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Research Note

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 (*ganjang*), 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.

MATERIALS ANS METHODS

Materials

Fish meat (frozen itoyori surimi) used in this study was purchased from Minh Hai Private Branch (Vung Tau, Vietnam). Wheat flour, sugar, and monosodium glutamate (MSG) were from CJ (Seoul, Korea). D-Xylose (Sinochem Jiangsu Suzhou Imp. & Exp. Co., Jiangsu, China), potassium sorbate (Ningbo Wanglong Technology Co., Ltd., Yuyao, China), glucono-δ-lactone (AnHui XingZhou Medicine Food Co., Anhui, China), NaCl (Hanjusalt Co., Ulsan, Korea), and KCl (Daejung Chemicals & Metals Co., Ltd., Gyeonggi, Korea) were also purchased.

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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 overall formula for the FFCs prepared in the present study is shown in Table 1. The obtained mixture was shaped ($100\times40\times5$ mm^3) and fried in soybean oil at 170°C. The resultant FFCs were cooled down to room temperature and then stored at 4°C until further analysis.

Color analysis

Color analyses on the surface of FFCs were carried out using a colorimeter (Minolta CR-200, Osaka, Japan), and the results were expressed in L (lightness), a (redness), and b (yellowness) Hunter scale parameters (13). The colorimeter was standardized against a white tile before each measurement, where L=98.11, a=−0.33, and b=+2.13. Overall color difference (ΔE) was calculated by the following equation; $\Delta E=[(\Delta L)^2+(\Delta a)^2+(\Delta b)^2]^{1/2}$.

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 FFC was 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

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	25.00	1.00	0.50	0.50	0.20	0.20	11.10	1.50	
10% SRFFC[1)]		60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	1.35	
20% SRFFC[1)]		60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	1.20	
30% SRFFC[1)]	100 : 0	60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	1.05	0.00
	80 : 20	60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	0.84	0.21
	60 : 40	60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	0.63	0.42
	40 : 60	60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	0.42	0.63
	20 : 80	60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	0.21	0.84
	0 : 100	60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	0.00	1.05
40% SRFFC[1)]		60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	0.90	
50% SRFFC[1)]		60.00	25.00	1.00	0.50	0.50	0.20	0.20	11.10	0.75	

[1)]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 values[2)]				Texture analysis			
		L	*a*	*b*	ΔE	Strength (×10^3 Dyne/cm^2)	Hardness (×10^3 Dyne/cm^2)	Adhesiveness (g)	Folding test
0% SRFFC		65.63^{b}	6.09^{a}	37.23^{a}	0	28.27^{b}	30.59^{c}	−1.33^{d}	AA
10% SRFFC[1)]		66.03^{b}	6.16^{a}	37.44^{a}	0.46	28.88^{b}	31.64^{c}	−1.28^{d}	AA
20% SRFFC[1)]		66.57^{b}	6.08^{a}	37.19^{a}	0.94	29.56^{b}	32.83^{c}	−1.17^{cd}	AA
30% SRFFC[1)]	100 : 0	67.62^{b}	6.04^{a}	37.45^{a}	2.00	30.11^{ba}	33.69^{c}	−1.00^{c}	AA
	80 : 20	72.89^{ab}	4.43^{b}	37.24^{a}	7.45	11.22^{c}	25.02^{d}	−0.33^{a}	AA
	60 : 40	72.11^{ab}	4.28^{b}	36.96^{a}	6.73	28.00^{b}	31.84^{c}	−0.63^{b}	AA
	40 : 60	73.12^{ab}	4.58^{b}	37.59^{a}	7.65	28.70^{b}	38.07^{b}	−0.70^{b}	AA
	20 : 80	72.87^{ab}	3.45^{c}	36.81^{a}	7.72	53.22^{a}	57.27^{a}	−1.10^{c}	AA
	0 : 100	75.11^{a}	1.86^{d}	34.59^{a}	10.71	29.28^{b}	40.35^{b}	−0.47^{ab}	AA
40% SRFFC[1)]		71.66^{ab}	4.39^{b}	36.83^{a}	6.28	24.31^{a}	32.50^{c}	−0.50^{ab}	AA
50% SRFFC[1)]		73.39^{ab}	4.49^{b}	37.97^{a}	7.96	30.66^{b}	36.25^{bc}	−0.87^{bc}	AA

[1)]Each number in front of SRFFC means reduced amount (w/w) percent of sodium compared with non-reduced control (0% SRFFC).
[2)]*L*, degree of whiteness; *a*, degree of redness; *b*, degree of yellowness; and ΔE, overall color difference ($\Delta E=[(\Delta L)^2+(\Delta a)^2+(\Delta b)^2]^{1/2}$).
Different letters (a-d) within a column indicate significant difference ($P<0.05$), n=5.

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

SRFFCs	NaCl : KCl (w : w)	Sensory characteristic				
		Color	Taste	Odor	Chewiness	Overall acceptance
0% SRFFC[1)]		5.00^{a}	5.00^{b}	5.00^{b}	5.00^{a}	5.00^{a}
10% SRFFC[1)]		5.12^{a}	5.31^{a}	5.24^{a}	4.83^{ab}	5.05^{a}
20% SRFFC[1)]		5.13^{a}	5.16^{b}	5.17^{ab}	4.79^{ab}	5.08^{a}
30% SRFFC[1)]	100 : 0	5.16^{a}	5.06^{b}	5.26^{a}	4.64^{b}	5.12^{a}
	80 : 20	5.20^{a}	4.53^{c}	5.13^{ab}	4.67^{b}	4.60^{b}
	60 : 40	5.13^{a}	4.67^{c}	4.80^{c}	4.47^{bc}	4.60^{b}
	40 : 60	5.07^{a}	3.80^{d}	4.33^{d}	4.20^{c}	3.73^{e}
	20 : 80	4.73^{a}	3.07^{e}	3.67^{e}	3.60^{d}	3.73^{e}
	0 : 100	4.73^{a}	2.40^{f}	3.47^{e}	3.27^{e}	3.37^{f}
40% SRFFC[1)]		5.13^{a}	4.67^{c}	5.13^{ab}	4.40^{bc}	4.40^{bc}
50% SRFFC[1)]		5.07^{a}	4.13^{cd}	5.00^{b}	3.93^{cd}	4.07^{d}

[1)]Each 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 contents 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 ($3<\Delta E<6$), distinct ($1.5<\Delta E<3$) and light ($1.5<\Delta E$) (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.

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AUTHOR DISCLOSURE STATEMENT

The authors declare no conflict of interest.

REFERENCES

1. KFDA. 2012. *Food code*. Article 1-5-12. Korea Food and Drug Administration, Seoul, Korea.
2. KFDA. 2011. *Statistics of Food and Food Additive Production of 2010*. Korea Food and Drug Administration, Seoul, Korea. p 60.
3. MIFAFF. 2011. *Statistics of Fisheries Processing*. Ministry for Food, Agriculture, Forestry and Fisheries, Seoul, Korea.
4. Yook HS, Lee JW, Lee HJ, Cha BS, Lee SY, Byun MW. 2000. Quality properties of fish paste prepared with refined dietary fiber from ascidian (*Halocynthia reretzi*) tunic. *J Korean Soc Food Sci Nutr* 29: 642-646.
5. Ha JU, Koo SG, Lee HY, Hwang YM, Lee SC. 2001. Physical properties of fish paste containing *Agaricus bisporus*. *Korean J Food Sci Technol* 33: 451-454.
6. Koo SG, Ryu YK, Hwang YM, Ha JU, Lee SC. 2001. Quality properties of fish paste containing enoki mushroom (*Flammulina velutipes*). *J Korean Soc Food Sci Nutr* 30: 288-291.
7. Bae MS, Lee SC. 2007. Quality characteristics of fried fish paste containing anchovy powder. *J Korean Soc Food Sci Nutr* 36: 1188-1192.
8. Dahl LK. 2005. Possible role of salt intake in the development of essential hypertension. *Int J Epidemiol* 34: 967-972.
9. WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of a joint WHO/FAO expert consultation. WHO Technical Report Series 916. World Health Organization, Geneva, Switzerland.
10. Lim HJ. 2001. A study on the calcium and sodium intakes and urinary calcium excretion of preschool children in Busan. *Korean J Nutr* 34: 786-796.
11. Tsugane S. 2005. Salt, salted food intake, and risk of gastric cancer: epidemiologic evidence. *Cancer* Sci 96: 1-6.
12. KFIA. 2012. *Guideline for sodium reduction in 7 processed foods*. Korea Food Industry Association, Seoul, Korea.
13. Mastrocola D, Lerici CR. 1991. Colorimetric measurements of enzymatic and non-enzymatic browning in apple purees. *Ital J Food Sci* 3: 219-229.
14. Park EK, Shin JW, Park KH, Yang ST. 1987. Seasonal variation in gel forming ability of wild common carp and conger eel. *Korean J Food Sci Technol* 19: 1-4.
15. Kang KH, No BS, Seo JH. 1998. *Food analysis*. SungKyunKwan University Academic Press, Seoul, Korea. p 387-394.
16. Jomduang S, Mohamed S. 1994. Effect of amylose/amylopectin content, milling methods, particle size, sugar, salt and oil on the puffed product characteristics of a traditional Thai rice-based snack food (Khao Kriap Waue). *J Sci Food Agric* 65: 85-93.
17. Lynch EJ, Bello FD, Sheehan EM, Cashman KD, Arendt EK. 2009. Fundamental studies on the reduction of salt on dough and bread characteristics. *Food Res Int* 42: 885-891.
18. Jeong GH, Lim JS, Oh MH, Kim JK. 2007. *Food processing*. Moonundang, Seoul, Korea. p 322.