KOREAN J. FOOD SCI. TECHNOL.
Vol. 14, *No.* 4 (1982)

Processing Conditions and Quality Stability of Precooked Frozen Fish Foods during Frozen Storage

I. Processing Conditions and Quality Stability of Mackerel Steak during Frozen Storage

Eung-Ho Lee, Joong-Kyun Jeon, Soon-Yeong Cho, Yong-Jun Cha and Soo-Yeol Jung

Dept. of Food Science and Technology, National Fisheries University of Busan, Busan, 608 Korea

(Received August 2, 1982)

魚肉凍結調理食品의 加工條件 및 品質安全性에 관한 研究

제 1 보 : 고등어 Steak 加工條件 및 凍結貯藏中의 品質安全性

李應昊 · 錢重均 · 趙舜榮 · 車庸準 · 鄭秀烈

釜山水產大學 食品工學科

(1982년 8월 2일 수리)

Abstract

Processing conditions of fish steaks and the effect of soybean protein on quality during frozen storage were investigated. Added to the fish meat were 1.0% of table salt, 0.5% of sodium bicarbonate, 0.2% of polyphosphate, 0.2% of monosodium glutamate, 2.0% of sugar, 0.2% of red pepper powder, 0.2% of white pepper powder, 0.2% of garlic powder and 0.2% of nutmeg. The mixture was minced with stone mortar and then stored at $-3°$ to $-5°C$ for two days prior to frozen storage. The beneficial effects of adding soybean protein(5%) to the fish steaks were the control of color change, free drip, oxidative rancidity and in texture that exhibited the improvement of quality. The quality of frozen mackerel steaks, by sensory evaluation, was not inferior to that of hamburger on the market.

Introduction

Mackerel which is commonly consumed as a fresh fish, salted products or as canned products, has some problems being eaten as fresh fish. So many researchers[1~3] in other countries have devoted their time to the development of new food resources such as frozen minced meat paste, frozen fish block or functional fish protein(FFP).

Lee and Kim[4] and Lee *et al.*[5] reported the processing conditions of fish protein concentrate (FPC) from mackerel. In this study, we investigated the processing conditions of frozen mackerel steaks. In addition, this study was conducted to ascertain the effect of soybean protein on quality stability of frozen fish steaks during frozen storage.

Materials and Methods

Materials

Mackerel, *Scomber japonicus*, was purchased at the fish market in Busan, Korea. The chemical composition of the raw material is given in Table 1.

Table 1. Chemical composition of mackerel

(g/100g)

Moisture	Crude protein	Crude lipid	Ash	CHO	VBN* (mg/100g)	pH
71.3	20.7	5.5	1.7	0.8	14.68	6.07

* Volatile basic nitrogen CHO: Carbohydrate

Processing and storage of frozen fish steaks

Head and viscera of mackerel were removed, filletted and then the fish meat was separated by meat separator. The fish meat was minced with stone mortar while adding 0.5% of sodium bicarbonate, 1% of table salt, 0.2% of polyphosphate(polyphosphate: pyrophosphate=1 : 1) and a quantity of food additives such as monosodium glutmate(MSG), sugar, red pepper powder, white pepper powder, garlic powder and nutmeg. The fish paste was stuffed with saran film(Asahi Dow Co.,Ltd.) and stored at two different temperatures (−3° to −5°C and −20°C) for four days.

During low temperature storage,the quality changes of the fish steaks were investigated for cohesiveness[5], hardness[7] and toughness[6] using an Instron food testing machine(Model 1140) and jelly strength by Okada type jelly strength tester. From this, the proper time, temperature for processing frozen were determined. The fish steaks stored at low temperature were then stored at −35°C.

Processing of frozen fish steaks with soybean protein

To study the effect of soybean protein on quality stability of the product during frozen storage(−35°C), two levels of soybean protein (5% and 10%) were added to the fish meat. Mixtures of the fish meat and additives were minced and the product was manufactured.

Measurements of chemical composition, volatile basic nitrogen(VBN), pH and salinity

Chemical composition was determined by conventional method and VBN was determined by Conway micro-diffusion method[8]. pH was measured by pH meter(Fisher accument pH meter Model 630) and salinity was measured according to the method of Mohr[9].

Color measurement

Lightness("L"), redness("a") and yellowness ("b") values for surfaces and cross-sections of the product were determined using the color difference meter(Nippon Denshoku Kogyo Co., Ltd., Model ND-1001DP).

Changes in free drip, expressible drip and water holding capacity (WHC)

Free drip,expressible drip and WHC were measured according to the method of Tanaka[10]. Frozen fish steaks were weighed immediately to determine the initial weight. Then they were thawed at 5°C in a refrigerator for three hours and reweighed to determine the thaw weight. The thawed products were pressed at 0.5 *kg/cm²* on filter paper (Whatman No. 40, 11 *cm* dia.) between two plexiglass plates using a Carver laboratory press for one minute and weighed to determine the final weight. Free drip is the percentage difference in weight between the initial and thaw weight. Expressible drip is the percentage difference in weight between the thaw and final weight. Approximately 5*g* of the product was pressed at 10 *kg/cm²* for two minutes and determined the content of remained moisture of the pressed product by conventional method. WHC was reported as percentage of moisture content in the product before and after pressing. Data were analyzed by analysis of variance.

Thiobarbituric acid(TBA) analysis

TBA of the product was obtained according to the method of Tarladgis *et al.*[11]. Absorbance was read at 531 *nm* and the optical density was used to represent TBA value.

Texture measurement

Frozen fish steaks were allowed to cook for three minutes before the test. Using an Instron food testing machine, textural properties were evaluated in terms of cohesiveness, hardness and elasticity.[12] Conditions of Instron were: Sample height, 1.5×2 *cm*; % deformation, 25; crosshead speed, 5 *cm*/min; and chart speed, 10 *cm*/min.

Sensory evaluation

The sensory evaluation of the product in compa-

Table 2. Changes in hardness, toughness, cohesiveness and jelly strength of mackerel steak during storage

	Storage time (days)									
	0		1		2		3		4	
	−3°C	−20°C	−3°C	−20°C	−3°C	−20°C	−3°C	−20°C	−3°C	−20°C
Hardness(kg)	13.3	13.3	16.1	15.0	15.8	15.3	15.8	15.2	11.2	9.7
Toughness	—	—	4.2	4.4	4.9	5.2	3.9	3.8	3.7	3.5
Cohesiveness	0.42	—	0.43	—	0.49	—	0.40	—	0.40	—
Jelly strength(g)	372	—	385	—	414	—	365	—	343	—

rison with hamburger on the maket was carried out by 10-panel member. Evaluation was given on a five-point intensity scale for rancidity, texture and over-all acceptance.

Results and Discussion

Changes in rhelogical properties of the fish steaks during low temperature storage

The fish steaks stored −3° and −20°C showed a slight increase in hardness (Table 2). On fourth day, hardness of both samples suddenly decreased, recording a lower value than the original. Hardness of the fish steak at −3°C showed a slightly greater increase than that stored at −20°C.

And thoughness of both samples were only slight changes. Therefore, it was considered that the proper storage temperature of the fish steak was −3°C for processing frozen fish steaks from mackerel.

As shown in Table 2. toughness, cohesiveness and jelly strength of the fish steak stored at −3°C reached maximum value at second days and then showed a tendency to decrease.

On the basis changes in rheological properties, it was considered that the proper condition for processing frozen mackerel steaks was to store at −3°C for two days.

Changes in color

Changes in "L", "a" and "b" values for surfaces and cross-sections of the product during frozen storage are shown in Table 3. In general, "L" and "a" values showed change in the early stage of frozen storage and then changed little thereafter, while "b" value showed modest change during the entire period of frozen storage.

The cross-section was higher in "L", "a" and "b" values than the surface during storage. In "L" value of the cross-section, product without soybean protein (A) became slightly darker as storage time progressed but product B and C containing soybean protein showed a tendency to lighten. This result agreed with Judge *et al.*[13]. All "a" values of cross-section each product decreased during frozen storage, but

Table 3. Changes in "L", "a" and "b" values for surfaces and cross-sections of frozen mackerel steaks during storage at −35°C

Product			Storage time (days)					
			0	20	30	60	75	90
"L"	A	S*	29.9	28.3	27.7	26.7	26.3	26.2
		C**	34.6	30.8	30.1	29.4	29.0	29.8
	B	S	13.0	28.8	29.3	30.7	31.0	30.8
		C	31.6	31.1	30.6	32.0	32.3	32.5
	C	S	14.8	30.5	31.3	32.7	33.6	33.6
		C	31.8	33.3	35.7	34.3	34.3	35.6
"a"	A	S	5.9	4.5	4.3	3.8	4.1	4.0
		C	6.8	4.9	4.2	4.2	4.2	4.1
	B	S	2.0	3.6	3.8	4.3	4.3	4.5
		C	7.0	5.5	5.2	4.8	4.7	4.7
	C	S	1.4	3.9	4.0	4.2	4.5	4.7
		C	7.4	5.3	5.2	5.0	5.0	5.1
"b"	A	S	6.0	5.9	6.0	5.7	6.0	6.2
		C	6.3	5.3	5.1	5.0	5.0	5.2
	B	S	0.3	6.4	7.0	7.0	7.1	7.0
		C	4.9	5.4	6.1	6.6	6.6	6.7
	C	S	0.5	7.3	7.3	7.4	7.2	7.4
		C	6.5	6.5	6.7	7.9	8.4	8.4

* S: Surfaces **C: Cross-sections
A=control, B=5% soybean protein
C=10% soybean protein

all of "b"values increased except product A.

As for the surface "L", "a" and "b" values of product A showed little changes but those of product B and C showed a slight increase. Increasing soybean protein levels were found to affect "L", "a" and "b" values of each product.

Changes in free drip, expressible drip and WHC

Changes in free drip, expressible drip and WHC, when frozen mackerel steaks were thawed, are showen in Fig. 1. Free drip and expressible drip of the product increased gradually, but WHC decreased with frozen storage time. The reduction of WHC and the formation of drips of product A were greater than those of products containing soybean protein.

In fisheries products,free drip appears to be a more serious problem than in other foods of animal origin. Therefore the effect of soybean protein to control

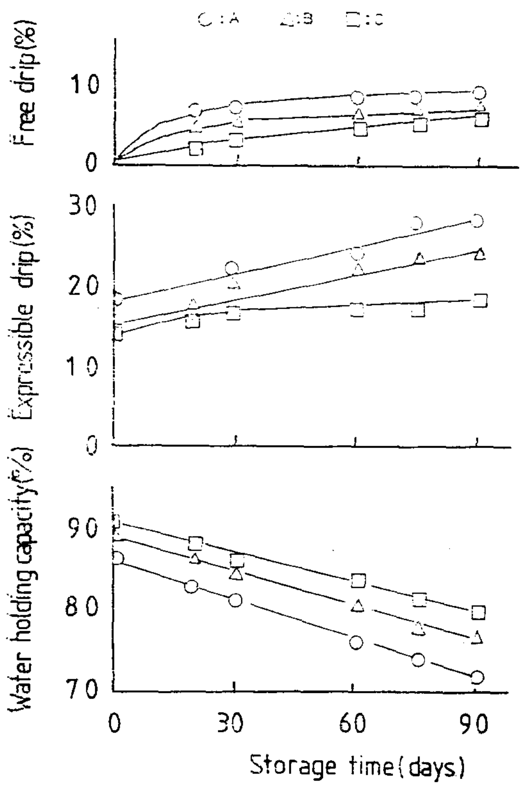

Fig. 1. Changes in free drip, expressible drip and water holding capacity of frozen mackerel steaks during storage at −35°C. A=Control, B=5% soybean protein, C=10% soybean protein

Table 4. Effect of the addition of soybean protein and storage time on free drip of frozen mackerel steaks by analysis of variance

Factor	F-ratio
Addition of soybean protein	30.07*
Storage time	42.42*

* $p<0.01$

Table 5. Test of significant difference in frozen mackerel steaks between every two levels of soybean protein on free drip

	Addition level of soybean protein		
	0%	5%	10%
0%	—		
5%	1.85*	—	
10%	3.17*	1.32*	—

* $p<0.01$

drips was invertigated. The result of analysis of variance for the effect of soybean protein and storage time on free drip is presented in Table 4. A significant effect was found as free drip was related to soybean protein ($p<0.01$) and storage time ($p<0.01$). Also, as shown in the Table 5, a significant effect was found as free drip was related to the soybean protein level ($p<0.01$) and with or without soybean protein($p<0.01$). Namely increasing soybean protein levels were found to affect the control of free drip of the product. Therefore it was considered that 5% of soybean protein level was effective for the control of free drip.

Changes in pH and salinity

As shown in Table 6, pH increased a little during frozen storage. On the other hand, salinity decreased a little. Changes in pH and and salinity of product without soybean protein were greater than those of products containing soybean protein. This was considered due to the lower percentage of the fish meat in the product as soybean protein level increased.

Change in lipids

Change in TBA value, one of the indicators of oxidation, of the product during frozen storage is shown in Fig. 2. Observed values from products containing soybean protein remained unchanged up to

Table 6. Changes in pH and salinity in frozen mackerel steaks during storage at −35°C

Storage time (days)	pH			Salinity(g/100g)		
	A	B	C	A	B	C
0	6.54	6.54	6.50	1.78	1.76	1.64
10	6.56	6.54	6.51	1.39	1.30	1.23
20	6.56	6.53	6.54	1.23	1.21	1.10
30	6.62	6.59	6.57	1.28	1.23	1.13
60	6.64	6.61	6.59	1.45	1.31	1.26
90	6.68	6.63	6.60	1.51	1.40	1.35

A: Control, B: 5% soybean protein,
C: 10% soybean protein

the three month in frozen storage. In contrast, TBA values in product without soybean protein showed almost constantly during the early storage of frozen storage and then increased two time for the remaining period.

Hinosita and Tanikawa[14] reported that TBA value of the surface of mackerel block increased three times when it was stored up to six months at -30°C, but there was no quality deterioration by sensory evaluation in the product.

As shown in Table 7, hardness and cohesiveness of the product showed a modest increase but elasticity remained unchanged as storage time progressed.

Sensory evaluation

The result of sensory evaluation of frozen mackerel steaks with hamburger on the market is presented in Table 8.

Panelists did not perceive the rancidity, the deterioration of texture and over-all acceptance of the product until three months' storage.

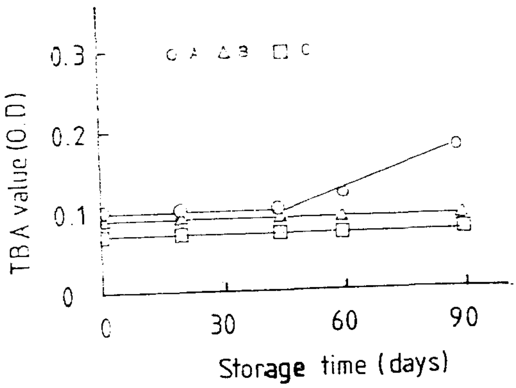

Fig. 2. Changes in thiobarbituric acid (TBA) values of frozen mackerel steaks during at −35°C. A=Control, B= 5% soybean protein, C=10% soybean protein

Table 7. Changes in hardness, cohesiveness and elasticity of frozen mackerel steaks during storage at −35°C

Product		Storage time (days)				
		0	20	30	60	90
Hardness (kg)	A	8.0	9.8	10.6	11.7	12.0
	B	11.9	12.1	12.4	14.2	14.9
	C	13.7	13.9	14.0	16.1	16.6
Cohesiveness	A	0.45	0.47	0.48	0.50	0.52
	B	0.46	0.46	0.46	0.47	0.49
	C	0.48	0.50	0.51	0.52	0.53
Elasticity	A	0.88	0.87	0.85	0.84	0.83
	B	0.87	0.86	0.86	0.84	0.83
	C	0.90	0.89	0.88	0.86	0.86

Table 8. Sensory score of frozen mackerel steaks and hamburger

Storage time (days)	Hamburger on the market			Mackerel steaks								
				No Soybean pretein			5% soybean protein			10% soybean protein		
	R[a]	T[b]	O[c]	R	T	O	R	T	O	R	T	O
0	4.9	4.0	4.5	4.8	3.9	4.1	4.8	4.2	4.4	4.8	4.3	4.4
30				4.2	3.5	3.9	4.5	3.9	4.2	4.4	3.9	4.2
60				4.0	3.4	3.7	4.3	3.8	4.0	4.3	3.8	4.0
90				3.8	3.2	3.4	4.1	3.7	3.8	4.0	3.8	3.9

a) R : Rancidity; 5, none; 1, extreme b) T : Texture; 5, very good; 1, very bad
c) O : Over-all acceptance; 5, very good; 1, very bad

Products containing soybean protein were superior to product without soybean protein in texture and over-all acceptance of the product during the entire period of storage. The quality of frozen mackerel steaks was not inferior to that of hamburger on the market by sensory evaluation.

요 약

고등어를 이용하여 어육냉동 steak을 만들어 이것의 가공조건을 구명하고 또한 대두단백질의 첨가가 제품 품질에 미치는 효과에 대하여 검토하였다. 고등어 냉동 steak를 가공하기 위해서는 어육에 탄산수소나트륨 0.5%, 식염 1.0%, 중합인산염 0.2%, 글루탐산나트륨 0.2%, 설탕 2.0% 및 향신료로서 고추가루 0.2%, 후추가루 0.4%, 마늘가루 0.2%와 nutmeg 0.2%를 첨가하여 고기갈이한 다음 −3°C∼−5°C에서 2일간 저온저장한 후 동결저장하는 것이 가장 좋았다.

또한 대두단백질을 5% 첨가하므로서 제품의 동결저장중 색조변화, 유리드립생성, 지방산패억제 및 텍스튜어의 개선효과가 있었으며 관능검사 결과로서도 고등어냉동 steak는 동결저장 90일동안 품질이 안정하게 유지되었다.

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