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SOBRE AVANÇOS NA TECNOLOGIA DE FILMES E COBERTURAS FUNCIONAIS EM ALIMENTOS

PROGRAMA E RESUMOS

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CARACTERIZATION OF PECTIN-BASED EDIBLE FILMS AND EFFECT OF ADDITION OF PAPAYA PUREE AND CINNAMALDEHYDE NANOEMULSIONS ON ANTIMICROBIAL, THERMAL AND MECHANICAL PROPERTIES

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Traditional packaging is limited in increasing shelf-life of food products and protecting consumers from foodborne outbreaks. Active packaging may interact with food by releasing antimicrobial agents, which may be incorporated into edible films instead of directly into food matrix.

1.5% (w/v) solutions of low (LMP) or high (HMP) methoxyl pectin were either dried to form LP or HP films or mixed with 3% (w/v) papaya puree, which were either dried to form LPP or HPP films or mixed with 1% (w/v) cinnamaldehyde at 7000 or 16000 $rpm \cdot min^{-1}$ for 4 min and dried to form LPPC7 or HPPC16 films, respectively. Tween 80 was used as surfactant to stabilize the emulsions.

The average particle size of cinnamaldehyde droplets in emulsion was determined by dynamic light scattering (Malvern Instruments, Inc.). The speed of 7000 $rpm \cdot min^{-1}$ led to particles of 271.95 ± 8.70 nm in diameter, while 16000 $rpm \cdot min^{-1}$ reduced droplet size to 41.31 ± 1.05 nm.

Fourier Transform Infrared Spectroscopy (FTIR) was used to characterize the films in the range from 4000 to 400 cm^{-1}. The presence of bands at 1676 cm^{-1} in the nanoemulsion-containing films (Figure 1) is due to stretched –C=C– bonds from cinnamaldehyde molecules. Spectroscopic changes from 3406 cm^{-1} (HPP) to 3386-3390 cm^{-1} (HPPC7 and HPPC16) indicate that the nanoemulsion is stabilized by hydrogen bonds with the pectin matrix. LMP-based films showed similar behavior.

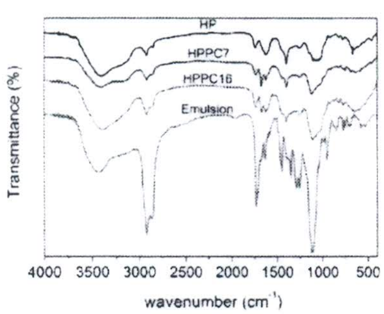

Figure 1. FTIR spectra of films and emulsion.

The thermal stability of the films was assessed by Thermogravimetric Analysis (TGA). LP and HP films showed two well-defined degradation stages, around 208 and 440 °C. Two stages were also observed in films added by papaya puree, but around 135 and 475 °C. The increase in the second degradation stage is a result of the incorporation of fibers, which degrade at temperatures higher than most polymers, including pectin. The addition of cinnamaldehyde led to a third degradation stage, around 380 °C, resulting from the degradation of the nanoemulsion structure.

The glass transition temperatures (Tg) of the films were determined by Differential Scanning Calorimetry (DSC). The incorporation of cinnamaldehyde and the reduction in droplet size did not affect Tg of LMP- (-19 °C) and HMP-based (-22 °C) films. The lower Tg for HMP-based films is due to the better interaction of the papaya puree with LMP than HMP. Such interaction makes polymer chain mobility harder.

Films were shaped according to ASTM D638 and tested on a universal testing machine (Instron Corp.). As shown in Table 1, the addition of papaya puree reduced maximum strength (MS) and elastic modulus (EM), but increased percent elongation (%E). Contrastingly, the addition of cinnamaldehyde improved MS and EM, however slightly reduced %E. MS appears to be improved by the reduction on cinnamaldehyde droplet size, though its effect on EM and %E was nonsignificant.

Table 1. Mechanical properties of pectin edible films.

Film	MS (MPa)	EM (MPa)	%E (%)
LP	20.54 ± 1.67^{a}	1645. 13 ± 119.96^{a}	0.17 ± 0.03^{c}
LPP	5.36 ± 0.42^{cd}	30.00 ± 3.86^{b}	2.46 ± 0.23^{a}
LPPC7	6.34 ± 0.71^{bcd}	75.13 ± 27.28^{b}	1.74 ± 0.40^{abc}
LPPC16	6.53 ± 0.68^{bcd}	93.27 ± 5.38^{b}	1.46 ± 0.17^{bc}
HP	19.23 ± 0.73^{a}	1694.49 ± 286.85^{a}	0.18 ± 0.06^{c}
HPP	4.84 ± 0.29^{d}	37.37 ± 5.41^{b}	1.92 ± 0.39^{ab}
HPPC7	7.70 ± 1.17^{bc}	107.69 ± 18.82^{b}	1.55 ± 0.30^{ab}
HPPC16	8.37 ± 0.21^{b}	82.56 ± 7.41^{b}	1.80 ± 0.14^{abc}

^{a,b,c,d} Different letters following mean values ± standard deviations within a column indicate significant differences by Tukey test at 95% confidence level.

The antimicrobial activities of the films against *Escherichia coli*, *Salmonella enterica* serovar Choleraesuis (Gram -); and *Staphylococcus aureus*, *Listeria monocytogenes* (Gram +) were evaluated by disk inhibition test.

Table 2. Antimicrobial properties of pectin edible films.

Film	Diameter of the inhibitory zone (mm)			
	E. coli	*S. enterica*	*L. monocytogenes*	*S.* [illegible]
LPPC7	0.19 ± 0.22^{a}	3.20 ± 1.77^{bc}	9.24 ± 1.95^{c}	5.32 ± [illegible]
LPPC16	1.79 ± 0.87^{b}	4.91 ± 3.49^{cd}	12.66 ± 1.75^{d}	14.9[illegible]
HPPC7	1.07 ± 0.93^{ab}	1.71 ± 0.91^{b}	6.17 ± 1.32^{b}	9.8[illegible]
HPPC16	3.97 ± 1.99^{c}	7.04 ± 2.96^{d}	7.69 ± 4.71^{bc}	12.9[illegible]

^{a,b,c,d} Different letters following mean values ± standard deviations within a column indicate significant differences by Tukey test at 95% confidence level.

Cinnamaldehyde-free films did not show antimicrobial properties, which were either improved or maintained by reducing droplet size (Table 2). Gram positive bacteria were more susceptible than the Gram negative.

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