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Films for Food Packaging based on xylan from agricultural waste residues

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Introduction

Currently most of the plastic used for food packaging is made from petroleum sources due to the low cost of producing these types of plastics, and these plastics are non-biodegradable [1]. Alternative to these non-renewable plastics are bio-based plastics from polysaccharides. Hemicellulose, which is a group of heteropolymers, is the second most abundant polysaccharide in nature, making up between 15-35% of lignocellulosic biomass. Xylan is the most common type of hemicellulose. Xylan films have low oxygen permeability at low to moderate relative humidity values [2]. Films made from xylan are hydrophilic and are therefore good barriers against oils and fats [3]. Xylan forms transparent films, which is an important feature of films meant for food packaging. One of the difficulties with using xylan as a material for food packaging is that it has poor film-forming ability [4]. Xylan film mechanical properties are difficult to predict since the xylan chemical structure varies with the source from which it is obtained. Xylan films also suffer from the drawback that as they hydrophilic they have a high, water vapour permeability which affects the time which food can be on the shelf [1]. To eliminate the disadvantages of xylan as a polymer for film formation it can be blended with another biopolymer that is also naturally abundant.

Experimental

Polymers were dissolved in water and the solution was then mixed → The dope was then sonicated → The dope was then decanted to moulds and dried overnight in a fan oven

Figure 1: Scheme of experimental

Table 1: Composition of films

Sample	Alginate (%)	Xylan (%)	Glycerol (%)
1-2-8	31	61	8
1-1-8	46	46	8
2-1-8	61	31	8
1-2-10	30	60	10
1-1-10	45	45	10
2-1-10	60	30	10
1-2-12	29	59	12
1-1-12	44	44	12
2-1-12	59	29	12

Figure 2: Sample of the films produced

Figure 2 shows a picture of one of the alginate and xylan blend films produced. It can be seen in this picture that the films produced are transparent and have a slight brown hue to them.

Results and Discussion

Table 2: Colour values of the alginate and xylan samples

Sample	L^*	a^*	b^*
Sheet of paper	93,81	-0,18	-4,47
1-2-8	90,67	-0,70	2,61
1-1-8	88,42	-0,55	5,27
2-1-8	87,66	-0,34	8,11
1-2-10	89,05	-0,67	3,54
1-1-10	88,75	-0,64	3,66
2-1-10	88,17	-0,53	6,10
1-2-12	89,49	-0,54	2,75
1-1-12	89,51	-0,52	4,25
2-1-12	88,76	-0,47	6,60

The colour of films used for packaging is important, as this allows people to clearly see what they are purchasing and changes the aesthetic of the items being purchased.. Table 2 gives the colour values for alginate and xylan films. A sheet of paper was used at the target as this would indicate if the materials are suitable for packaging, given that a close match with the sheet of paper would mean the samples were transparent. The value L^* gives the white of black value of the target, with 100 being absolute white and 0 being absolute black. The value a^* represents the redness or greenness, with the values ranging from +60 to -60, the value +60 is red and the value -60 is green. The value b^* represents yellow and blue, the values range from +60 to -60, with +60 being yellow and -60 being blue. The results in Table 2 that the L^* values decrease with an increase in the alginate content meaning that the samples get darker as the amount of alginate in the samples increase, though the changes are very small. The red and green values do not change much with a change in the concentration of alginate and xylan. The greatest difference in colour of the samples can be seen with the yellow and blue values. With an increase in the amount of alginate in the films, the films become more yellow in colour.

Table 3: Mechanical properties of alginate and xylan films

Name of sample	Elongation at break/ %	Stress at break/ MPa	Maximum load/ N	Young's modulus/ MPa
1-2-8 Al-Xyl-Gly	72.45 ± 9.21	2.99 ± 0.54	3.41 ± 0.61	6.44 ± 0.82
1-1-8 Al-Xyl-Gly	27.56 ± 6.87	17.52 ± 2.47	23.75 ± 3.94	83.97 ± 17.31
2-1-8 Al-Xyl-Gly	11.11 ± 2.29	10.46 ± 1.72	16.74 ± 2.75	162.2 ± 17.76
1-2-10 Al-Xyl-Gly	123.2 ± 17.68	3.28 ± 0.64	4.60 ± 0.90	4.48 ± 1.07
1-1-10 Al-Xyl-Gly	51.29 ± 5.89	8.87 ± 2.05	11.34 ± 2.46	31.91 ± 7.04
2-1-10 Al-Xyl-Gly	30.38 ± 4.80	13.07 ± 2.69	19.61 ± 4.04	75.96 ± 17.34
1-2-12 Al-Xyl-Gly	155.9 ± 27.19	1.65 ± 0.39	2.27 ± 0.54	1.28 ± 0.25
1-1-12 Al-Xyl-Gly	77.92 ± 6.52	4.94 ± 0.94	6.42 ± 1.22	12.10 ± 2.87
2-1-12 Al-Xyl-Gly	50.91 ± 8.94	11.77 ± 1.86	15.31 ± 2.42	43.85 ± 9.76
LDPE	535	23,1		

Table 3 shows the mechanical properties of alginate-xylan film blends. The Young's modulus showed an increase with the lower amount of glycerol, the maximum load at break did not show a linear decrease with an increase in glycerol. The samples with 8% glycerol while having a higher Young's modulus, displayed a lower maximum load at break than the samples with 10% glycerol, meaning the samples with 8% glycerol were more brittle. This shows that samples with 10% glycerol have better overall mechanical properties.

The tensile strength of the samples increase with an increase in the amount of alginate in the films, the Young's modulus also shows this trend. The elongation at break of the films decrease with an increase in the amount of alginate in the samples, showing that the samples become more brittle with a higher concentration of alginate. None of the films had mechanical properties to match that of LDPE.

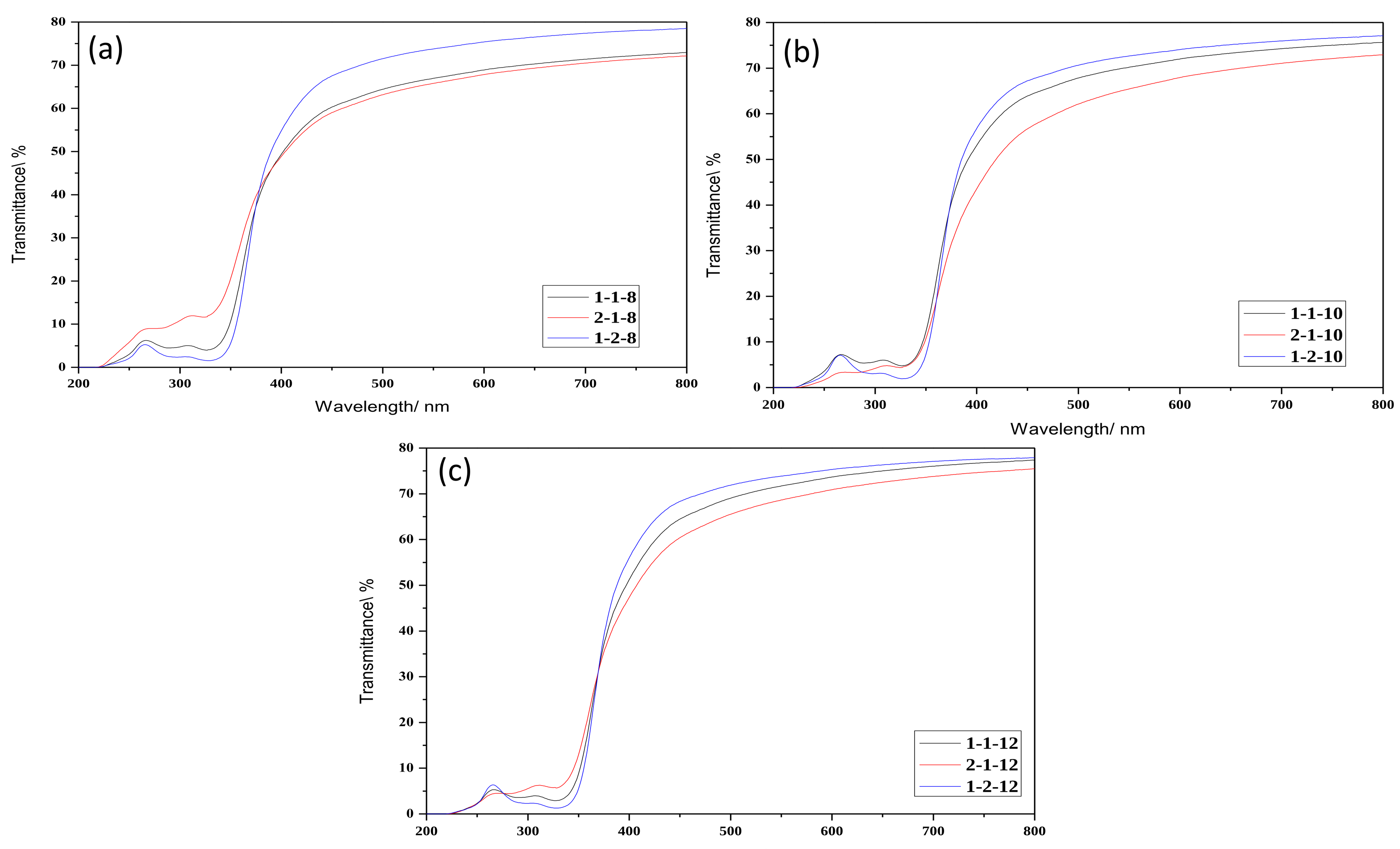

Figure 3: Light transmittance of alginate and xylan films (a) containing 8% glycerol, (b) containing 10% glycerol and (c) containing 12% glycerol.

Figure 3 (a)-(c) shows the light transmission spectra of alginate and xylan blend films. The light transmittance of films for food packaging is important as it allows people to see the contents of the packaging. It can be seen in Figure 3 (a)-(c) that the light transmittance of the films in the visible light region decreases with an increasing amount of alginate. This means that a greater amount of xylan should be used if transparent films are to be obtained. In the UV region of the spectra it can be seen that the higher the xylan content the lower the transmittance of the films. A lower transmittance in the UV region is good as it will retard lipid oxidation of the food, which is triggered by UV radiation.

Conclusions

Alginate and xylan blend films were successfully produced. In terms of colour and aesthetic the higher the xylan content the better. Mechanical properties were better with a higher alginate content and 10% of glycerol, at 8% glycerol films were brittle. Further improvements need to be made in terms of mechanical properties to match that of LDPE.

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