FILM-FORMING PROPERTIES AND STRUCTURE CHARACTERIZATION OF EDIBLE BONES COLLAGEN-CHITOSAN BLEND FILM

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I. INTRODUCTION

Biodegradable and edible films based on biopolymers, such as polysaccharides, proteins and lipids, have being become one of hotspots in innovative materials for food packaging. Collagen exhibits excellent film-forming properties, which can used be as an outstanding carrier of bioactive compounds considered for food packaging [1]. Chitosan-gelatin blend films are homogeneous due to the good miscibility between the two biopolymers. The objective of the study was to prepare sheep bones collagen-chitosan blend film and to characterize its film-forming properties and structure.

II. MATERIALS AND METHODS

Sheep bones collagen (BC), pig skin gelatin (SG), and chitosan (CS) were separately dissolved in 0.5 M acetic acid at a concentration of 1.5% (w/v). The collagen and chitosan solutions were mixed at different ratios (BC: CS= 100:0, 60:40, 50:50, 40:60 and 0:100) at 40°C for 30 min to prepare film forming solution. After adding 25% glycerol (w/w), the film forming solution was poured into a plastic disk and dried at 50°C for 18 h. The BC-CS blend film was peeled off and stored in a glass desiccator (50% RH, 22°C). SG-CS films were prepared in the same way as BC-CS films. The thickness, tensile strength (TS), elongation-at-break (EAB), water vapor permeability (WVP), water solubility (WS) and surface microstructure of collagen/gelatin-chitosan blend films were analyzed. The differences of means were evaluated by Duncan's test and the least significant difference (LSD) test ($p \leq 0.05$) using SPSS 17.0 (SPSS Inc., Chicago, IL, USA).

III. RESULTS AND DISCUSSION

Film-forming properties of collagen/gelatin-chitosan blend films are shown in Table 1. The thickness of blend films increased with the increase of chitosan. The pure chitosan film was 1-2 times thicker than collagen/gelatin films. These changes in thickness of gelatin films of various origins could be contributed by difference in gelatin amino acid compositions and molecular weight. The TS of BC-CS blend film greater than pure BC film. The pure BC film had the minimum TS. The TS of BC-CS blend films increased with the addition of chitosan. EAB of BC-CS blend films decreased when the addition of chitosan was more than 50%, showing that the fluidity of collagen molecules reduced with the addition of chitosan. The interaction between gelatin and chitosan is dependent on the physical and chemical properties of the gelatin, which vary considerably with the origin of gelatin [2]. The water vapor permeability of both BC-CS and SG-CS films increased with the addition of chitosan. There were no visual differences between pure BC film and SG film in water vapor permeability. The water vapor permeability of pure BC and SG film was lowest and pure chitosan film was highest among all treatments. The higher water vapor permeability of BC-CS films compared to that of SG-CS films of the same proportion of chitosan could be explained by the higher molecular weight of BC. With the addition of chitosan, the water solubility of blend films decreased. The water solubility of pure BC film was 88.15%, which was highest among all treatments. The water solubility of pure chitosan film was the lowest, which was 53.91% lower than that of pure BC film. Water solubility of pure BC film was higher than that of SG film.

The surface morphology of collagen/gelatin-chitosan films analyzed by Atomic force microscopy (AFM) are shown in Figure 1, the surface roughness of the film changed obviously with addition of chitosan. The surface of pure BC film was harsh and rough, and the surface uniformity was poor. Surface of pure BC films was rougher than that of SG films. This may be caused by the greater molecular weight of bone collagen compared to that of gelatin, and the stronger intermolecular interaction, which is not conducive to the uniform dispersion of molecules [3]. When collagen/gelatin was mixed with chitosan at the ratio of 1:1, the film was smoothest and the surface roughness was the smallest. This may be due to the formation of interaction between film molecules and the arrangement of different combinations. The surface of blend films was more compact, smooth and uniform compared to single-component films.

Table 1 Film-forming properties of collagen/gelatin-chitosan blend films.

Groups	Thickness (mm)	Ts (MPa)	EAB (%)	WVP (g mm/KPa h m^2)	WS (%)
100BC:0CS	0.035 ± 0.009^{ab}	29.40 ± 0.12^{a}	5.12 ± 0.44^{a}	0.367 ± 0.007^{a}	88.15 ± 6.01^{c}
60BC:40CS	0.046 ± 0.022^{bc}	48.13 ± 11.35^{cd}	4.18 ± 0.38^{ab}	0.500 ± 0.006^{b}	43.23 ± 10.07^{b}
50BC:50CS	0.062 ± 0.008^{de}	39.39 ± 4.10^{bc}	5.73 ± 1.99^{a}	0.649 ± 0.048^{ef}	33.57 ± 1.22^{a}
40BC:60CS	0.062 ± 0.022^{cde}	37.98 ± 2.12^{b}	3.35 ± 0.62^{b}	0.677 ± 0.021^{f}	34.64 ± 2.08^{a}
0BC:100CS	0.072 ± 0.007^{e}	45.22 ± 0.10^{bcd}	3.01 ± 0.41^{b}	0.766 ± 0.024^{g}	34.11 ± 4.92^{a}
100SG:0CS	0.028 ± 0.012^{a}	57.89 ± 1.01^{e}	4.24 ± 0.30^{ab}	0.311 ± 0.013^{a}	44.72 ± 4.33^{b}
60SG:40CS	0.050 ± 0.010^{bcd}	50.12 ± 3.87^{de}	4.06 ± 0.88^{ab}	0.542 ± 0.008^{bc}	42.23 ± 3.01^{ab}
50SG:50CS	0.055 ± 0.012^{cd}	48.82 ± 5.78^{de}	5.08 ± 0.99^{a}	0.588 ± 0.013^{cd}	43.83 ± 2.72^{b}
40SG:60CS	0.060 ± 0.015^{cde}	51.22 ± 4.81^{de}	4.70 ± 0.60^{ab}	0.602 ± 0.067^{de}	34.43 ± 1.75^{a}

Different lower-case letter in the same column indicate significant differences ($P < 0.05$) among samples.
CS, chitosan; BC, sheep bones collagen; SG, pig skin gelatin.

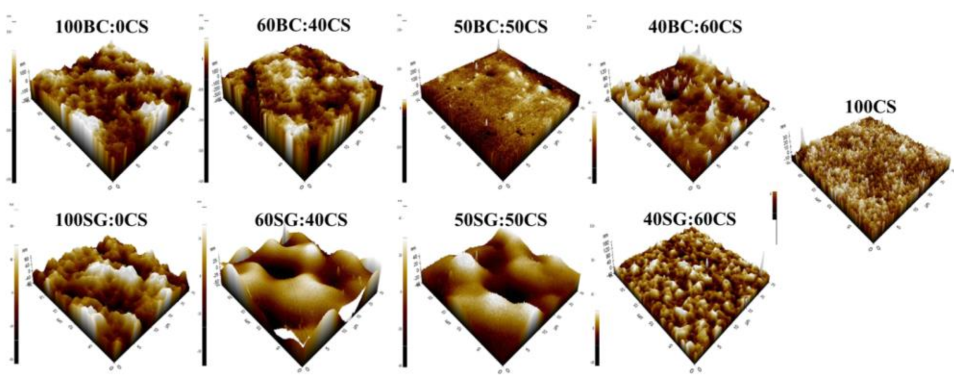

Figure 1. AFM topographic images of bones collagen-chitosan blend films
CS, chitosan; BC, sheep bones collagen; SG, pig skin gelatin. The numbers represent different blend proportions of collagen/gelatin and chitosan.

IV. CONCLUSION

The results confirmed that bone collagen had excellent film-forming properties. The BC-CS films were smoother and more homogeneous than pure BC film. The blend films of bone collagen and chitosan at the ratio of 50:50 were the best for food packaging.

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