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The investigation of edible packaging films based on pullulan and alginate

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Introduction

Using the edible packaging films which are renewable, biodegradable and versatile, can reduce the amount of plastic waste and extend shelf life of food. Sodium alginate can be used for edible films with excellent properties such as transparency. But, its applications in food packaging are limited because of poor mechanical and barrier properties. At the same time, pullulan is an extracellular and water-soluble microbial polysaccharide with good film-formation properties.

The objective of this study was to formulate pullulan and sodium alginate based edible films for food packaging. A series of designed films were solvent cast from aqueous polymer solution. Understanding the film-forming mechanism during the drying process is crucial to predict properties of the obtained films, so rheological properties of prepared solutions were investigated. Formulated films have the potential to be used as inner primary packaging and can be manufactured by preparing a film-forming composition and enclosing a food product with the film.

Methods

The pullulan and alginate solutions were prepared by dissolving pullulan and alginate (5 wt%) in distilled water at 50 °C, under stirring for 2 h. Films were prepared by mixing of solutions in different weight ratios (1:1, 1.5:1, and 2:1). Glycerol was used as a plasticizer in the amount of 30 wt% per total polymers mass. The films were obtained by casting of solutions on Petri dishes and drying at 50 °C in a vacuum drying oven.

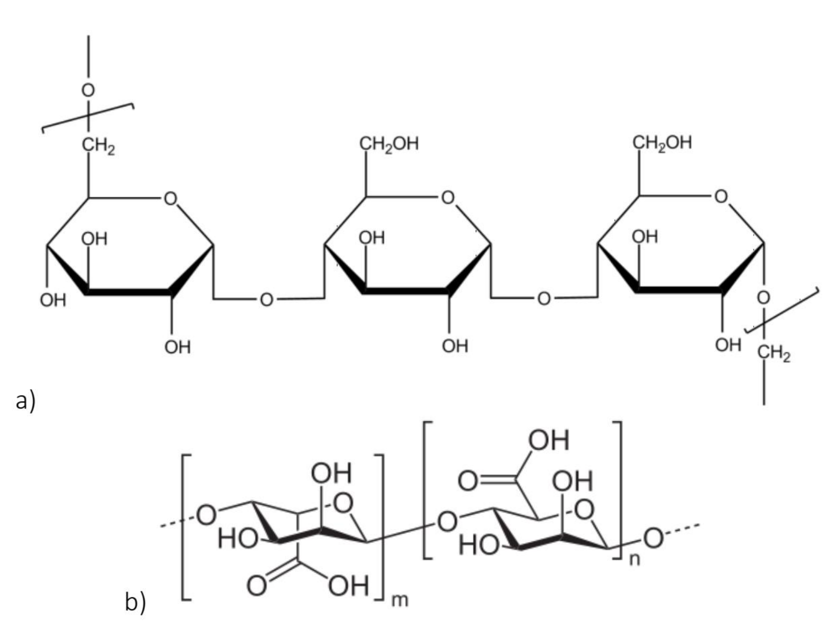

Figure 1
Structural formula of pullulan (a), and alginic acid (b)

Table 1
Composition of pullulan/alginate blends

Sample	Pullulan (g)	Alginate (g)	Amount of plasticizer (wt%)
Pul/Alg 1:1	1.00	1.00	30
Pul/Alg 2:1	1.33	0.67	30
Pul/Alg 1.5:1	1.20	0.80	30

The **rheological properties** of film-forming solutions were carried out by Haake Mars rheometer equipped with a cone-plate geometry at 25°. Steady–state measurements were performed at a shear rate from 1 to 100 s^{-1}. Two dynamic studies were performed:

a) frequency sweep test, over a range of 0.1 to 10 Hz
b) amplitude sweep test at a constant frequency of 0.1 Hz, over a range of 0.05 to 400 Pa.

Storage or elastic modulus (G′, Pa) and viscous or loss modulus (G″, Pa) were monitored in the function of linear frequency and stress in order to obtain mechanical spectra.

Results

The rheological measurements have shown that obtained solutions display thixotropic behavior, and the viscosity of solutions decreases with increasing in pullulan amount.

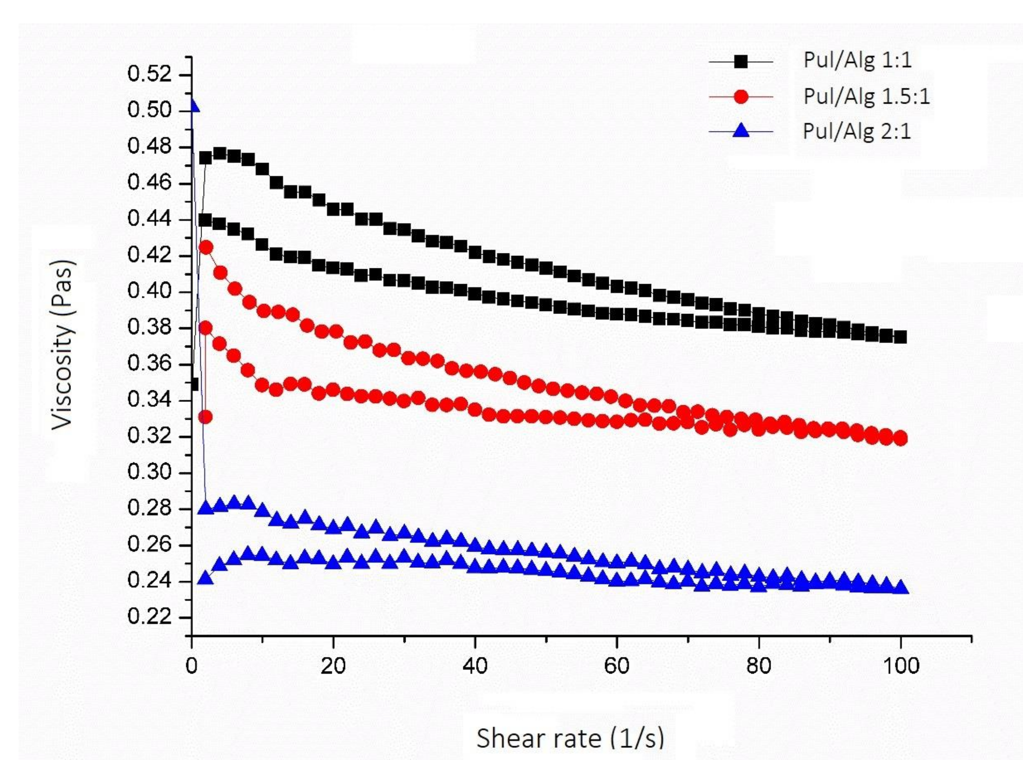

Figure 2
Steady rheological behavior of composite solutions

The values of elastic (G`) and viscous modulus (G”) increase with increasing in linear frequency. The greatest values of moduli are recorded for the sample with the lowest value of pullulan (1:1).

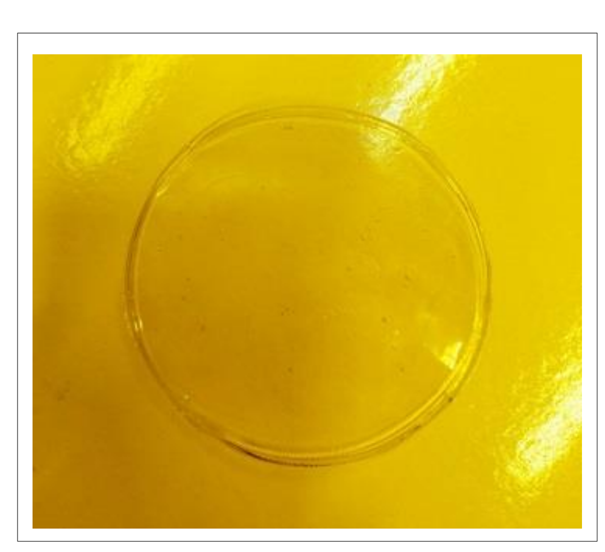

Figure 3
Pullulan/alginate film (sample Pul/Alg 2:1)

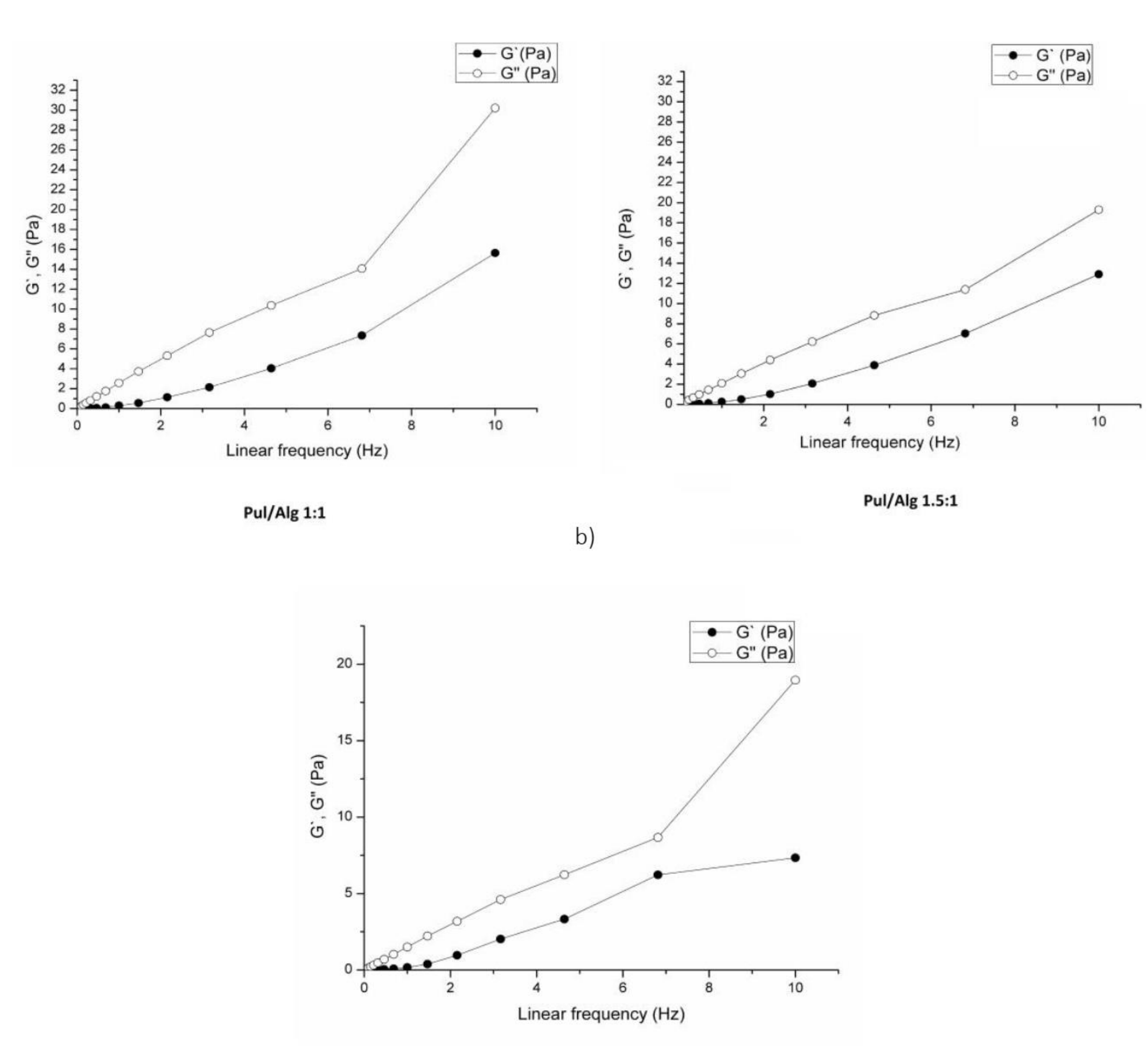

Figure 4
Variation of shear elastic and viscous moduli versus frequency

Results

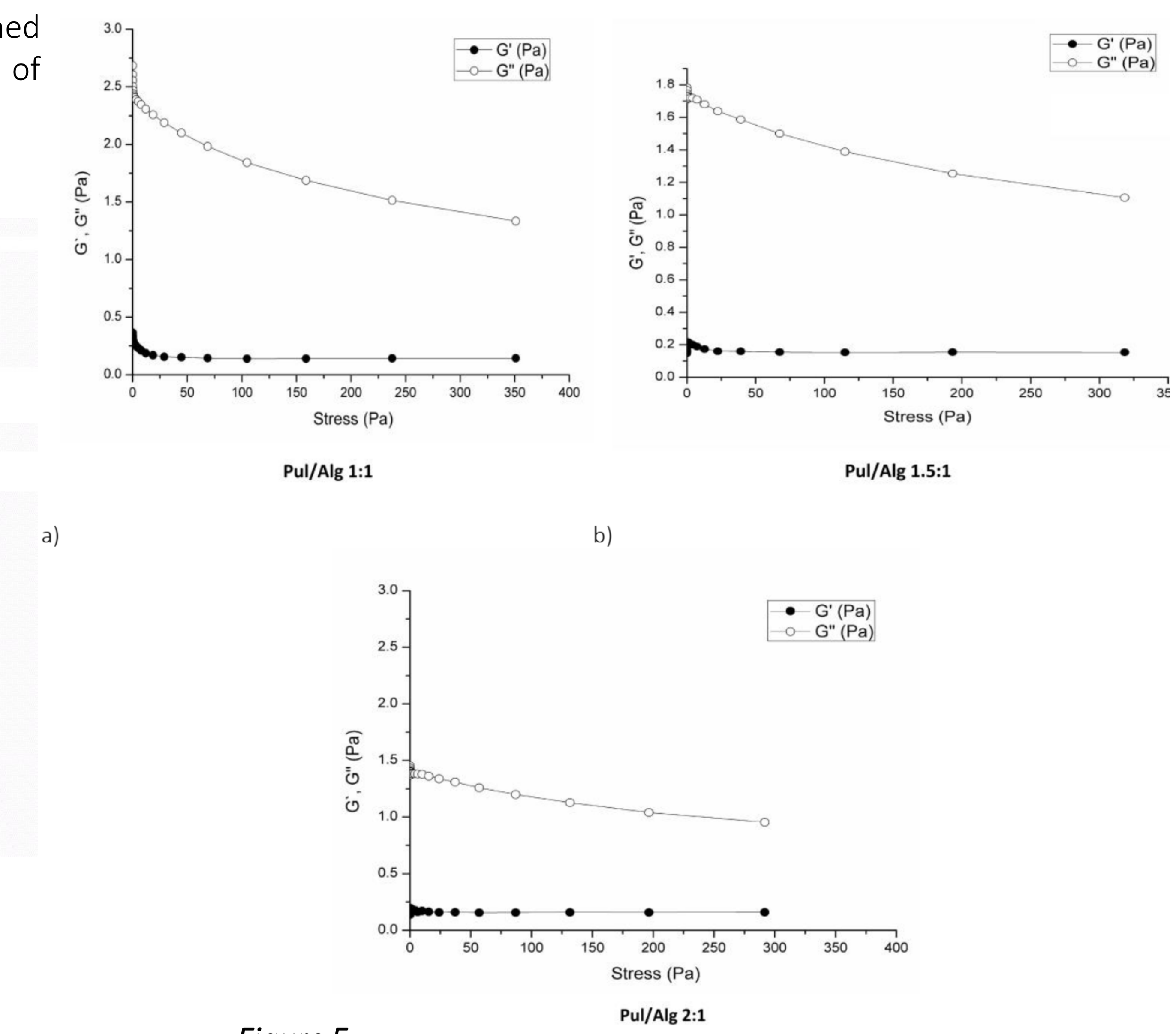

Figure 5
Variation of shear elastic and viscous moduli versus shear stress

Discussion / Conclusion

From the results of the amplitude sweep test shown in Figure 5 it can be seen that elastic modulus values decrease with an increase in shear stress, while the viscous modulus is practically independent of stress over the whole investigated range. Considering the higher values of viscous moduli over the whole frequency and shear stress range, low and constant elastic modulus values, prepared solutions show typical viscous behaviour.

Finally, it can be concluded that the steady shear and dynamic rheological measurements have shown that composite blends expose non-Newton, shear-thinning behaviour. The results of dynamic rheological measurements have shown a dominant viscous behaviour. The greatest values of apparent viscosity and viscous moduli were observed for blend with pullulan/sodium alginate ratio 1:1.

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