	0.1	0	casting + TP (6 min)					
A_TP	0.1	13	casting + TP (6 min)					
F_IMTP	0.1	0	IM (2 min) + TP (4 min)					
A_IMTP	0.1	13	IM (2 min) + TP (4 min)					

TP: thermo-press (160°C/5 tons); IM: internal mixer (160 °C, 50 rpm)

The **bixin loss** due to thermal processing of films was evaluated by films dissolution in dichloromethane, followed by bixin quantification by spectroscopy (λ =467 nm; A_{1%=}2826). $\Delta E = \sqrt{(L * -L *_{cast})^2 + (a * -a *_{cast})^2 + (b * -b *_{cast})^2}_{(1)}$ where L*, a* and b* were measured in TP and IMTP films.

Bixin **migration kinetic** to ethanol 95% v/v (used as a fat food simulant) was evaluated over 65 days at 40 °C. Quantification was made by spectroscopy and the **overall mass transfer coefficient** (K) of bixin was obtained using the following equation:

$$\frac{dC}{dt} = K \frac{A}{V} (C^* - C) - k_d C \quad (2)$$

C: bixin concentration in the food simulant (μ g mL⁻¹); C*: bixin concentration (μ g mL⁻¹) in the inner part of the film; K:overall mass transfer coefficient (m s⁻¹); A:surface area of films; V: volume of food simulant; (Stoll *et al.*, 2019)

 k_d :first-order kinetic degradation coefficient of bixin in ethanol 95% at 40 °C (2.155 s⁻¹×10⁻⁷)

3. Results and Discussion

Table 2. Color parameters, bixin loss and bixin overal migration rate (K) of PLA films

Figure 1. Bixin migration from films to ethanol 95% (v/v)

	_				_	
	L*	a*	b*	ΔE	Bixin loss (%)	K (m s ⁻¹)
F_cast	79.17	13.14	87.10	-	_	1.6 c
A_cast	80.47	9.51	89.36	-	-	5.8 ab
F_TP	83.67	2.88	105.50	21.5 b	74.5 b	2.1 c
A_TP	84.88	-1.54	103.01	18.2 b	85.3 a	4.4 b
F_IMTP	80.62	6.00	99.86	39.9 a	79.9 a	7.1 a
A_IMTP	81.94	5.75	103.83	39.4 a	79.2 a	6.9 a

Different letters in the same column indicate significant differences (p < 0.05) among the treatments

- ✓ A decrease in films redness (reduction in a*) and an increase in yellowness (increase in b*) occurred due to bixin thermal degradation, where films produced by **IMTP presented the highest change in color** ($\Delta E \approx 40$). Despite the color changes, films presented a strong and vibrant orange-yellow color after the thermal treatments.
- ✓ The presence of ATBC increased in 10% the bixin loss in TP films. ✓ Considering PLA is frequently used on the encapsulation of diversal bioactive compounds presenting a protective effect its replacement by ATBC might



IMTP films presented the **highest overall mass transfer coefficient (K)** of bixin to the food simulant. The cleavage of PLA long chains caused by internal mixer shear forces might facilitate bixin diffusion through the polymeric matrix, increasing its release rate to the food simulant.

have reduced bixin stability in films matrix.

✓ The presence of ATBC greatly increased bixin migration rate from casting and TP films, which has been ascribed to the increased polymer chain mobility caused by the plasticizer, favoring the active compound release.

4. Conclusion

5. References

The presence of ATBC and mixing shear forces affected bixin stability and migration rate. Since antioxidants' _S concentration and release rate greatly affect the performance of antioxidant active packaging, these findings erare of great importance and are currently being explored on the extension of fatty food products shelf-life.

Stoll *et al*. Poly(acid lactic) films with carotenoids extracts: Release study and effect on sunflower oil preservation. Food Chem 281 (2019) 213–221

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Acknowledgments: This study is part of a collaborative research project between AgroParisTech and the Federal University of Rio Grande do Sul (UFRGS), funded by the brazilian program PDSE - CAPES 2019

JRU 1145 Food Processing and Engineering between INRA and AgroParisTech, Group "Interactions between Materials and Media in Contact", 1 avenue des Olympiades, 91300 Massy, France

