2013 2nd International Conference on Nutrition and Food Sciences
IPCBEE vol.53 (2013) © (2013) IACSIT Press, Singapore
DOI: 10.7763/IPCBEE. 2013. V53. 16

Physico-Chemical Properties of Gelatin Films Incorporated with Different Hydrocolloids

Thummanoon Prodpran [1+], Soottawat Benjakul [2], Manee Vittayanont [2] and Sitthipong Nalinanon [3]

[1] Department of Material Product Technology, Faculty of Agro-Industry, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand
[2] Department of Food Technology, Faculty of Agro-Industry, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand
[3] Faculty of Agro-Industry, King Mongkut's Institute of Technology Ladkrabang, Ladkrabang, Bangkok 10520, Thailand

Abstract. Effect of different hydrocolloids (chitosan, rice flour, soy protein isolate and curdlan) at different ratios (gelatin/hydrocolloid = 10/0, 8/2, 6/4, and 5/5 (w/w)) on some properties of fish gelatin film was investigated. Incorporation of chitosan at the ratio of 8/2 yielded the blend film with higher tensile strength (TS) and elongation at break (EAB), compared to the control gelatin film ($p<0.05$). However, incorporation of chitosan at other ratios as well as addition of other hydrocolloids at all ratios studied resulted in decreased TS of the resulting blend film as the amount of hydrocolloids increased ($p<0.05$). Among blend films tested, incorporation of chitosan rendered the blend films with better mechanical properties, compared to those added with other hydrocolloids of the same ratio. Moreover, all gelatin-based blend films added with all types of hydrocolloids of all ratios exhibited lower water vapor permeability (WVP) than did the control gelatin film without hydrocolloid addition ($p<0.05$). Nevertheless, blend films added with all types and ratios of hydrocolloids studied were more yellowish (higher b*-value) and less transparent than the control gelatin film, especially for those incorporated with soy protein isolate. Therefore, incorporation of appropriate type and amount of hydrocolloid (i.e. chitosan at 8/2 in this study) could improve water vapor barrier and mechanical properties of gelatin-based film.

Keywords: Film, Gelatin, Hydrocolloids, Chitosan, Rice flour, Soy protein isolate, Curdlan, Blend.

1. Introduction

Gelatin is an animal protein obtained by a controlled hydrolysis of the fibrous insoluble collagen present in the bones and skin generated as waste during animal slaughtering and processing. Most commercial gelatins are made from pork or bovine [1] and [2]. But, nowadays fish-gelatins have been receiving interest, since gelatin from marine sources is without the risk associated with Bovine Spongiform Encephalopathy (BSE) disease and is not prohibited for some religions use. Gelatin can be used as biopolymer for film preparation. Gelatin has excellent film forming ability. The properties of gelatin films are varied depending on gelatin sources, preparing conditions and substances incorporated to form a film [1] and [3]. Gelatin films are very transparent and excellent in gas (O_2 and CO_2) barrier property. However, they have moderate mechanical property as well as poor water-vapor barrier property as compared to synthetic films [2] and [3]. To improve the properties of gelatin film, several researchers have tried to develop films based on mixtures of biopolymers [2] and [3]. Blending gelatin with other miscible or compatible hydrocolloids such as chitosan, soy protein, and polysaccharides would improve the properties of the gelatin films. Different hydrocolloids added might affect the properties of gelatin film differently. Therefore, the objective of this

+ Corresponding author. Tel.: + 66 7428 6357; fax: 66 7455 8866.
E-mail address: thummanoon.p@psu.ac.th (T. Prodpran).

study was to investigate the comparative effect of different hydrocolloids incorporated at various levels on the properties of fish gelatin film.

2. Methods

2.1. Preparation of Film-Forming Solutions (FFS)

2.1.1. Preparation of Gelatin FFS

Gelatin powder was mixed with distilled water to obtain the final concentration of 2% (w/v). Glycerol as plasticizer was added to gelatin solution at the level of 25% of protein. The solution was then mixed thoroughly for 10 min followed by heating at 60 ℃ for 30 min [1].

2.1.2. Preparation of Chitosan FFS

Chitosan powder was mixed with 0.5% acetic acid solution to obtain the final concentration of 1.5% (w/v) and stirred until totally dissolved. Glycerol at 25% of chitosan was added and mixed for 24 h [4].

2.1.3. Preparation of Rice Flour FFS

Rice flour (RF) was placed in distilled water of pH 11 to obtain the concentration of 2% (w/v). The mixture was stirred for 30 min followed by heating at 80 ℃ for 60 min for gelatinization. Glycerol at 25% of rice flour was added to the solution and mixed for 15 min.

2.1.4. Preparation of Curdlan FFS

Curdlan powder was mixed in distilled water at 2% (w/v) and stirred for 30 min. The solution was then heated at 65 ℃ for 30 min. Glycerol at 25% was added and mixed for 15 min.

2.1.5. Preparation of Soy Protein Isolate FFS

Soy protein isolate (SPI) was placed in distilled water of pH 11 at 2% (w/v). The mixture was stirred for 30 min followed by heating at 85 ℃ for 60 min. Glycerol at 25% of protein was added and mixed for 15 min.

2.2. Preparation of Gelatin/Hydrocolloid Blend FFS and Films

The FFSs of the blends of gelatin and different hydrocolloids were prepared by mixing the gelatin FFS and each hydrocolloid FFS at appropriate amount to obtain the gelatin: hydrocolloid ratio of 10/0, 8/2, 6/4, 5/5 and 0/10 (w/w). Then, FFS was stirred gently at room temperature for 15 min. The FFS (4 g) was cast onto a rimmed silicone resin plate (50 x 50 mm^2) and air blown for 12 hr at room temperature prior to further drying in a ventilated oven at 25 ℃ and 50% RH. Finally, films were manually peeled off and used for analyses.

2.3. Analyses of Films

Tensile strength (TS), elongation at break (EAB), water vapor permeability (WVP), color and flight transmission of films were measured [3] and [5].

2.4. Statistical Analysis

Data were subjected to ANOVA and differences between means of samples were carried out via DMRT.

3. Results

3.1. Visualized Appearance and Thickness of Films

Films from gelatin without and with addition of different hydrocolloids at varying ratios had the thickness in the range of 0.035-0.041 mm. The resulting films exhibited different visualized appearances as shown in Fig. 1. Films from gelatin, gelatin/chitosan and gelatin/curdlan had smooth, clear and rather transparent while those from gelatin/rice flour and gelatin/SPI showed slightly rough surface and translucent. Gelatin/SPI film was more yellowish than other films.

3.2. Mechanical Properties

Mechanical properties of films from gelatin added with and without different hydrocolloids at various ratios are shown in Fig. 2. Films had varying properties depending on type of hydrocolloids and level used. Among blend film, that from gelatin/chitosan blend at the ratio of 8/2 had the highest tensile strength (TS) which was higher than the gelatin (control) film ($p<0.05$), more likely due to good molecular miscibility and interaction. However, incorporation of other types of hydrocolloids at other ratios resulted in decreased TS of the gelatin film, as compared to the control. This was probably due the increased immiscibility of the blend. The incorporated hydrocolloids at inappropriate level might interfere with the interaction of gelatin molecules in the film matrix, resulted in non-uniform network and thus the decrease in strength of the resulting blend films. For elongation at break (EAB) of the film, chitosan film had the highest EAB, which was higher than that of gelatin film ($p<0.05$). Films incorporated with chitosan exhibited higher EAB than the gelatin film. Gelatin films incorporated with other hydrocolloids used had decreased EAB with increasing the incorporated levels, as compared to the gelatin (control) film.

Fig. 1: Photograph of films from gelatin incorporated without and with different hydrocolloids (at the ratio of 8/2 (w/w)).

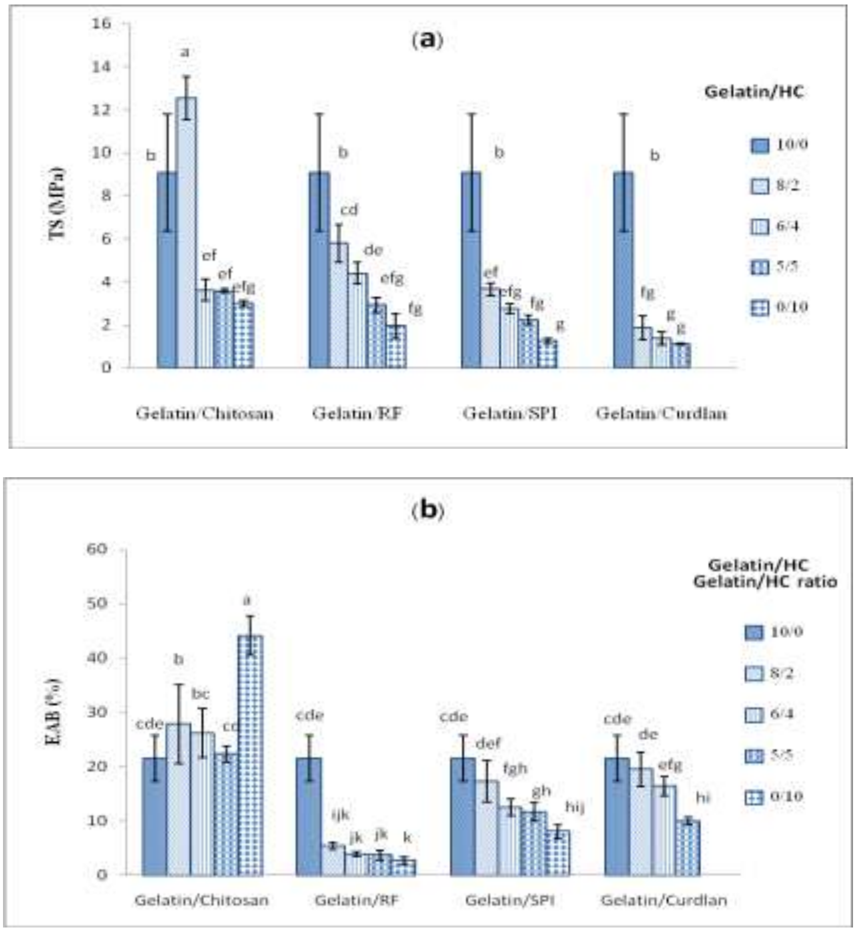

Fig. 2: Tensile strength (TS) and elongation at break (EAB) of gelatin films incorporated without and with different hydrocolloids at various ratios.

3.3. Water Vapor Permeability

Fig. 3 shows WVP of films from gelatin added with and without different hydrocolloids at various ratios. Gelatin film incorporated with hydrocolloids of all types and levels used had lower WVP than did the gelatin film ($p<0.05$). This suggested the improvement of water vapor barrier property of the gelatin film by incorporation of hydrocolloids. This was most likely attributable to the interaction between gelatin and hydrocolloid molecules, which resulted in the decrease in free hydrophilic functional groups, such as amino, carboxyl and hydroxyl groups, available for water to absorb. However, WVP of the blend films increased with increasing the level of hydrocolloids added ($p<0.05$), regardless of type of hydrocolloids incorporated.

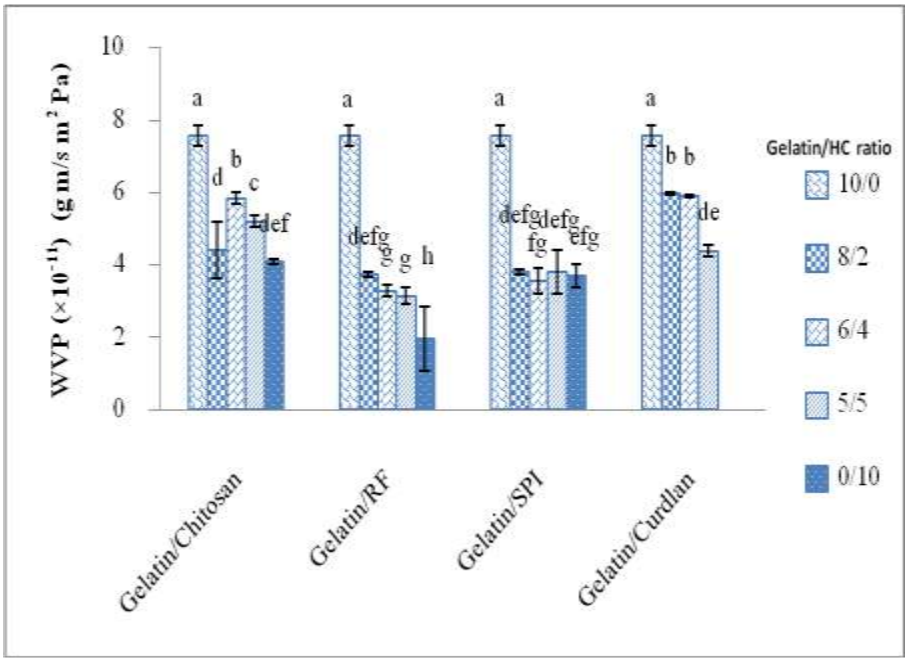

Fig. 3: Water vapor permeability (WVP) of gelatin films incorporated without and with different hydrocolloids at various ratios.

3.4. Color and Light Transmission of the Films

Color parameters (L*(lightness), a* (redness/greenness) and b* (blueness/yellowness)) and light transmission of films from gelatin incorporated without and with different hydrocolloids at various ratios are present in Table I. Blend gelatin films added with chitosan or rice flour had slightly different L*-value while gelatin/SPI and gelatin/curdlan films showed lower L*-value, compared to the control gelatin film. All films exhibited slight greenness and yellowness in color. SPI and gelatin/SPI films had higher b*-value than the other films. The different in color resulted from the different components especially pigments present in various hydrocolloid raw materials. Maillard reaction occurring during film preparation might play a role in yellowness of the resulting films especially in SPI and its blend films [6].

All gelatin-based films possessed very low transmission (0.003 – 0.027) of UV light (200 nm). Gelatin film had decreased light transmission when increasing amount of hydrocolloids was incorporated, irrespective of hydrocolloid types. Incorporation of hydrocolloids resulted in decreased visible light transmission (Table I), indicating lower transparency of the blend film. The interaction between gelatin molecules and hydrocolloids in the film matrix might decrease the transmission of light through the film. Besides, partial phase separation in the blend film as well as pigments presented especially when rice flour (RF) and SPI were incorporated might play a role in lowering the transmission of light.

4. Conclusion

Type and level of hydrocolloids used in this study affected the properties of fish gelatin film differently. Addition of hydrocolloids could decrease water vapor permeability of the gelatin film. Addition of rich flour, SPI and curdlan at 20 – 50% resulted in decreased mechanical properties of gelatin film. However, incorporation of appropriate hydrocolloid at proper amount (i.e., chitosan at 20%) could improve the mechanical and water vapor barrier properties of gelatin film.

Table I: Color and light transmission of gelatin films incorporated without and with different hydrocolloids at various ratios.

Film	Blend ratio	Color parameter			Transmittance (%) at 600 nm
		L*	a*	b*	
Gelatin	-	$90.12 \pm 0.13^{b\#}$	-1.29 ± 0.03^{abc}	2.64 ± 0.13^{e}	89.54
Gelatin/Chitosan	8/2	90.55 ± 0.21^{abc}	-1.39 ± 0.03^{d}	3.22 ± 0.18^{de}	89.88
	6/4	90.06 ± 0.11^{bcd}	-1.33 ± 0.21^{cd}	3.06 ± 0.10^{e}	89.51
	5/5	90.27 ± 0.05^{bc}	-1.31 ± 0.11^{bcd}	3.14 ± 0.14^{de}	87.39
	0/10	90.42 ± 0.61^{abc}	-1.36 ± 0.05^{cd}	3.45 ± 0.51^{de}	83.56
Gelatin/RF	8/2	90.88 ± 0.44^{ab}	-1.62 ± 0.61^{f}	4.28 ± 0.41^{d}	57.51
	6/4	91.34 ± 0.04^{a}	-1.39 ± 0.44^{d}	3.09 ± 0.32^{e}	48.92
	5/5	91.23 ± 0.29^{a}	-1.51 ± 0.04^{e}	4.27 ± 0.48^{d}	38.93
	0/10	90.79 ± 0.44^{ab}	-1.28 ± 0.29^{abc}	2.67 ± 0.14^{e}	66.07
Gelatin/SPI	8/2	89.84 ± 0.73^{cd}	-1.75 ± 0.44^{g}	7.80 ± 0.97^{c}	49.59
	6/4	87.77 ± 0.41^{f}	-1.71 ± 0.73^{f}	9.32 ± 0.35^{b}	23.49
	5/5	88.87 ± 0.91^{e}	-1.63 ± 0.41^{f}	9.33 ± 1.95^{b}	38.39
	0/10	87.98 ± 0.82^{f}	-1.76 ± 0.91^{g}	11.40 ± 0.60^{a}	62.37
Gelatin/Curdlan	8/2	88.92 ± 0.30^{e}	-1.22 ± 0.82^{a}	3.00 ± 0.03^{e}	69.99
	6/4	89.18 ± 0.27^{de}	-1.24 ± 0.30^{ab}	3.41 ± 0.15^{de}	55.59
	5/5	89.31 ± 0.92^{de}	-1.21 ± 0.27^{a}	3.62 ± 0.24^{de}	37.15
	0/10	N/D[##]	N/D	N/D	N/D

[#] The difference superscripts in the same column indicate the significant differences ($p<0.05$).

[##] N/D: Not be determined since the film was too brittle and could not be peeled out from the casting plate.

5. Acknowledgements

We would like to thanks National Research Council of Thailand (NRCT) and Prince of Songkla University for the financial support.

6. References

[1] A. Jongjareonrak, S. Benjalul, W. Visessanguan, T. Prodpran, and M. Tanaka. Characterization of edible films from skin selatin of brownstripe red snappwe and bigeye snapper. *Food Hydrocoll.* 2006, 20 (4): 492-501.

[2] J. Gómez-Estaca, M.C. Gómez-Guillen, F. Fernández-Martín, F. and P. Montero. Effects of gelatin origin, bovine-hide and tuna-skin, on the properties of compound gelatin-chitosan films. *Food Hydrocoll*. 2011, 25 (6): 1461-1469.

[3] Md. S. Hoque, S. Benjakul, T. Prodpran, and P. Songtipya. Properties of blend film based on cuttlefish (*Sepia pharaonis*) skin gelatin and mungbean protein isolate. *Int. J. Biol. Macro.* 2011, 49 (4): 663-673.

[4] Y. Pranoto, S.K. Rakshit, and V.M. Salokhe. Enhancing antimicrobial activity of chitosan films by incorporating garlic oil, potassium sorbate and nisin. *LWT Food Sci. Tech*. 2005, 38 (8): 859-865.

[5] K. Iwata, S. Ishizaki, A. Handa, and M. Tanaka. Preparation and characterization of edible films from fish water-soluble proteins. *Fish. Sci*. 2000, 66: 372 - 378.

[6] A. Gabriela, D. Miriam, P. Rez-Mateos, C. Marı, and A. Montero. Structural and functional properties of soy protein isolate and cod gelatin blend films. *Food Hydrocoll.* 2009, 23 (8): 2094–2101.