Original Article

The effect of additional sucrose on the value of tensile strength and elongation of chicken legs gelatin film

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Abstract

Gelatin is a clear, flavorless, and colorless biopolymer formed by the denaturation of collagen protein in animal tissues. Gelatin is an important ingredient in the manufacture of capsule shell films. The tensile strength and elongation values of gelatin film indicate its quality. Sucrose is one of the ingredients that can affect the tensile strength and elongation of the gelatin film. To determine the effect of adding sucrose on the tensile strength and elongation of the chicken leg skin gelatin film. To extract the gelatin, clean, sliced chicken leg skin was freeze-dried, ground into powder, and extracted. The characteristics of chicken skin gelatin were measured using Fourier-transform infrared, and the data were read in the 4000–400 cm^{-1} range for 32 scans. Pouring the solution into a mold, flattening it, and drying it at 40°C results in a film that has been tested for tensile strength and elongation. Gelatin films with a 30% sucrose addition had the best tensile strength and elongation values, with a tensile strength of 3.03 MPa and an elongation of 152.02%. Sucrose alters the tensile strength and elongation of chicken leg gelatin film. 30% sucrose provides better tensile and elongation strength.

Key words: Elongation, gelatin, sucrose, tensile strength

INTRODUCTION

Muslims make up 86.9% of Indonesia's 273.32 million people.[1] This highlights the importance of halal-certified foods and pharmaceuticals. One type of medicine dosage form used in the pharmacy industry is capsules with gelatin shells. Gelatin is a colorless, flavorless, and transparent biopolymer created by denaturing collagen protein found in animal body components such as skin and bones.[2] Indonesia requires a lot of gelatin, and the amount it imports grows year after year.[3,4] However, the majority of gelatin is derived from pig skin,[4] and there is no halal designation for pharmaceutical preparations such as capsules from the Indonesian Ulema Council (MUI). Since drug use is becoming a problem in Indonesia's Muslim community, halal products are now among the things that can be bought.

Several studies have discovered high-quality, halal, and low-cost gelatin substitutes. Gelatin derived from chicken skin and bones is one of these.[5,6] Chicken legs are wasted by farmers and chicken meat producers because they are underutilized. However, several biochemical substances found in the chicken leg can still be used, including the collagen protein found in the skin. The most common types of collagen found in skin, bone, and cartilage are types 1 and 2.[7] When collagen proteins are heated in water, they lose their structure and turn into gelatin.[8,9]

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The film is a thin gelatin sheet that can be manufactured. In the pharmaceutical industry, films are frequently used to make capsule shells. Plasticizers influence film production by keeping intermolecular connections strong and stable during manufacturing and storage. The molecular weight of the plasticizer is proportional to the strength of the film when pulled apart.[10]

According to one study, adding sucrose to a gel strengthens it,[11] allowing it to be used as a plasticizer. Sucrose is used as a plasticizer in the manufacture of pea starch and guar gum films,[12] as well as cassava starch and gelatin films.[13] The purpose of this research is to determine how sucrose, a plasticizer, affects the tensile strength and elongation of chicken leg skin film so that halal, low-cost, high-quality gelatin and gelatin films can be produced and used as raw materials for capsule shells.

SUBJECTS AND METHODS

Materials

The chemical materials used such as 0.7% citric acid, 0.15% NaOH, *n*-hexane, 0.15% H_2SO_4, sucrose, and silica gel (preservative) were purchased from the Merck (Darmstadt, Germany). Chicken leg skin and commercial beef gelatin were purchased from the local market.

Methods

Extraction of gelatin from chicken legs

Clean, sliced chicken leg skin was freeze-dried and ground into powder (Gea Lr-600). After that, 2–3 cycles of soxhletation with n-hexane degrease the fat. 2 h at 30°C were spent baking the residue. The fat degreasing residue was then stirred in 0.15% NaOH for 40 min. Next, the solvent was changed twice and washed until pH was neutral. Soaking the leftovers in 0.15% H_2SO_4 and stirring with a magnetic stirrer for 40 min rendered them less mineralized.

The demineralized findings were steeped in 0.7% citric acid for 2 × 40 min before being washed to pH 4–5. Next, dilute the residue with 1:1 distilled water and hydrolyze it at 50°C for 24 h before filtering. For a gel, the filtrate was cooled. Furthermore, the items are microwaved for 48 h on a baking sheet covered in aluminum foil (Memmert).

Gelatin characteristic test

The characteristics of chicken skin gelatin were measured using Fourier-transform infrared (FTIR) (Agilent Technology Cary 630) and the data was read in the 4000-400 cm^{-1} area for 32 scans. The results of the obtained chicken skin gelatin spectra will be compared with the commercial beef gelatin spectra.

Tensile strength and film elongation test

A gelatin and sucrose solution with sucrose concentrations of 0%, 20%, 30%, 40%, 50%, and 6.67% (w/v) gelatin was dispersed at room temperature (25°C) for 1 h. After stirring occasionally, the mixture was cooked at 65°C for 15 min. Pouring the solution into a mold, flattening it, and drying it at 40°C makes a film. The film was tested. The mold was cut into 3 cm × 13 cm pieces and tensile tested three times. The results were averaged from three tests.

RESULTS

Extraction of gelatin from chicken legs

Collagen is hydrolyzed and split into gelatin in two rounds of extraction, one with a citric acid solvent and the other with thermal extraction. This extraction technique yielded the 33.4% gelatin as presented in Figure 1.

Gelatin characteristic test

Chicken leg skin gelatin and commercial beef gelatin had similar spectra, indicating they both contained collagen. Figure 2 and Table 1 show chicken leg skin gelatin and beef gelatin FTIR spectra. Even the three spectra have nearly

Table 1: Fourier-transform infrared analysis of chicken leg skin gelatin and beef gelatin

Absorption area	Wavenumber at the absorption peak (cm^{-1})		Alleged functional group
	Chicken gelatin	Commercial beef gelatin	
Amide A	3278.2	3276.3	NH stretching of the amide associated with hydrogen bonds
Amide B	2983.4	2931.6	CH stretching
Amide I	1625.1	1627.0	C=O stretching with contributions from NH bending or hydrogen bonding coupled to COO−
Amide II	1522.6	1522.6	CNH bond
	1436.9	1436.9	CH bond
Amide III	1235.6	1235.6	NH stretching joins CN stretching
Fingerprint	1079.1	1079.1	CO skeletal stretch

Figure 1: Gelatin extracted from chicken leg skin

identical peak wavelengths for each sample. Chicken leg skin gelatin and commercial beef gelatin had similar spectra, indicating they both contained collagen.

Figure 3 and Tables 2 and 3 show the findings of the analysis. When compared to chicken gelatin, the spectra obtained by gelatin film with 50% sucrose revealed a significant absorption intensity. Another result is evidenced by the absorption area of the amide A region, which also shows the presence of strong hydrogen bonds in the absorption region.

Tensile strength and film elongation test

Adding sucrose to gelatin and chicken leg skin gelatin film affected tensile strength and elongation. Figure 4 compares beef gelatin, chicken leg skin, and gelatin films with 20%, 30%, 40%, and 50% sucrose. Table 4 and Figure 5 show that the tensile strength of chicken and beef gelatin without sucrose was 3.6 MPa. Sucrose did not increase the gelatin film's tensile strength. Films with 50% sucrose had no tensile strength, but those without sucrose did. Because the film is sticky and brittle [Figure 6], testing is impossible. Prolonged heating makes the film crystalline and brittle. Elongation results of gelatin film with sucrose addition were >50% at 30% and 40% concentrations, 152.02% and 167.96%, respectively.

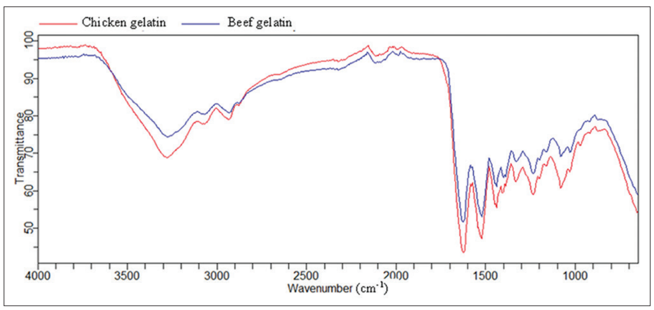


Figure 2: FTIR spectra of chicken and beef gelatin. FTIR: Fourier-transform infrared

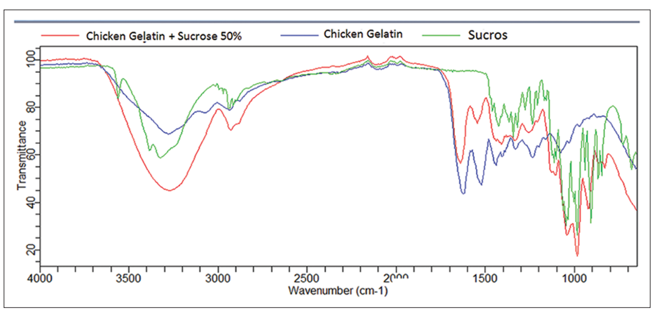


Figure 3: FTIR spectra of gelatin, sucrose, and gelatin + 50% sucrose. FTIR: Fourier-transform infrared

DISCUSSION

The initial chicken skin drying process aims to keep the skin stable at room temperature.[14] According to the findings, the chicken leg skin dried out and the collagen did not denature into gelatin. During fat degreasing, dry chicken skin turns pale white, indicating fat removal, thar improves gelatin quality and accelerates rancidity.[15] Noncollagen protein removal and demineralization reduce other chicken skin matrices. Hydrolyzing collagen and thermally extracting it yields gelatin. Figure 1 shows that this extraction yielded 33.4% gelatin.

Due to collagen fiber modification, 0.7% citric acid was used for extraction. The acid boosts H^+ through electrostatic interactions between polar and nonpolar groups and atoms, allowing water to more easily infiltrate collagen fibers. Acidic atmospheres, stirring, and heating are catalysts. Citric acid's H^+ atoms break collagen peptide bonds,[16] and during the heat hydrolysis process, collagen proteins are broken down and gelatin is produced.[17]

FTIR spectroscopy studies changes in collagen and gelatin's secondary structure.[18,19] Due to gelatin's molecular vibrations, FTIR data are transmitted. Figure 2 and Table 1 show chicken leg skin gelatin and beef gelatin FTIR spectra. Gelatin is a protein, as shown by unique bands in the amide A, B, I, II, III, and fingerprint absorption zones. Even the

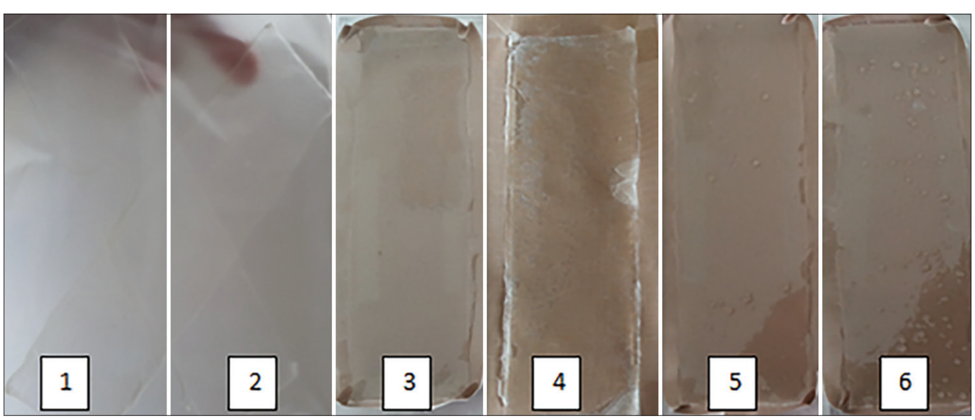


Figure 4: Gelatin film: (1) chicken gelatin and 0% sucrose; (2) beef gelatin and 0% sucrose; (3) chicken gelatin and 20% sucrose; (4) chicken gelatin and 30% sucrose; (5) chicken gelatin and 40% sucrose; and (6) chicken gelatin and 50% sucrose

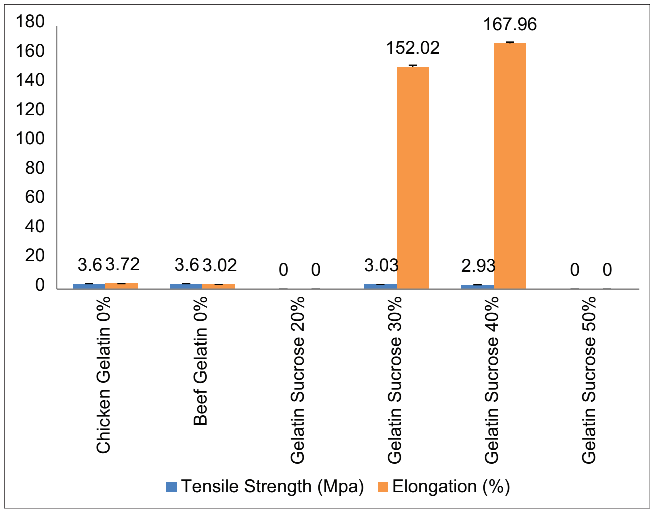


Figure 5: Diagram of the tensile strength (MPa) and % elongation value of gelatin film

Table 2: Fourier-transform infrared analysis of chicken leg skin gelatin and gelatin film with 50% sucrose

Absorption area	Wavenumber at the absorption peak (cm⁻¹)		Alleged functional group
	Chicken gelatin	Gelatin film+50% sucrose	
Amide A	3278.2	3270.7	NH stretching of the amide is associated with hydrogen and OH bonds
Amide B	2983.4	2927.8	CH stretching
Amide I	1625.1	1653.1	C=O stretching with contributions from NH bending or hydrogen bonding coupled to COO−
Amide II	1522.6	1541.3	CNH bond
	1436.9	1420.1	CH bond
Amide III	1235.6	-	NH stretching joins CN stretching
Fingerprint	1079.1	1107.0	CO skeletal stretch
		1041.8	
		985.9	CH_2 out-of-plane wagging
		922.5	

three spectra have nearly identical peak wavelengths for each sample. Chicken leg skin gelatin and commercial beef gelatin had similar spectra, indicating they both contained collagen. According to a study, beef and chicken skin both contain collagen fibrils of type 1 and type 3 collagen.[20]

FTIR functional group analysis was used to determine the effect of adding 50% sucrose to chicken leg skin gelatin film. Compared to chicken leg skin gelatin, the fingerprint region on the film changed. Figures 3 and Tables 2 and 3 show the analysis's findings. Gelatin film with 50% sucrose showed greater absorption than chicken gelatin. The intensity of OH group hydrogen on sucrose with gelatin OH and NH cover an area of 3000–3700 cm[1]. Absorption by NH bonds is less intense than absorption by OH bonds because some amine hydrogen bonds are weaker and less polar.[21] Chicken gelatin's absorption spectrum had a sharper peak than gelatin film with sucrose. The amide A absorption region also shows strong hydrogen bonds. Sucrose has more OH groups than other sugars. Infrared spectra show hydrogen OH bond absorption.

Figure 6: Gelatin film with the addition of 50% sucrose

Adding sucrose to gelatin and chicken leg skin gelatin film affected tensile strength and elongation. Figure 4 compares beef gelatin, chicken leg skin, and gelatin films with 20%, 30%, 40%, and 50% sucrose. Tensile strength and elongation impact film production. Sucrose affects gelatin's tensile strength and elongation. Sucrose increased the film's elongation break value during production. Sucrose can soften and plasticize.[13,22] Sucrose reduces intermolecular pressure and increases polymer chain mobility, increasing film flexibility and extensibility.[23]

Table 4 and Figure 5 show that the tensile strength of chicken and beef gelatin without sucrose was 3.6 MPa. Sucrose did not increase the gelatin film's tensile strength. The film's texture is too flexible to stretch. According to a study, adding 20% sucrose reduces gelatin gel strength, 11 and tensile strength is linked to gelatin gel strength.[24] While gelatin films with 50% sucrose had no tensile strength, those without sucrose did. Because the film is sticky and brittle [Figure 6], testing is impossible. Prolonged heating makes the film crystalline and brittle. As the film isotherm shows, plasticizers with more hydroxyl groups absorb water quickly, resulting in increased mobility and loss of film plasticization. This adds 50% more sucrose to the unstable film, making it brittle and breakable.

Table 3: Analysis of fourier-transform infrared absorption area for sucrose

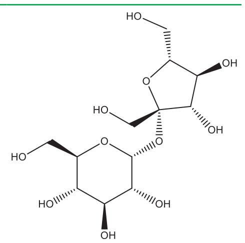
Wavenumber at the absorption peak (cm^{-1})	Alleged functional group	Structure of sucrose
3384.4	OH stretching	
3322.9		
2939.0	CH stretching	
2912.9		
1343.7	CO	
985.9	CH_2 out-of-plane wagging	
866.6	CH deformation (carbohydrates)	
680.2	CC skeletal stretch	

Table 4: Data on tensile strength and elongation of chicken leg skin gelatin film

Name	Mean±SD	
	Tensile strength (Mpa)	Elongation (%)
Chicken gelatin 0%	3.6±0.037	3.72±0.012
Beef gelatin 0%	3.6±0.026	3.02±0.064
Gelatin sucrose 20%	0±0	0±0
Gelatin sucrose 30%	3.03±0.069	152.02±1.148
Gelatin sucrose 40%	2.93±0.059	167.96±0.929
Gelatin sucrose 50%	0±0	0±0

SD: Standard deviation

Elongation results of gelatin film with sucrose addition were >50% at 30% and 40% concentrations, 152.02% and 167.96%, respectively. If the value is above 50%, the elongation is good; below 10%, it is bad.[25,26] At 20% concentration, there was no tensile strength, and gelatin film with 50% sucrose crystallized and clung to the mold, so there was no elongation value.

The percentage of elongation increases as the concentration of plasticizer/sucrose increases.[11,26] More plasticizer in gelatin reduces film tensile strength and increases elongation. The increasing concentration of sucrose shows a strong bond.[10]

CONCLUSION

According to research, adding sucrose to the chicken leg skin gelatin film changes its tensile strength and elongation. A 30% sucrose concentration gives a high-quality tensile and elongation strength value.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Jumlah Penduduk Muslim di Indonesia. Available from: https://dataindonesia.id/ragam/detail/sebanyak-869-penduduk-indonesia-beragama-isla. [Last updated on 2022 Feb 16; Last accessed on 2022 Apr 13].
2. Aasim M, Rauf AN, Wahid UR, Shruti C, Sapna T, Amandeep S, *et al*. Cellulose: A multifaceted biopolymer. Vol. 1. New York: Nova Science Publishers; 2016.
3. Windyasmara L, Pertiwiningrum A, Asmoro NW, Afriyanti A. Chemical quality of chicken bone waste gelatin extracted using chloride acid. Bul Peternakan 2018;42:322-6.
4. Arnamalia A, Nabila JR, Lutviyani A. Tinjauan Perspektif Islam dan Sains: Penggunaan Kulit Ikan Nila Sebagai Alternatif Bahan Baku Gelatin Halal. Vol. 17. Kaunia: Integration and Interconnection Islam and Science; 2022. p. 61-6.
5. Bichukale AD, Koli JM, Sonavane AE, Vishwasrao VV, Pujari KH, Shingare PE. Functional properties of gelatin extracted from poultry skin and bone waste. Int J Pure Appl Biosci 2018;6:87-101.
6. Mrázek P, Mokrejš P, Gál R, Orsavová J. Chicken skin gelatine as an alternative to pork and beef gelatines. Potravinarstvo Slovak J Food Sci 2019;13:224-33.
7. Murray K, Rodwell V, Bender D, Botham KM, Weil PA, Kennelly PJ. Harper's Biochemistry. Translation by Lilian RM and Lydia IM. 29th ed. Jakarta: EGC; 2014.
8. Nelson DL, Lehninger AL, Cox MM. Lehninger Basic Biochemistry. Vol. 1. Jakarta: Erlangga Publisher; 1982.
9. Haryati D, Nadhifa L, Abdullah N. Extraction and characterization of gelatin from rabbitfish skin (*Siganus canaliculatus*) with enzymatic method using bromelin enzyme. IOP Conf Ser Earth Environ Sci 2019;355:012-95.
10. Wirawan SK, Prasetya A, Ernie E. Effect of plasticizer on edible film characteristics of pectin. J Reaktor 2012;14:61-7.
11. Kuan YH, Nafchi AM, Huda N, Arifin F, Karim AA. Effect of sugars on the gelation kinetics and texture of duck feet gelatin. J Food Hydrocolloids 2016;58:267-75.
12. Saberi B, Chockchaisawasdee S, Golding JB, Scarlett CJ, Stathopoulos CE. Physical and mechanical properties of a new edible film made of pea starch and guar gum as affected by glycols, sugars and polyols. Int J Biol Macromol 2017;104:345-59.
13. Veiga SP, Oliveira LM, Cereda MP, Scamparini AR. Sucrose and inverted sugar as plasticizer. Effect on cassava starch-gelatin film mechanical properties, hydrophilicity and water activity. Food Chem 2007;103:255-62.
14. Wan Omar WH, Sarbon NM. Effect of drying method on functional properties and antioxidant activities of chicken skin gelatin hydrolysate. J Food Sci Technol 2016;53:3928-38.
15. Ahmed M, Pickova J, Ahmad T, Liaquat M, Farid A, Jahangir M. Oxidation of lipids in foods. Sarhad J Agric 2016;32:230-8.
16. Alhana SP, Tarman K. Extraction and characterization of collagen from gamma sea cucumber flesh. Indonesian Journal of Fishery Products Processing 2015;8:150-61.
17. Fessenden RJ, Fessenden JS. Organic Chemistry. 3rd ed. Jakarta: Erlangga Publisher; 1982.
18. Muyonga JH, Cole CG, Duodu KG. Extraction and physico-chemical characterization of Nile perch (*Lates niloticus*) skin and bone gelatin. Food Hydrocolloids 2004;18:581-92.
19. Jamili S, Sadeghi H, Rezayat M, Attar H, Kaymaram F. Extraction and evaluation of gelatin from yellow fin tuna (*Thunnus albacares*)

skin and prospect as an alternative to mammalian gelatin. Iran J Fisheries Sci 2016;18:903-14.

20. Oechsle AM, Akgün D, Krause F, Maier C, Gibis M, Kohlus R, *et al*. Microstructure and physical-chemical properties of chicken collagen. J Food Struct 2016;7:29-37.
21. Hamzah A. The characteristics and the making of biopolymer film from oil palm trunk starch (*Elaeis guineensis* Jacq.) using sorbitol plasticizer. J Chem Nat Resour 2019;1:11-22.
22. Melissa GA, Mariana AS, Lucielen OS, Marisa MB. Natural-based plasticizers and biopolymer films: A review. Eur Polymer J 2011;47:254-63.
23. Nugrahaningsih N, Lukiati B, Setiowati FK. Profile of Tensile Strength of Gelatin from Chicken leg Skin and Speed of Wound Closure in Musculus after Gelatin Administration. In Proceeding Biology Education Conference: Biology, Science, Enviromental, and Learning 2014;11:547-51.
24. Hasdar M, Erwanto Y, Triatmojo S. Characteristics of edible film produced from a combination of chicken leg skin gelatin and soy protein isolate. Bul Peternakan 2012;35:188-96.
25. Chodijah S, Husaini A, Zaman M, Hilwatulisan. Extraction of pectin from banana peels (*Musa paradiasica* Fomatypica) for biodegradable plastic films. J Phys Conf Ser 2019;1167:012061.
26. Sanyang ML, Sapuan SM, Jawaid M, Ishak MR, Sahari J. Effect of plasticizer type and concentration on tensile, thermal and barrier properties of biodegradable films based on sugar palm (*Arenga pinnata*) starch. Polymers 2015;7:1106-24.