EFFECTS OF PH AND CORN OIL ADDITION ON MECHANICAL AND PERMEABILITY PROPERTIES OF GELATIN-BASED FILMS

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Introduction

Biopolymer films and coatings produced from renewable substances have attracted much research interest in recent years. Gelatin is an important by-product of the beef processing industry and offers considerable potential, due to its abundance, low-cost and functionality, for use in biodegradable food packaging applications (Arvanitoyannis, 2002). The sensitivity of gelatin-based films to moisture, however, limits their potential as a potential food packaging material. In contrast, films made from lipids have suitable water vapour barrier properties but poor mechanical properties (Kamper and Fennema, 1984). The production of composite films incorporating both gelatin and lipid components may enhance the suitability of gelatin-based edible films. This study determines the effects of pH and corn oil addition on the mechanical and permeability properties of gelatin films and uses response surface methodology (RSM) in attempting to optimise film formulation.

Materials and Methods

Glycerol (Gly) was added to 4% (w/w) gelatin (G) solutions to give a G to Gly ratio of 2:1 (w/w). Corn oil (CO) was added at concentrations ranging from 7.5 to 55.18% (of G powder weight) and the pH was adjusted to range from 3.46 to 10.54. Solutions were heated to 80°C and homogenised at 480 bar. Films were cast by pouring solutions onto level Teflon-coated perspex plates and dried for 24h at 50 ± 5% RH and 23h ± 2°C. Dried films were subsequently peeled from the casting plates and held as above for a further 12h prior to testing. Film thickness was measured using a 25mm micrometer screw gauge. Mechanical properties (tensile strength (TS), elongation at break point (E), and puncture strength (PT)) were evaluated according to the ASTM-D882 (ASTM, 1985) standard test methodologies. Water vapour permeability (WVP) was determined according to McHugh *et al.* (1993). Oxygen permeability (OP) was conducted at 23 ± 2°C, 50 ± 3 % RH according to Papkovsky *et al.* (2000). Film morphology was determined by scanning electron microscopy (SEM) (JSM-5510, JEOL Ltd. Tokyo, Japan) at 10kV. The experimental design and statistical analyses were performed using Minitab 14 for Windows (Minitab Inc., PA, USA).

Results and Discussion

TIK, TS and PT increased with increasing addition of CO but were not significantly affected by pH (Figures 1, 2 and 4). The highest TS (15.30MPa) and PT values (28.30N) were observed from films produced using a CO content of 47% at pH 9.5. Such effects may be attributed to the degree of crystallinity and orientation of the crystalline protein network in which CO is actively entangled by gelatin molecules. Composite films showed a heterogeneous structure (Figure 7), composed of a continuous matrix with CO incorporation. Increasing CO content of films resulted in increased opacity. Elasticity was greatest in films prepared at extreme alkali values (10.54) and CO of 27.25% (Figure 3). It is probable that protein denaturation and charge repulsion effects at such pH values contributed to a stretching of polymer chains. CO addition had a greater effect on WVP than pH adjustment. The lowest WVP values (50.55 g·mm/kPa·d·m^2) were observed in films produced with a combination of pH 10 and CO addition of 55.18% (Figure 5). It was evidenced by SEM that CO addition led to a decrease in free volume within the film matrix and that more dense films were less permeable to WVP (Figure 7). The lower WVP values obtained with higher CO addition may also be explained by formation of an interconnecting lipid network within the film matrix (Krochta, 1997). OP was highest at neutral pH (6.95) and increased linearly with increasing CO content (Figure 6). This may be due to the increasingly hydrophobic nature of high CO films and their associated facility for oxygen transfer.

Conclusion

Results showed that pH had a greater effect on E, WVP and OP than that exerted by CO addition. CO content of gelatin-based films showed a linear relationship with TIK, TS, PT and quadratic effects with both WVP and OP. The optimum formulation for gelatin-based test films, determined by RSM, was for 4% (w/w) gelatin solutions containing 55.18% CO adjusted to a pH of 10.54. Such films show considerable potential as alternative (biodegradable) materials for food packaging and increase the possible end uses for collagen.

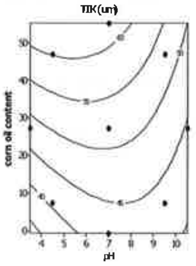

Figure 1.

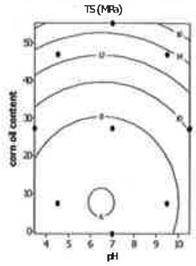

Figure 2.

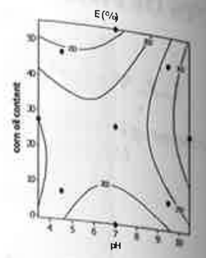

Figure 3.

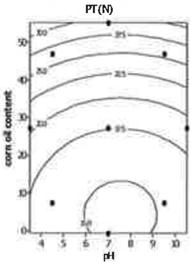

Figure 4.

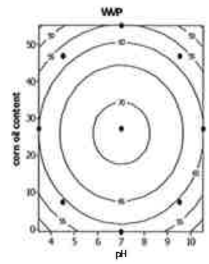

Figure 5.

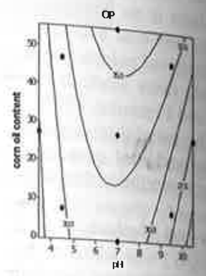

Figure 6.

Figure 1, 2, 3, 4, 5, 6 are counter plots of the effects of pH and CO on TIK, TS, E, WVP and OP respectively.

0 % 7.5% 27.5% 47 % 55.18 %

Figure 7: Scanning electron micrograph cross-sections of G films formed from solutions with varying CO conten (arrows indicate film cross-section).

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