Preparation and Quality Analysis of Sodium-Reduced Fried Fish Cakes

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ABSTRACT: To help reduce high intake of sodium in the Korean diet, sodium-reduced fried fish cakes (SRFFCs) were prepared and evaluated with regard to color, textural properties, and sensory attributes as indicators of quality. The quality characteristics of 30% SRFFCs were not notably different from those of full sodium FFCs; however, substitution of sodium with potassium altered the color and decreased consumer acceptance on sensory evaluation items. These results suggest that the SRFFCs that will be accepted by consumers can be prepared without compromising the quality.

Keywords: fried fish cake, sodium-reduction, quality evaluation

INTRODUCTION

Fish cakes (also called fishcakes or fish pastes) are highly consumed in Korea and Japan. In the Korean Food Standards Codex, fish cakes are defined as a processed marine product containing salt-soluble protein from fish meat (1). In South Korea, 141,544 tons (worth approximately 340 billion won) of fish cakes were produced in 2010 (2). Fish cakes are prepared by frying, boiling, or broiling, although more than 95% of fish cakes are made by frying in South Korea (3). According to several reports, fried fish cakes (FFC) contain functional materials such as fiber (4), mushrooms (5,6), and anchovies (7).

Recently, high levels of sodium in foods have become a global social problem. The primary deleterious effect of excess sodium intake is increased blood pressure (8), and the resulting hypertension subsequently causes cardiovascular disease (CVD), including heart attack, stroke, and related diseases (9), as well as osteoporosis (10) and gastric cancer (11). Given that relatively moderate restrictions on sodium intake have the potential to reduce the average blood pressure, reduction of sodium in processed foods may substantially reduce the burden of morbidity and mortality from CVD at a population level. Therefore, the Korean government is trying to reduce sodium intake on a national level. The seven most widely consumed food items, i.e., soy sauce (ganjjang), soybean paste (doenjang), seasoned foods (sauce and ketchup), noodles, salted fish (jeotgal), processed fish meat products (fish cake), and processed meat products (ham and sausage), were selected as target foods for development of sodium-reduced guidelines in 2012 by the Korea Foods Industry Association (KFIA) (12).

In the case of fish cakes, the inclusion of salt is essential during processing because the texture of the fish cake is provided by salt-soluble proteins. Therefore, to the best of our knowledge, little work has been done on the development of sodium-reduced fried fish cakes (SRFFCs). In this study, we prepared SRFFCs and SRFFCs containing potassium substituted for sodium, and we analyzed their color, texture, and sensory characteristics.
**Preparation of fried fish paste**

Frozen fish meat surimi was ground in a Silent Cutter Mixer (Yasui Co., Ltd., Shimane, Japan) until the meat temperature was approximately 0°C. Salt (NaCl) and/or KCl was added and mixed, and then all other materials except wheat flour were inputted and mixed. Water was added as ice cubes for maintenance of low temperature during mixing. Wheat flour was finally added, and all mixing procedures were completed within 40 min. The obtained mixture was equilibrated at room temperature (20±2°C) for 30 min, prior to the addition of MSG and D-Xylose.

**Texture analysis**

The texture of the FFCs was analyzed using a Rheometer (Compac-100, Sun Scientific Co., Tokyo, Japan) equipped with a cylindrical probe (Adaptor No. 34) with a diameter of 10 mm. After storage at 4°C, the sliced FFCs were equilibrated at room temperature (20±2°C) for 30 min before measurements were made. Samples were compressed at a distance of 5 mm with a test speed of 60 mm/min, where the graph interval was 30 ms and the pressure of the load cell was 2 kg.

**Folding test**

The flexibility of the FFCs was analyzed by using a folding test (14). Sliced samples with a thickness of 3 mm were folded in half. The samples were given a score of AA or A when they did not crack after being folded in half four or two times, respectively. When half of the sample showed a crack after being folded in half two times, a score of B was given. When cracks were found throughout the sample after it was folded in half two times, a C score was given. When the sample was broken after being folded in half two times, it was given a score of D.

**Sensory evaluation**

The panel consisted of 17 assessors aged 20~26 years. The assessors were trained with regard to the color, taste, odor, moistness, chewiness, and overall acceptance of the FFCs; they were also trained in the importance of sensory evaluation and issues to be considered while assessing the samples. A questionnaire form was developed. A nine-point scale from 1 to 9 was used for evaluating properties from “worst” to “best”, respectively. Full-sodium FFCs were used as a control and they received a score of 5 for all sensory properties.

**Statistical analyses**

All measurements were performed in triplicate, and analysis of variance was analyzed using the SPSS package for windows ver. 12 (SPSS Inc., Chicago IL, USA). A P-value less than 0.05 was considered statistically significant.

### RESULTS AND DISCUSSION

**Color of SRFFCs**

Reduction of the sodium level altered the color of the FFCs. As the sodium content in the FFCs was reduced, the L value increased (Table 2). Little change was found in the b value in SRFFCs. In SRFFCs with high sodium

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**Table 1. Formulas of several sodium-reduced fried fish cakes (SRFFCs)**

| SRFFCs | NaCl : KCl (w/w) | Fish meat surimi | Wheat flour | Sugar | MSG | D-Xylose | Potassium sorbate | GDL | Water | NaCl | KCl |
|--------|------------------|------------------|-------------|-------|-----|---------|-----------------|-----|-------|------|-----|
| 0% SRFFC | 60.00 | 60.00 | 0.50 | 0.00 | 0.20 | 0.20 | 0.110 | 1.50 | |
| 10% SRFFC | 60.00 | 60.00 | 60.00 | 60.00 | 0.50 | 0.50 | 0.20 | 0.20 | 0.110 | 1.50 | 1.35 |
| 20% SRFFC | 60.00 | 60.00 | 60.00 | 60.00 | 0.50 | 0.50 | 0.20 | 0.20 | 0.110 | 1.50 | 1.20 |
| 30% SRFFC | 60.00 | 60.00 | 60.00 | 60.00 | 0.50 | 0.50 | 0.20 | 0.20 | 0.110 | 1.50 | 1.05 |
| 40% SRFFC | 60.00 | 60.00 | 60.00 | 60.00 | 0.50 | 0.50 | 0.20 | 0.20 | 0.110 | 1.50 | 0.84 |
| 50% SRFFC | 60.00 | 60.00 | 60.00 | 60.00 | 0.50 | 0.50 | 0.20 | 0.20 | 0.110 | 1.50 | 0.75 |

*Each number in front of SRFFC means reduced amount (w/w) percent of sodium compared with non-reduced control (0% SRFFC). MSG, mono-sodium glutamate; GDL, glucono-δ-lactone.*
Table 2. Texture characters of sodium-reduced fried fish cakes (SRFFCs)

| SRFFCs | NaCl : KCl (w : w) | Color values² | Strength (×10³ Dyne/cm²) | Hardness (×10³ Dyne/cm²) | Adhesiveness (g) | Folding test |
|--------|--------------------|---------------|--------------------------|--------------------------|------------------|--------------|
|        |                    | L  a  b  ΔE   |                          |                          |                  |              |
| 0% SRFFC |                   | 65.63  6.09  37.23  0  | 28.27⁵  30.59⁴  -1.33b  AA |
| 10% SRFFC (¹) |                | 66.03  6.16  37.44  0.46 | 28.88⁵  31.64⁴  -1.28d  AA |
| 20% SRFFC (¹) |                | 66.57  6.08  37.19  0.94 | 29.56⁵  32.83⁴  -1.17d  AA |
| 30% SRFFC (¹) | 100 : 0      | 67.62  6.04  37.45  2.00 | 30.11⁴  33.69³  -1.00c  AA |
|           | 80 : 20      | 72.89  4.43  37.24  7.45 | 11.22c  25.02d  -0.33a  AA |
|           | 60 : 40      | 72.11  4.28  36.96  6.73 | 28.00³  31.84³  -0.63a  AA |
|           | 40 : 60      | 73.17  4.58  37.59  7.65 | 28.70³  38.07³  -0.70a  AA |
|           | 20 : 80      | 72.87  3.45  36.81  7.72 | 53.22a  57.27a  -1.10a  AA |
|           | 0 : 100      | 75.11  1.86  34.59  10.71 | 29.28b  40.35b  -0.47a  AA |
| 40% SRFFC (¹) |                | 71.66  4.39  36.83  6.28 | 24.31a  32.50b  -0.50ab  AA |
| 50% SRFFC (¹) |                | 73.39  4.49  37.97  7.96 | 30.66b  36.25ab  -0.87ac  AA |

¹Each number in front of SRFFC means reduced amount (w/w) percent of sodium compared with non-reduced control (0% SRFFC).
²L, degree of whiteness; a, degree of redness; b, degree of yellowness; and ΔE, overall color difference (ΔE=[(ΔL)²+(Δa)²+(Δb)²]¹/²).
Different letters (a-f) within a column indicate significant difference (P<0.05), n =17.

Table 3. Sensory analysis of sodium-reduced fried fish cakes (SRFFCs)

| SRFFCs | NaCl : KCl (w : w) | Sensory characteristic | Color | Taste | Odor | Chewiness | Overall acceptance |
|--------|--------------------|------------------------|-------|-------|------|-----------|--------------------|
|        |                    |                        | 5.00⁵ | 5.00⁵ | 5.13b | 3.07³ | 4.39cd | 5.00a |
| 0% SRFFC |                   |                        | 5.00⁵ | 5.00⁵ | 5.13b | 3.07³ | 4.39cd | 5.00a |
| 10% SRFFC (¹) |                |                        | 5.12a | 5.31b | 5.24a | 3.67c | 4.07d | 5.05a |
| 20% SRFFC (¹) |                |                        | 5.13a | 5.16b | 5.17ab | 3.79c | 4.40bc | 5.08a |
| 30% SRFFC (¹) | 100 : 0      |                        | 5.16a | 5.06a | 5.26a | 3.67c | 4.40bc | 5.12a |
|           | 80 : 20      |                        | 5.20a | 4.53c | 4.80a | 3.67c | 4.40bc | 5.08a |
|           | 60 : 40      |                        | 5.13a | 4.67b | 4.80a | 3.67c | 4.40bc | 5.08a |
|           | 40 : 60      |                        | 5.07a | 3.80b | 4.33a | 3.67c | 4.40bc | 5.08a |
|           | 20 : 80      |                        | 4.73a | 3.07³ | 3.67c | 3.67c | 4.40bc | 5.08a |
|           | 0 : 100      |                        | 4.73a | 2.40a | 3.47c | 3.47c | 4.40bc | 5.08a |
| 40% SRFFC (¹) |                |                        | 5.13a | 4.67b | 5.13ab | 3.47c | 4.40bc | 5.12a |
| 50% SRFFC (¹) |                |                        | 5.07a | 4.13c | 5.00b | 3.93d | 4.07d | 4.07d |

¹Each number in front of SRFFC means reduced amount (w/w) percent of sodium compared with non-reduced control (0% SRFFC).
Different letters (a-f) within a column indicate significant difference (P<0.05), n =17.

reduction (40% and 50% SRFFCs), the a value decreased. Substitution of sodium with potassium in 30% SRFFCs increased the L value but reduced the a value. The total color difference (ΔE) indicated that the magnitude of color difference between the full-sodium control (i.e., 0% SRFFCs) and SRFFCs increased as the sodium content decreased, and the change increased with increasing substitution of sodium with potassium in 30% SRFFCs. Differences in the perceivable color were analytically classified as very distinct (1.5<ΔE<3) and light (1.5<ΔE) (15). The color of FFCs is mainly attributed to the Maillard reaction between fish proteins (amino group) and wheat carbohydrates (carbonyl group), and to caramelization among sugars. Jomduang and Mohamed (16) reported that the presence of salt can increase the rate of caramelization in a puffed product when toasted at high temperatures. We were not able to achieve the appropriate color without using sodium in FFCs; therefore, sodium appears to be important for FFC color development.

Texture analysis
The texture of FFCs is affected by the preparation condition, extent of protein cross-linking, and the ingredients. The textural characteristics of several FFCs are shown in Table 2. The hardness increased as the sodium level was reduced and a significant increase in the hardness was observed with increasing replacement of NaCl with KCl in 30% SRFFCs. Lynch et al. (17) also reported that the hardness of bread increased with decreasing salt content. The proteins that comprises fish cake is mainly fibrous myosin of surimi. Myosin is not soluble in pure water but soluble in neutral salt solution; thus the surimi mixture becomes a sticky paste in the presence of salt (18). With heating, such as that applied in frying or steaming, the proteins in the paste react with each other and make a strong network that finally results in a flexible fish cake. The use of less sodium may have weakened this network and thus resulted in increased hardness. In contrast, the adhesiveness of FFC slightly increased as the sodium level was reduced. In the folding test, all FFCs in...
this study showed good flexibility.

**Sensory evaluation**
The impact of different sodium and potassium levels on a wide range of fish cake quality characteristics was assessed. In the 9-point scale evaluation, sensory aspects of color, taste, odor, chewiness, and overall acceptance of SRFFCs were compared with those of full-sodium control fish cakes (Table 3). Although some differences were observed in the mean values for color among the fish cakes, no significant differences \((P>0.05)\) were observed. In the cases of taste and odor, there were no significant differences between the control fish cakes and SRFFCs; however, the values significantly decreased as sodium was substituted with potassium in 30% SRFFC. Chewiness and overall acceptance also significantly decreased as the sodium level decreased and sodium was replaced with potassium in 30% SRFFC. In the present study, sodium was simply removed or substituted by potassium; however, the manufacturing price for preparing FFCs with potassium might be slightly higher than with sodium, and persons with compromised renal function should be careful of potassium intake. Moreover, to increase the preference of consumers for SRFFCs, the use of food additives may be considered.

**ACKNOWLEDGMENTS**

This study is supported by a research grant from Kyungnam University, Korea, in 2013.

**AUTHOR DISCLOSURE STATEMENT**

The authors declare no conflict of interest.

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