LWT - Food Science and Technology 57 (2014) 586–593

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Effects of vegetable oils on gel properties of surimi gels

Liu Shi [a], Xianfeng Wang [a], Tong Chang [a], Chenjie Wang [a], Hong Yang [a,b,c,d,*], Min Cui [e,f,**]

[a] College of Food Science and Technology, Huazhong Agricultural University, Wuhan, Hubei 430070, China
[b] Key Laboratory of Environment Correlative Dietology, Huazhong Agricultural University, Ministry of Education, Wuhan, Hubei 430070, China
[c] National R&D Branch Center for Conventional Freshwater Fish Processing, Wuhan, Hubei 430070, China
[d] Aquatic Product Engineering and Technology Research Center of Hubei Province, Wuhan, Hubei 430070, China
[e] State Key Laboratory of Agricultural Microbiology, Huazhong Agricultural University, Wuhan, Hubei 430070, China
[f] Laboratory of Animal Virology, College of Veterinary Medicine, Huazhong Agricultural University, Wuhan, Hubei 430070, China

ARTICLE INFO

Article history:
Received 27 August 2013
Received in revised form
30 January 2014
Accepted 4 February 2014

Keywords:
Vegetable oil
Surimi gel
Texture
Color
Rheological property

ABSTRACT

The objective of this study was to determine effects of vegetable oils (soybean, peanut, corn, and rap oils) on the textural, color, microstructural, sensory and rheological properties of surimi gels. As the vegetable oil concentration increased in surimi gels, breaking force of gels was decreased ($P < 0.05$), while expressible water and whiteness values were increased ($P < 0.05$). Surimi gels with peanut oil had higher breaking force values, comparing to those with other vegetable oils. Transmission electron microscope shows the similar-size droplets of peanut oil and corn oil in surimi gels. Sensory evaluation indicated that fish balls with 10 g/kg vegetable oils were accepted in term of taste, color and overall likeness by the panelists. Storage modulus (G′) and loss modulus (G″) decreased along with increasing vegetable oil concentration. Results demonstrated that vegetable oils could be used potentially to modify the qualities of surimi-based products, such as color and taste.

1. Introduction

Surimi, a stabilized fish myofibrillar protein, is an intermediate foodstuff for producing various texturized products. Surimi-based products become increasingly popular due to its unique textural properties as well as high nutritional value. Oil/fat can increase brittleness and change the functional properties of fish protein gels (Chojnicka, Sala, De Kruif, & Van de Velde, 2009). In China, the lard has been added into surimi-based products, such as fish balls, to enhance the qualities of products (Li, 2008; Wang, Li, Xiong, & Hong, 2006). However, animal fat contains highly saturated fatty acids and cholesterol, which can potentially increase incidences of obesity, hypertension, cardiovascular diseases, and coronary heart diseases (Paneras & Bloukas, 1994). Thus it is trend that consumers prefer to choose food products with less or even no animal fat.

Vegetable oil is also commonly used in surimi-based products as textural modifier, color enhancer and processing aid (Park, 2005). The whiteness of surimi-based products with vegetable oil is often higher than these without vegetable oil (Benjakul, Visessanguan, & Kwalumtharn, 2004; Hsu & Chiang, 2002). Additionally, vegetable oil has no cholesterol but higher ratio of unsaturated fatty acids than animal fat (Liu, Huffman, & Egbert, 1991). Nowadays, vegetable oil is used to replace the animal fat in meat products. Vegetable oils (soya-seed oil, sunflower oil, cotton-seed oil, corn-seed oil, and palm oil) were used to replace animal fat in beef frankfurters (Ambrosiadis, Vareltzis, & Georgakis, 1996). Olive oil was used to replace up to 200 g/kg of pork back fat and had no effect on the quality of dry fermented sausages (Bloukas, Paneras, & Fournitzis, 1997).

Soybean, corn, rap and peanut oils are major cooking oils in China. Different vegetable oils had different effects on the quality and nutritional values of meat products (Ambrosiadis et al., 1996; Hsu & Yu, 2002; Wu, Xiong, & Chen, 2011). However, there were few studies in the effects of different vegetable oils (soybean, corn, rap and peanut oils) on the gel properties of surimi-based products. Therefore, the objective of this study was to determine effects of different vegetable oils on the textural, color, microstructural, sensory and rheological properties of surimi gels.

* Corresponding author. College of Food Science and Technology, Huazhong Agricultural University, Wuhan, Hubei 430070, China. Tel.: +86 27 87671045; fax: +86 27 87278373.
** Corresponding author. State Key Laboratory of Agricultural Microbiology, Huazhong Agricultural University, Wuhan, Hubei 430070, China. Tel./fax: +86 27 87270170.
E-mail addresses: yangh@mail.hzau.edu.cn (H. Yang), cuimin@mail.hzau.edu.cn (M. Cui).

http://dx.doi.org/10.1016/j.lwt.2014.02.003
0023-6438/

2. Materials and methods

2.1. Materials

Frozen silver carp surimi was purchased from Honghu Jingli Aquacultural Food Ltd (Jingzhou, Hubei, China), and then cut into small blocks (~300 g) and vacuum-packaged and stored at −24 °C. The moisture content of surimi was determined as 767.8 g/kg. Soybean oil and corn oil (Yihai Kerry Grain and Oil Industry Co., Ltd, Wuhan, Hubei, China), peanut oil (Shandong Luhua Group Co., Ltd, Xiangyang, Hubei, China), rap oil (Hubei Aoxing Grain and Oil Industry Co., Ltd, Laohekou, Hubei, China) and salt (Hubei Salt Industry Group Co., Ltd, Wuhan, Hubei, China) were purchased from a local supermarket (Wuhan, Hubei, China).

2.2. Preparation of surimi gels

Following thawing at room temperature (about 25 °C) for 1hr, surimi was cut into small pieces (about $3 \times 3 \times 3$ cm^3) and then was chopped for 2 min in food processor (HR7625, Philips, Hong Kong, China). Salt (25 g/kg) was added into surimi and mixed for 2 min. Then vegetable oil was added and mixed for 2 min. The final concentrations of vegetable oils were 10, 20, 30, 40 and 50 g/kg, respectively. Sample without vegetable oil was served as a control. During homogenization, ice water was added to adjust the final moisture content of the paste up to 780 g/kg and maintain the temperature in the range of 4–10 °C. The pastes were then stuffed into plastic casing (20 mm in diameter and 150 mm in length), and both ends were sealed tightly. Then the samples were heated in a water bath (HH-4, Changzhou Guohua Electric Co., Ltd, Jintan, Jiangsu, China) at 90 °C for 30 min. The gels were then cooled in ice water for 20 min and stored at 4 °C for further analysis.

2.3. Punch test

A penetration test was performed with a TA.XTPlus Texture Analyzer (Texture Technologies Corp., Scarsdale, NY, USA). After tempered at room temperature for 2 h, gel samples were cut into cylinders (20 mm in diameter and 20 mm in height) and penetrated to 15 mm at a speed of 1 mm/s with a spherical-ended stainless steel plunger (P/0.25 S). Breaking force (g) and deformation (mm) were determined (Kim, Park, & Yoon, 2005). Eight replicates of measurements were taken.

2.4. Expressible water

The amount of expressible water (EW) for the samples was measured by Avanti J-E centrifuge (Beckman Coulter Inc., Fullerton, CA, USA). Samples (3 ± 0.2 g) of gels were weighed and placed between two layers of filter paper (No. 102φ = 11 cm, Hangzhou Xinhua, Filter Paper Co., Ltd, Hangzhou, Zhejiang, China). Samples were then placed at the bottom of 50 ml centrifuge tubes and centrifuged at 1000 g for 15 min. After centrifugation, gels were weighed again. The expressible water is calculated as: EW (%) $= (W_i - W_f)/W_i \times 100$, where W_i is the initial weight of gel and W_f is the final weight of gel (Mao & Wu, 2007). Eight replicates of measurements were taken.

2.5. Color evaluation

The color values of gel samples were determined by a HunterLab Ultra Scan XE colorimeter (HunterLab Co., Ltd, Reston, VA, USA). Ten replicates of measurements were taken. Usually, lightness (L^*), redness (a^*) and yellowness (b^*) values were recorded. The whiteness (W) was calculated using the following equation (Park, 1994):

$$W = 100 - \left[\left(100 - L^*\right)^2 + a^{*2} + b^{*2}\right]^{1/2}$$

2.6. Dynamic rheological properties

For dynamic rheological test, the pastes containing the oils at different concentration were placed in an AR2000ex Rheometer (TA Instruments Ltd., New Castle, DE, USA) equipped with a 40 mm parallel steel plate. A gap of 1 mm was set and silicone oil was used to prevent water evaporation. To obtain the linear range for the dynamic analysis, stress and frequency sweep tests were conducted, respectively. Strain of 0.02 and frequency of 1 Hz were obtained from stress and frequency sweep in the linear range. During the temperature sweep, the sample was heated from 10 to 90 °C at a heating rate of 1 °C/min with 0.02 strain and 1 Hz frequency. Storage modulus (G′) and loss modulus (G″) values were recorded.

2.7. Transmission electron microscopy (TEM)

Gel samples (about 1 cm^3 pieces) were fixed at room temperature in 25 g/kg glutaraldehyde for 4 h at 4 °C, and then postfixed in 10 g/kg osmic tetroxide for 1 h. Gel samples were rinsed in 0.1 mol/L sodium phosphate buffer three times after each step. The samples were dehydrated with an ethanol series (500, 700, 800, 950, and 1000 ml/L; 2×15 min) and pure acetone (2×30 min). The samples were then submerged in EPON812:acetone (1:1) for 30 min and EPON812 for 1 h. After that, the samples were polymerized for 48 h at 60 °C and followed by 24 h at 30 °C. Thin sections were prepared on a diamond knife in a LKB Ultra microtome (BROMMA, Sweden) and deposited on a collodion-coated Formvargrids. Ultrathin sections were stained in uranyl acetate and lead citrate and viewed using a transmission electron microscopy (Hitachi H-600, Hitachi Corp., Japan).

2.8. Preparation of fish balls

Fish balls were prepared as follow: The thawed surimi was weighted (200 g) and ground with the food processor (HR7625, Philips, Hong Kong, China) for 1 min. Then salt (20 g/kg of total weight), starch (60 g/kg of total weight), and other ingredients (10 g/kg chicken essence, 20 g/kg sugar, 20 g/kg egg white, 10 g/kg cooking wine of total weight) were added and mixed with surimi paste, while vegetable oils (10 g/kg and 30 g/kg of total weight, respectively) were added as well, Additionally, sample without oils was taken as the control. The final moisture of all surimi pastes was 760 g/kg. Fish balls (2.0 cm in diameter) were shaped by hand and cooked in boiling water for 6 min. The cooked fish balls were cooled in room temperature for sensory evaluation.

2.9. Sensory evaluation of fish balls

Hedonic sensory test was used to determine the sensory properties of fish balls. For this study, 63 untrained consumers (36 females and 27 males, aged between 22 and 55) were recruited from students, staffs and faculties at Huazhong Agriculture University. They were interested volunteers and informed that they would evaluate fish balls. All samples were coded with random three-digit number before presented to the panelists. Samples were placed on the paper plates. Five attributes were taste, color, elasticity, texture, and overall likeness of each sample using a seven-point hedonic scale ranging from 1 (dislike extremely) to 7 (like extremely). All samples were evaluated in the same condition.