ELSEVIER

Food Chemistry 77 (2002) 81–84

Food Chemistry

www.elsevier.com/locate/foodchem

# Properties of gelatins from skins of fish—black tilapia (*Oreochromis mossambicus*) and red tilapia (*Oreochromis nilotica*)

B. Jamilah*, K.G. Harvinder

*Faculty of Food Science and Biotechnology, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*

Received 22 May 2001; received in revised form 15 August 2001; accepted 15 August 2001

**Abstract**

Fish skins are potential sources of gelatin. Therefore a study on the extraction and determination of the physicochemical characteristics of gelatin obtained from the skins of black (*Oreochromis mossambicus*) and red (*Oreochromis nilotica*) tilapia was undertaken. The extraction was carried out by a series of steps involving washings with 0.2% (w/v) sodium hydroxide and sulfuric acid, and 1.0% (w/v) of citric acid. This was followed by a final extraction with water at 45 °C for 12 h and the colloidal suspension was freeze-dried. Visual appearance, odour, pH, bloom strength, viscosity, melting point and amino acid profile of the gelatins were evaluated. The gelatins from both the black and the red tilapias were snowy white, shiny and light-textured in appearance. The gelatin of black tilapia skin had a strong fishy odour while that of the red tilapia skin had a barely detectable odour. Their pH values were in the vicinity of 3. The bloom strength of gelatin from black tilapia skin was higher (180.8 g) than that from red tilapia skin (128.1 g). The black tilapia skin gelatin was also significantly more viscous, had a higher melting point, and had a higher total amino acid content. 

*Keywords:* Fish gelatin; Tilapia; Physicochemical characteristics

## 1. Introduction

Gelatin has a very broad application in the food, pharmaceutical, and photographic industries. Gelatins are produced on a large scale from skin and bones of mammalian origin (mainly beef and pork) by alkaline or acidic extraction (Veis, 1964). Gudmunsson and Hafsteinsson (1997) and Choi and Regenstein (2000) suggested that, in addition to producing fish gelatins to meet religious needs, the commercial use of fish skin and bones, which are normally discarded, is good waste management as well as of economic benefit.

Collagens and their denatured forms, gelatins, are composed of long chains of amino acids connected by peptide bonds (Ockerman & Hansen, 1988; Ward & Courts, 1977). Furthermore, the amino acid composition of collagen, and consequently gelatin, is almost completely lacking in tryptophan and is low in methionine, cystine and tyrosine. However, the physical properties of gelatins are dependent on the origin and the method by which the collagen is treated (Ward & Courts, 1977). It has been known for many years that fish gelatin can be produced from the discarded portions of the fish, such as its skin and offals. However, the main concern is the elimination of the unpleasant smell often associated with fish products (Grossman & Bergman, 1992).

Fish collagens, in general, have lower amino acid contents than mammalian collagens and this may be the reason for the lower temperature of denaturation (Grossman & Bergman, 1992). Extraction of gelatin has been reported for cod (Gudmundsson & Hafsteinsson, 1997), tilapia (Grossman & Bergman, 1992), shark skin, lungfish skin and carp skin (Ward & Courts, 1977).

The production of tilapia, through aquaculture in Malaysia, has increased steadily and has become an important source of fish supply within the last few years. The ensuing increase of filleting means that more waste is produced. Hence, the objective of this study was to extract gelatins from the skins of black and red tilapia, and to determine their physicochemical characteristics.

* Corresponding author. Fax: +60-8942-3552.
*E-mail address:* jamilah@putra.upm.edu.my (B. Jamilah).

0308-8146/02/$ - see front matter 
PII: S0308-8146(01)00328-4

## 2. Materials and methods

### 2.1. Materials

Two species of the Tilapia family were studied, i.e. red tilapia (*Oreochromis nilotica*) and black tilapia (*Oreochromis mossambicus*). The red tilapia is a cultured freshwater fish obtained from a local fish farm in Ulu Langat, Selangor, whereas the black tilapia grows in the wild and was obtained from a local supplier in Serdang, Selangor. The red tilapia weighed between 500 and 600 g while the black tilapia weighed between 300 and 400 g. Upon arrival at the laboratory, the fish were killed, filleted and the skin manually removed.

All the chemicals used were of analytical grade.

### 2.2. Methods

#### 2.2.1. Extraction of gelatin

The extraction procedure was essentially as described by Grossman and Bergman (1992), with slight modifications. The fish skins were thoroughly rinsed in excess water to remove superfluous material. They were then soaked in 0.2% (w/v) sodium hydroxide solution for 40 min. This was followed by soaking in 0.2% sulphuric acid and 1.0% citric acid. Rinsing with distilled water was carried out between soakings. The final extraction was carried out in distilled water at 45 °C for 12 h. The extract was then filtered through Whatman filter paper (No. 4), collected and freeze-dried.

#### 2.2.2. Analyses

The yield, visual appearance and odour of the gelatins were noted. The analyses carried out were for: colour using the Hunter Ultrascan Sphere Spectrocolorimeter (Minolta Cr-300 series), melting point by the procedure described by Wainewright (1977), gel strength according to the British Standard (BS 757 :1975) using the TA-XT2 Texture Analyser Stable Micro System, viscosity as measured in the computerized Brookfield DV III Rheometer (model RV), pH, and amino acid composition according to the Waters-501 Instruments manual. The amino acids compositions of the gelatins were determined on a Waters-PICO-TAG amino acid auto analyser high performance liquid chromatography (Model: Waters 501), equipped with the amino acid analyzing software. The column used was the Waters-Pico Tag (measuring 3.9×150 mm). Each sample was hydrolysed with 6 N hydrochloric acid at 110 °C for 24 h.

#### 2.2.3. Statistical analysis

All data collected were analysed using the analysis of variance (ANOVA) and Duncan's multiple range test to determine the significant differences between means (SAS, 1987).

## 3. Results and discussion

The gelatin yields obtained for the black and the red tilapias were 5.39 and 7.81%, respectively (Table 1). These yields were lower than those reported by Grossman and Bergman (1992) for tilapia spp., for lumpfish skin by Osborne, Voight, and Hall (1989) and for cod skin by Gudmundsson and Hafsteinsson (1997). This lower yield could be due to the loss of extracted collagen, through leaching, during the series of washing steps or due to incomplete hydrolysis of the collagen. Further work to improve this yield is presently being executed.

Table 1 shows the visual appearance, instrumental colour measurement and odour description for the gelatins. Both the gelatins had a snowy white appearance and were light-textured. The colour of the gelatin depends on the raw material. However, it does not influence other functional properties (Ockerman and Hansen, 1988). There is no significant difference in the lightness, '*L*' values, of the two gelatins. This confirms the visual observations on the gelatins and could be a positive attribute, since it is easier to incorporate these gelatins into any food system without imparting any strong colour attribute to the product.

Fishy odour in the red tilapia gelatin was barely detectable but this was not so for the gelatin from black tilapia. This may be due to the stronger muddy odour and flavour associated with black tilapia.

The pH of the gelatin from black tilapia was 3.91 and that of red tilapia was 3.05. These pHs are slightly different compared with the pH of the gelatin from tilapia skin (3.77) obtained by Grossman and Bergman (1992). However, they did not indicate the species of tilapia in their report. This difference in pH of the gelatin may also be due to the type and strength of acids employed during the extraction procedures.

Table 2 shows the viscosity, melting point and bloom strength of the gelatins. Viscosity is the second most important commercial physical property of a gelatin (Ward & Courts, 1977). The viscosity of black tilapia gelatin was almost double that of the gelatin obtained

Table 1
The yield,visual appearance, odour and instrumental colour of gelatin from tilapia skin

| Properties | Red tilapia | Black tilapia |
|---|---|---|
| Yield (%) | 7.81 | 5.39 |
| Appearance | Snowy white, crystal-like and light-textured | Snowy white, crystal-like and light-textured |
| Odour description | Barely detectable fishy odour | Strong fishy odour |
| Hunter colour values | '*L*' 92.35±0.77<br>'*a*' −0.47±0.14<br>'*b*' 2.30±0.51 | '*L*' 93.32±1.70<br>'*a*' −0.56±0.07<br>'*b*' 3.09±0.37 |

Table 2
The viscosity, melting point and bloom strength of gelatin from tilapia skin

| Properties | Red tilapia | Black tilapia |
|---|---|---|
| Viscosity (cP) | 3.20±0.00 | 7.12±0.26 |
| Melting point (°C) | 22.45±0.77 | 28.90±0.50 |
| Bloom strength (g) at 10 °C | 128.11 | 180.76 |

from red tilapia. The viscosity of the gelatin of black tilapia can be considered to be in the mid-range and that of the red tilapia at the lower range since viscosities for commercial gelatin have been reported to be from 2.0 to 7.0 cP for most gelatins and up to 13.0 cP for specialized ones (Johnston-Banks, 1990). The viscosity of gelatin solutions is partially controlled by molecular weight and polydispersity (Sperling, 1985). Minimum viscosity of gelatin has been noted to be in the range of pH 6–8 for many gelatins (Ward & Courts, 1977); the pH effect on viscosity is minimum at the isoionic point and maximum at pH 3 and 10.5.

The melting point of the gelatin obtained from black tilapia is also significantly higher than that of the gelatin from red tilapia. These melting points are far higher than those reported for cod skin which were in the range 8–10 °C (Gudmunsson & Hafsteinsson, 1997). It is also known that fish gelatin has a lower melting point than mammalian gelatin (Norland, 1990). The melting point of a gelatin increases with increase in its molecular weight (Ward & Courts, 1977). Choi and Regenstein (2000) reported that the melting point increases with the maturation temperature. The amino acid composition may also contribute to the melting point characteristics (Norland, 1990).

The gel strength or bloom strength is a measure of the hardness, stiffness, strength, firmness and compressibility of the gel at a particular temperature and is influenced by concentration and molecular weight (Ockerman and Hansen, 1988). The bloom strength of the black tilapia gel (~181 g) is higher than that of red tilapia (~128 g). However, Grossman and Bergman (1992) reported a bloom strength of 263 g for the tilapia spp. Gudmunsson and Hafsteinsson (1997) also suggested that the gel strength may be dependent on the isoelectric point and may also be controlled, to a certain extent, by adjusting the pH. More compact and stiffer gels can be formed by adjusting the pH of the gelatin close to its isoelectric point, where the proteins will be more neutral and thus the gelatin polymers are closer to each other.

Table 3 shows the amino acid (a.a) composition of the gelatins from skins of both black and red tilapias. The a.a. profile obtained was from an acid hydrolysate. A proportion of the acidic amino acids occurs as the side-chain amides glutamine and asparagine in collagen (Ward & Courts, 1977). During acid hydrolysis of gelatin, some of the glutamine and asparagine will be converted to the acidic forms, i.e. glutamic acid and aspartic acid, respectively. The amino acid content of the gelatin of black tilapia is higher than that of the red tilapia. Both have very high contents of glycine and threonine, and are essentially low in proline, while serine, tryptophan and histidine are not detectable. This composition is different from that reported for tilapia by Grossman and Bergman (1992). Osborne et al. (1989) also reported that the amino acid profile, as well as the total amino acid content obtained from the lumpfish skin, was lower than the Knox™ gelatin. Johnston-Banks (1990) reported that the imino acids (proline and hydroxyproline) impart considerable rigidity to the collagen structure and that a relatively limited imino acid content should result in a less sterically hindered helix and may affect the dynamic properties of the gelatin. However, Gudmunsson and Hafsteinsson (1997) reported that the viscosity of the gel may be mainly due to the molecular weight distribution rather than the amino acid composition of the gelatin.

Table 3
The amino acid composition of gelatin from black and red tilapia skin (mg/g)

| Amino acid | Red tilapia | Black tilapia |
|---|---|---|
| Aspartic acid | 38.9±4.59 | 39.9±2.78 |
| Glutamic acid | 71.7±1.08 | 76.9±2.23 |
| Serine | Not detected | Not detected |
| Glycine | 308±12.1 | 338±55.3 |
| Histidine | Not detected | Not detected |
| Arginine | 29.5±0.84 | 35.1±1.34 |
| Threonine | 134±8.35 | 155±7.86 |
| Alanine | 76.1±5.20 | 90.3±1.44 |
| Proline | Not detected | 0.55±0.07 |
| Tyrosine | 5.95±0.78 | 6.84±0.22 |
| Valine | 17.7±1.60 | 22.8±1.25 |
| Methionine | 14.2±2.03 | 17.8±1.12 |
| Cysteine | 1.51±0.14 | 2.97±1.37 |
| Isoleucine | 8.39±0.14 | 9.40±0.71 |
| Leucine | 18.2±1.27 | 20.3±0.38 |
| Phenylalanine | 18.6±0.51 | 21.8±1.27 |
| Lysine | 21.3±2.21 | 28.0±2.01 |
| Tryptophan | Not detected | Not detected |
| Total | 764 | 865.41 |

Values are means ± standard deviations of eight analyses from four replicates.

## 4. Conclusion

The gelatins obtained from the skins of red and black tilapias exhibited different physicochemical properties. The viscosity and the melting point of the gelatins indicate that they can be used for applications different from cold water fish gelatin.

## References


Choi, S. S., & Regenstein, J. M. (2000). Physicochemical and sensory characteristics of fish gelatin. *Journal of Food Science*, *65*(2), 194–199.

Grossman, S., & Bergman, M. (1992). Process for the production of gelatin from fish skin. *United States Patent* No. 5,093,474.

Gudmunsson, M., & Hafsteinsson, H. (1997). Gelatin from cod skin as affected by chemical treatments. *Journal of Food Science*, *62*(1), 37–39, 47.

Johnston-Banks, F. A. (1990). Gelatin. In P. Harris (Ed.), *Food gels* (pp. 233–291). London: Elsevier Applied Food Science Series.

Norland, R. E. (1990). Fish gelatin, technical aspects. In M. N. Voight, & J. K. Botta (Eds.), *Advances in fisheries and technology and biotechnology for increased profitability* (pp. 325–332). Lancaster, USA: Technomic Publishing Co.

Ockerman, H. W., & Hansen, C. L. (1988). *Glue and gelatin. In Animal by-product processing*. Chichester, England: Ellis Horwood Ltd.

Osborne, R., Voight, M. N., & Hall, D. E. (1989). Utilization of lumpfish (*Cyclopterus lumpus*) carcass for the production of gelatin. In M. N. Voight, & J. R. Botta (Eds.), *Advances in fisheries technology and biotechnology for increased profitability* (pp. 143–150). Lancaster, USA: Technomic Publishing Co.

Sperling, L. H. (1985). *Introduction to physical polymer science*. New York: John Wiley.

SAS. (1987). *Statistical analysis system for data analysis*. North Carolina, USA: The SAS Institute.

Veis, A. (1964). *The macromolecular chemistry of gelatin*. New York: Academic Press.

Wainewright, F. W. (1977). Physical tests for gelatin and gelatin products. In A. G. Ward, & A. Courts (Eds.), *The Science and Technology of Gelatins*. (pp. 508–531). London: Academic Press Inc.

Ward, A. G., & Courts, A. (1977). *The science and technology of gelatin*. London: Academic Press.