International Conference on Food and Agriculture Applications of Nanotechnologies

NanoAgri 2010

Tensile Properties of Alginate-Acerola Films as Affected by Cellulose Whiskers

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Abstract – The tensile properties of edible films made from sodium alginate and acerola puree were studied as affected by cellulose whiskers (CW) from different types (i.e., from cotton fiber or from coconut husk fiber submitted to different bleaching levels). The type of CW did not significantly affect the tensile properties of the films. On the other hand, increasing CW concentrations resulted in increased tensile strength and Young modulus, and decreased elongation at break.

The coconut agroindustries generate a large amount of unripe coconut husk as a byproduct, which demands for end uses, especially in Brazil Northeast. The high lignin contents of coconut fiber make cellulose whisker (CW) extraction difficult, requiring a bleaching treatment for partial delignification [2]. CW were extracted from cotton fibers (CW-A), or coconut husk fibers submitted to one-stage (CW-B) or multi-stage bleaching (CW-C) [2]. Nine nanocomposite films were produced with three concentrations (5, 10, and 15%, on a dry basis) of each of the three types of CW, besides a control film (without CW). 1.6 g of sodium alginate were diluted in 50 mL of distilled water in a magnetic stirrer. 100 g of acerola puree, 4 g of corn syrup, and CW were added, and the mixture was homogeneized in a magnetic stirrer and in a sonicator. The mixture was vacuum degassed, cast on glass plates and leveled (1.2 mm). The films were placed to dry on a lab bench (24°C) for 24 h. Samples were cut and detached from the plate for determination of tensile properties [1].

The tensile properties were not significantly affected by CW type or CW type x concentration interaction (Table 1). So, the effects of CW from coconut husk fiber (even when submitted to a single bleaching stage) on tensile properties of the films were similar to those of CW from cotton fiber. On the other hand, the effect of the CW concentration on all properties was highly significant ($p<0.01$). Tukey test (Table 2) indicates that increasing the concentration of any CW type resulted in films with higher strength and modulus, but lower elongation. Films added with 10% CW presented similar behavior as those with 15% CW.

Table 1. F values resulting from Anova of tensile properties of alginate-acerola films.

Properties		Source of variation		
		CW type	CW concentration	Interaction
TS	F	1.15	50.64	0.30
	p	0.33	<0.01	0.93
EB	F	0.06	54.10	0.31
	p	0.94	<0.01	0.93
YM	F	0.13	151.11	0.34
	p	0.88	<0.01	0.91

TS: tensile strength; EB: elongation at break; YM: Young modulus.

Table 2. Mechanical properties of films added with CW.

CW type	Property	CW concentration (%)			
		0	5	10	15
CW-A	TS (MPa)	3,16 b	3,63 b	4,72 ab	5,91 a
	EB (%)	28,26 a	19,32 b	16,60 b	19,44 b
	YM (MPa)	15,35 b	39,83 a	46,70 a	48,10 a
	RT (MPa)	3,16 b	3,86 b	5,19 a	6,10 a
CW-B	ER (%)	28,26 a	18,52 b	18,00 b	18,22 b
	ME (MPa)	15,35 c	38,25 b	45,74 a	50,85 a
	RT (MPa)	3,16 b	3,29 b	4,94 a	5,65 a
CW-C	ER (%)	28,26 a	18,08 b	17,74 b	18,39 b
	ME (MPa)	15,35 d	38,30 c	43,45 b	50,16 a

Values at the same row followed by the same letter are not significantly different ($p<0.05$).

[1] ASTM. D882-97. In: Annual book of American Standard Testing Methods. Philadelphia: ASTM, 1997. P. 162-170.
[2] M.F. Rosa, E.S. Medeiros, J.A. Malmonge, K.S. Gregorski, D.F. Wood, L.H.C. Mattoso, G. Glenn, W.J. Orts, and S.H. Imam. Carbohydr. Pol. (2010), *in press.*