Development of collagen based biodegradable film from fish scale

学位名	博士（海洋科学）
学位授与機関	東京海洋大学
学位授与年度	2019
学位授与番号	12614博甲第529号
URL	http://id.nii.ac.jp/1342/00001799/

［課程博士］
Doctoral Course

博士学位論文内容要旨
Abstract

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論文題目 Title	Development of collagen-based biodegradable film from fish scale		

It is well known that synthetic polymer films cause severe environmental pollution. As a result, collagen-based biodegradable film has been paid increasing attention as packaging material in food and pharmaceutical industries. However, commonly isolated porcine and bovine collagen have significant drawbacks owing to socio-cultural, religious, and health-related concerns (i.e., outbreaks of BSE). In contrast, by-products (such as scales) from fish processing companies are advantageous over mammalian resources and usually discarded; therefore, utilization of scales is imperative to elucidate the physico-chemical properties of collagen extracted from fish scale to substitute mammalian derived collagen in prospective applications.

Acid- and pepsin-soluble collagen (ASC and PSC, respectively) from scales of carp and lizardfish from temperate and sub-tropical countries were studied for thermostability. SDS-PAGE revealed that ASC and PSC were classified as type I collagen and molecular weight of ASC was higher than that of PSC. Both types of collagen from sub-tropical fish scales contained higher imino acids compared to temperate fish scales. Carp from Japan and Bangladesh showed similar thermal stability, but lizardfish from Vietnam showed higher stability than lizardfish from Japan for both types of collagen. Overall, PSC possessed a slightly lower denaturation temperature than their corresponding ASC, suggesting that a relationship between thermostability and molecular mass of collagen, as observed in SDS-PAGE, might exist. Maximal solubility was noticed in acidic pH (1-4) and solubility obviously declined at high salt concentration (>2%). ASC and PSC from these fish scales could be useful to food industry instead of mammalian collagens.

ASC and PSC were extracted from lizardfish scales, and the film-forming ability were examined. After extraction, both ASC and PSC (1%) were dissolved in 0.5 M acetic acid to attain film-forming solution (FFS) using glycerol as a plasticizer and cast the FFS (4 g). Afterwards, mechanical, physical, and chemical properties of both films were analyzed. The thickness of ASC and PSC films were 16.5 and 15.67 μm, respectively. In addition, tensile strength (TS) (17.52 and 11.85 MPa) and elongation at break (EAB) (10.37 and 7.23%), ΔE^* (3.37 and 1.96), transparency value (8.25 and 6.42), Water vapor permeability (WVP) (0.88 and 1.00 $\times 10^{-10}$ gm^{-1} s^{-1} Pa^{-1}), moisture (7.59 and 5.71%), film water solubility (41.13 and 43.37%) were recorded in ASC and PSC films, respectively. The SDS-PAGE pattern affirmed that original characteristics of both ASC and PSC were maintained in the corresponding films. Furthermore, the ATR-FTIR spectra indicated that collagen triple helix structure was intact in both films. ASC and PSC films showed potential as food packaging material.

ASC and PSC films incorporated with pyrogallol and curcumin at various concentrations (0%, 1%, 3% and 5%) were prepared and characterized. Incorporation of pyrogallol and curcumin resulted in the increase of TS but decrease of EAB in the films. Pyrogallol added films showed higher TS than curcumin added films did. WVP was not altered by type and concentration of phenolic compounds. The total differences in color significantly changed when curcumin was added at 3% or more. Films exhibited lower light transmission in visible wavelengths while pyrogallol and curcumin were added. SDS-PAGE pattern revealed that, molecular weight of phenolic compound treated films were higher than that of control films. FTIR analysis revealed that pyrogallol and curcumin changed the molecular structure and caused higher intermolecular interactions between collagen molecules as well as in the film matrix. Hence, ASC and PSC films added with pyrogallol and curcumin may be utilized as natural polymer material for packaging; however, the properties can be adjusted by changing the concentration of the phenolic compounds.

The results of our study suggest that ASC and PSC films prepared from lizardfish scales could be an alternative to mammalian derived biodegradable and low-density polyethylene films.