Available online at www.sciencedirect.com
ScienceDirect
Food Chemistry 103 (2007) 155–160
Food Chemistry
www.elsevier.com/locate/foodchem

The effect of oyster shell powder on the extension of the shelf life of tofu

Young Soon Kim [a], Yang Mun Choi [b], Dong Ouk Noh [c], Seung Yong Cho [d], Hyung Joo Suh [a,*]

[a] Department of Food and Nutrition, College of Health Sciences, Korea University, 1 Jeongneung-dong, Sungbuk-ku, Seoul 136-703, Republic of Korea
[b] Department of Food Service and Industry, Shinsung College, Chungnam 343-860, Republic of Korea
[c] Department of Hotel Culinary Arts and Nutrition, Kaya University, Gimhae 621-748, Republic of Korea
[d] Functional Food Research Center, College of Life Sciences, Korea University, Anam-dong, Seongbuk-gu, Seoul 136-713, Republic of Korea

Received 7 December 2005; received in revised form 10 July 2006; accepted 10 July 2006

Abstract

The effects of oyster shell powder addition (0%, 0.05%, 0.1% and 0.2% of soy milk) on quality and shelf life of tofu (soybean curd) were investigated. Yield and moisture of tofu prepared with 0.1% of shell powder were higher than that coagulated with a single use of $MgCl_2$. Syneresis was low when shell powder was added to tofu, but higher when $MgCl_2$ was added. Shell powder addition (0.05% and 0.2% of soymilk) showed a high level in hardness and gumminess comparing with tofu prepared with a single use of $MgCl_2$. However, there was no significant difference ($p > 0.05$) between 0.05% and 0.2% addition of shell powder. When 0.05% of shell powder was added, overall acceptability showed a high score because tofu had a good mouthfeel, moderate firmness and lower beany-flavour. However, there was not a significant difference ($p > 0.05$) between no addition and 0.05% and 0.1% addition of shell powder. Tofu prepared with shell powder (0.05% and 0.1% addition) had a shelf life of above 2 days longer than that prepared with a single use of $MgCl_2$. The addition of shell powder (0.05% and 0.1%) for tofu manufacturing resulted in a good sensory evaluation and the extension of shelf life.

Keywords: Shell powder; Tofu; Soybean curd; Shelf life; Sensory evaluation

1. Introduction

Soybean seeds have a protein content of 35–40% on a dry weight basis, which makes them a relatively inexpensive source of protein for human consumption (Derbyshire, Wright, & Boulter, 1976). Soybeans have been transformed into various forms of soy foods, tofu being the one most widely accepted throughout the world.

In Asia, for example, about 90% of soybean protein is consumed in the form of tofu. However, because of its high moisture content and rich nutrients, tofu is prone to spoilage. Some tofu purchased in the "fresh" form at an Asian Market or health-food store may have a shelf-life of only 3–4 days. In order to obtain a longer shelf-life for tofu, considerable attention has been given to the development of methods for extending the shelf life of tofu. Some researchers have studied quality improvement and shelf-life extension of tofu. To extend the shelf-life of tofu, microwave treatment, coagulation with organic acid and pH adjustment of immersion solutions have been tried (Champagene, Aurouze, & Goulet, 1991; Pontecorvo & Bourne, 1978; Wu & Salunkhe, 1977). Chitosan was used as an additive to tofu for the purpose of shelf-life extension because it has antimicrobial activity (No & Meyers, 2004). However, none of these methods have been employed by commercial tofu manufacturers. Thus, there is need for a more practical and efficient method.

At present, in oyster shell-harvesting districts, large amounts of shells are piled up near the seaside, which creates several serious problems such as the emission of

* Corresponding author. Fax: +82 2 941 7825.
E-mail address: suh1960@unitel.co.kr (H.J. Suh).

0308-8146/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2006.07.040

offensive odors and soil pollution from heavy metals contained in the viscera. The main component of shell is $CaCO_3$, and by heat treatment, $CaCO_3$ in the shell is converted to CaO, which exhibits antibacterial activity. In fact, there were reports that shell powder heated to over 700 °C exhibited a bactericidal activity (Sawai, Shiga, & Kojima, 2001; Shiga, Sawai, & Kojima, 1999). Oyster shell powder was applied to prepare noodles, fried chicken, sardine ball (Suhara, 1995) and *kimchi* (Choi, Whang, Kim, & Suh, 2006) for quality improvement or extension of shelf life. Therefore, the use of this material in food processing is expected not only to prolong the shelf life of foodstuffs, but also to be a source of minerals.

The objective of this study was to investigate the effect of oyster shell powder on the quality of tofu in order to extend the shelf life of tofu.

2. Materials and methods

2.1. Materials

To prepare tofu, soybean was purchased from a local supplier. The seed density was 40.29 g/100 beans. Food grade $MgCl_2 \cdot 6H_2O$ and oyster shell powder was purchased from Samwoo TD. (Seoul, Korea). Shell powder was composed of 93% crude ash containing 65.4% of calcium. And, shell powder contained other minerals as follows; magnesium 476 mg/100 g, iron 53 mg/100 g, phosphorus 21 mg/100 g, potassium 7 mg/100 g, and sodium 2 mg/100 g.

2.2. Preparation of tofu

Tofu was prepared by a modification of the methods proposed by Park, Nam, Jeon, Oh, and In (2003). Washed soybeans (≈110 g) were soaked in 500 mL tap water in 1litre beaker at room temperature (28 °C) for 16 h. After the stipulated soaking time, the beans were drained and ground with 1100 mL tap water in a Waring blender for 2 min at high speed. The mash was strained through a muslin cloth and pressed to obtain soymilk. Soymilk (1000 mL) was heated to boiling, and, then, mixed with 1.8% $MgCl_2 \cdot 6H_2O$ alone or together with 0.05%, 0.1%, and 0.2% shell powder at 80 °C, followed by being held for 15 min to coagulate. The curd was gently transferred to a perforated stainless steel container ($9.5 \times 5.0 \times 7.0$ cm depth) lined with a single layer of cheesecloth and pressed for 15 min using bricks weighing 3.5 kg. The tofu was immersed in the running tap water for 30 min, drained for 30 min to remove excess moisture, and subjected to the analysis and sensory evaluation.

2.3. Yield, moisture content and colour

Yield of tofu was expressed as fresh weight of tofu obtained from 1000 mL of soymilk. Moisture content was determined by drying 5 g of fresh tofu at 105 °C in air oven to constant weight (Tsai, Lan, Kao, & Chen, 1981).

Colour evaluation was performed on fresh tofu samples using a Hunterlab Model D25 Tristimulus Colorimeter, equipped with a D25 circumferential optical sensor. A standard white tile with reflectance values of $X = 83.24$, $Y = 85.23$ and $Z = 100.92$ was used as a reference. A representative sample was placed into a 6 cm Petri dish and covered to avoid stray light. Hunter L (lightness), $+a$ (red) to $-a$ (green), and $+b$ (yellow) to $-b$ (blue) were then determined for each sample. Each value represented a mean value of five replicate determinations. Coefficients of variations for all measurements were less than 3%.

2.4. Syneresis

Syneresis was measured by a modified method of Amstrong, Hill, Schrooyen, and Mitchell (1994). Three pieces of tofu samples of 1.5 cm diameter were weighed and filled into Visking tubing (2.5 cm diameter). The tube was wrapped with plastic wraps and tied to a wire frame placed over a 2 litre beaker in a hanging position for 24 h at 4 °C. Percentage syneresis was calculated as the weight of water released from the tofu in 24 h divided by the weight of sample and multiplied by 100.

2.5. Texture measurement of tofu

Texture profile analysis was applied to evaluate the textural properties of tofu samples using TA-XT2 Texture Analyzer (Stable Micro Systems, Goldaming, UK). Cube samples of tofu ($10\ mm \times 10\ mm \times 10\ mm$) were axially compressed to 50% deformation of their original height in a two-cycle compression test by a compression plunger (D: 25 mm). Force time deformation curves were obtained using a 5 kN load cell applied at a cross speed of 60 mm/min. Textural parameters of the tofu, hardness, cohesiveness, springiness, gumminess, chewiness and adhesiveness, were evaluated for each treatment according to the definitions given by Bourne (1982). Ten samples were analyzed for each treatment.

2.6. Storage test of tofu

The tofu ($9.5 \times 5 \times 7$ cm) obtained above was placed in a polypropylene container ($12 \times 8 \times 12$ cm) containing 100 mL of sterilized distilled water as an immersion solution. The container with plastic cover was stored at 10 °C for 11 days. All experiments were triplicated.

In order to determine viable bacterial counts, the tofu and immersion solution were homogenized together by using Polytron homogenizer (RT-1200C, Switzerland), and centrifuged at 3000*g* for 20 min. The above supernatant was diluted with 0.1% peptone water. Plate count agar (Difco, St. Louis, USA) was used for the determination of total viable counts. All plates were triplicated, incubated at