KOREAN J. FOOD SCI. TECHNOL.
Vol. 14, *No.* 1 (1982)

Processing Conditions and Quality Stability during Storage of Meaty Textured Fish Protein Concentrate

I. Processing Conditions of Meaty Textured Fish Protein Concentrate from Filefish and Sandfish

Eung-Ho Lee, Duck-Jae Cho*, Se-Kwon Kim and Bong-Ho Han
Department of Food Science and Technology, National Fisheries University of Busan, Busan 608
**Department of Food Industry, Kyung Nam Junior College of Technology*
(Received November 27, 1981)

축육과 유사한 텍스쳐를 가진 어육단백질 농축물의 가공조건 및 저장중의 품질변화

제 1 보 : 가공조건

이 응호 · 조 덕제* · 김 세권 · 한 봉호
부산수산대학 식품공학과, *경남공업전문대학 식품공업과
(1981년 11월 27일 수리)

Abstract

An investigation on optimum processing conditions for meaty textured fish protein concentrate (MT-FPC) was carried out with the fish meat of filefish, *Navodon modestus*, and sandfish, *Arctoscopus japonicus*. The processing conditions were determined by the lipid content and the rehydration capacity of MT-FPC. The optimum pH and sodium chloride content of fish meat were 8.0 and 1.0%, respectively. The most effective soaking conditions were: soaking time in chilled ethanol was 15 min for both filefish and sandfish; amount of chilled ethanol, 3 volumes and 4 volumes for filefish and sandfish, respectively; temperature of chilled ethanol, 25°C for both filefish and sandfish; soaking time in boiling ethanol, 15 and 25 min for filefish and sandfish, respectively; amount of boiling ethanol, 2 and 4 volumes for filefish and sandfish, respectively; and number of soaking in boiling ethanol, 2 and 4 times for filefish and sandfish, respectively. Yields of the product to the minced meat weight, the contents of protein and lipid in MT-FPC prepared from filefish were 13.7%, 84.5% and 0.2%, and those from sandfish were 12.5%, 84.2% and 1.1%, respectively.

Introduction

Fish protein concentrate (FPC) developed since 1950's is an excellent source of protein for man and animal, but its potential as a food additive is limited because of poor functional properties[1]. Therefore, the study concerning improvement of FPC has been

briskly advancing recently.

Tannenbaum *et al.*[2] studied on the solubilization of FPC using an alkaline process, Spinelli *et al.*[3], Groninger and Miller[4] and Miller and Groninger[5] studied on the acylation of fish meat protein. Bhumiratana *et al.*[6] reported that insoluble FPC was solubilized by the proteolytic enzyme, trypsin, in batch.

A new type FPC from Alaska pollack was developed by Suzuki *et al.*[7], which can be used as a new food material for the substitute of livestock meat, and Okazaki *et al.*[8] developed washing conditions in water and alcohol treatment in processing of these products.

A few researchers in Korea have studied on processing and utilization of FPC. Lee *et al.*[9] studied on processing and utilization of sardine protein concentrate, and Lee and Kim[10] studied on processing conditions and quality of meaty textured fish protein concentrate (MT FPC) from Alaska pollack and mackerel.

To utilize the fish effectively as protein resoures in coast of Korea, we carried out an investigation on the optimum processing conditions of MT-FPC from filefish and sandfish. The optimum processing conditions were determined with pH of the fish meat, concentration of sodium chloride, soaking time in chilled and boiling ethanol, amount of chilled and boiling ethanol, temperature of chilled ethanol, and repeat of soaking in boiling ethanol.

Materials and Methods

Materials

Filefish, *Navodon modestus*, and sandfish, *Arctoscopus japonicus*, were purchased at cooperative fish market in Busan, Korea, and stored at −25°C until used.

Processing methods of MT-FPC

Head of filefish and sandfish were removed and the fishes were filleted, and then the fish meat was separated by a meat separator. The fish meat was washed with 0.5% sodium bicarbonate solution, corresponding to 5 volumes of the weight of the fish meat, and washed 4 times with tap water. After washing, fish meat was dehydrated with centrifugal dehydrater, and minced with chopper. The minced fish meat was adjusted to various pH with sodium bicarbonate or citric acid, and kneaded with 1% sodium chloride for a few minutes. The fish meat paste was extruded into 95% ethanol through plate having hole of 2.5 *mm* diameter, and the temperature of ethanol was controlled at 5°C. The ethanol treatment changes muscle fiber structure and gives it a beef meat type texture. After soaking for 15 min in chilled ethanol of 3 volumes of the weight of fish meat, the alcohol was removed with filtration.

The noodle shaped coagulated fish meat pastes were cut in the length of about 2 to 4 *mm* with knife, and then soaked 2 times in boiling ethanol of 2 volumes for 15 min under continuous agitation. The remaining ethanol in the product was removed at 60°C for 30 min.

Determination of chemical composition

The contents of moisture, crude protein, ash, lipid and carbohydrate were determined by conventional method[11]. Volatile basic nitrogen was determined by Conway micro-diffusion method[12].

Amino acid of raw materials and MT-FPC

An accurately weighed 50 *mg* samples in ampoule were hydrolyzed with 2 *ml* of 6N HCl at 110±1°C for 22 hs in sand bath. The hydrolyzate was filtered through a glass filter, and then evaporated to dryness under reduced pressure in a rotary evaporator. The residue was measured up to 25 *ml* with citrate buffer solution (pH 2.2). The solution was ampouled and stored in refrigerator until analyzed. The amino acid compositions of raw materials and MT-FPC were determined by using an amino acid autoanalyzer.

Determination of rehydration capacity

Three grams of products were soaked in distilled water corresponding to 10 volumes of the weight of the product for one hour at 10°C, and then centrifuged at 2500 rpm for 5 min, and the weight of sediment was measured. The rehydration capacity was determined with following relation:

$$\text{Rehydration capacity} = \frac{kg\ H_2O\ \text{rehydrated}}{kg\ \text{dry product}}$$

Results and Discussion

Chemical composition of raw samples

Table 1. Chemical composition of raw fish

(Unit : %)

	Filefish	Sandfish
Moisture	81.1	79.5
Protein	16.0	12.8
Lipid	0.5	6.4
Ash	1.7	1.3
Carbohydrate	0.4	0.2
VBN*(*mg%*)	18.4	19.6
pH	6.7	7.1

*Volatile basic nitrogen

The contents of chemical composition of raw samples were as shown in Table 1. Lipid contents of sandfish and filefish were 6.4% and 0.5%, respectively. On the other hand, protein content of filefish was somewhat higher than that of sandfish.

Optimum conditions for processing of MT-FPC

1. Effect of pH

Minced meat of filefish and sandfish was adjusted to pH 6.0, 6.5, 7.0, 7.5, 8.0 and 8.5, respectively. The next processing conditions were the same as those mentioned above.

The effect of pH on the rehydration capacity of MT-FPC, which was dried in a hot air drier, is shown in Fig. 1. Rehydration capacity of the product of filefish and sandfish increased with increasing pH, however, it did not change at pH above 8.0. Organoleptic test showed that the taste of products at pH above 8.5 was not so good. Since dehydration of the product was occurred well at pH 8.0 and no alkaline taste was detected, it was considered that the optimum pH of fish meat for the processing of MT-FPC was 8.0.

In the case of preparation of MT-FPC with Alaska pollack, Suzuki *et al.*[8] reported that rehydration capacity of product increased with increasing pH, but dehydration of product was not occurred well at pH above 8.0 and alkali taste could be felt, therefore, the optimum pH was fixed at pH in range of 7.4 to 7.8. Also Suzuki *et al.*[13] reported that hydrophilicity of product was good in alkali.

2. Effect of sodium chloride concentration

Minced meat was adjusted to pH 8.0. and then only concentration of sodium chloride was changed. The next procedure for the model product was the same as that mentioned above. The effect of sodium chloride on the rehydration capacity of MT-FPC is shown in Fig. 2. The rehydration capacity of the product without sodium chloride was very low. The rehydration capacity of the product showed maximum value at 1% sodium chloride, but little change was observed at sodium chloride concentration above 1% and could be neglected. Subjective evaluation for brittleness indicated that the product was fragile when no sodium chloride was added. Therefore, it was considered that 1% sodium chloride was suitable to make the product with good rehydration capacity.

Suzuki *et al.*[7] reported that in the case of using 1 to 2% sodium chloride in processing of MT-FPC with Alaska pollack, the hardness of the product was similar to that of livestock meat. Lee and Kim[10] reported that 1% sodium chloride was suitable to produce MT-FPC with Alaska pollack and mackerel.

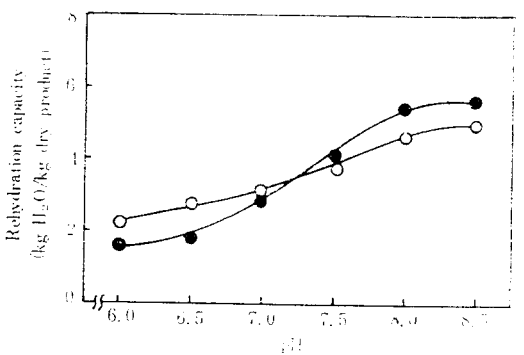

Fig. 1. Effect of pH on the rehydration capacity of meaty textured fish protein concentrate

—○—, filefish; —●—, sandfish

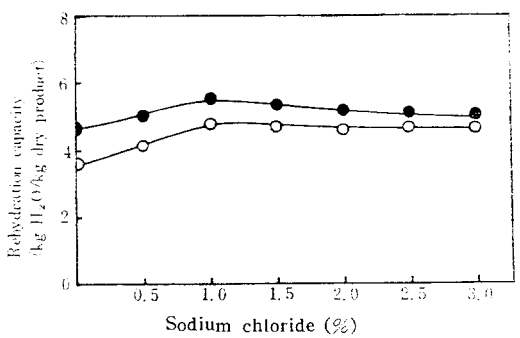

Fig. 2. Effect of the concentration of sodium chloride on the rehydration capacity of meaty textured fish protein concentrate

—○—, filefish; —●—, sandfish

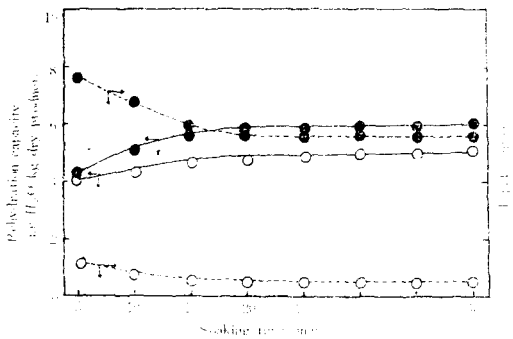

Fig. 3. Effect of soaking time in 95% ethyl alcohol on the rehydration capacity and lipid content of meaty textured fish protein concentrate
—○—, filefish; —●—, sandfish

Under the same condition, the rehydration capacity of the MT-FPC prepared from sandfish was higher than that of filefish.

3. Effect of soaking time in chilled ethanol

Minced meat was adjusted to pH 8.0, kneaded with 1% sodium chloride, extruded into ethanol and varied only soaking time in chilled ethanol. The effect of soaking time on rehydration capacity and lipid content of MT-FPC is shown in Fig. 3. The rehydration capacity of products from filefish and sandfish gradually increased as soaking time in chilled ethanol increased, but lipid content decreased. However, the rehydration capacity and lipid content at soaking time of 15 min and longer did not change. Therefore, it seemed that 15 min were reasonable for the chilled ethanol soaking time.

In processing of MT-FPC, Suzuki *et al.*[7] reported that 15 min were needed for the extraction of lipid in the case of Alaska pollack. According to the investigation of Lee and Kim[10], 40 min were adequate in the case of Alaska pollack and mack erel. Okazaki *et al.*[8] also reported that 15 min were suited in the case of sardine.

4. Effect of the amount of chilled ethanol for soaking

Minced meat was adjusted to pH 8.0, and varied only the amount of chilled ethanol. The effect of the amount of chilled ethanol on rehydration capacity and lipid content of MT-FPC is shown in Fig. 4. The rehydration capacity of the product increased with increasing the amount of chilled ethanol, but lipid

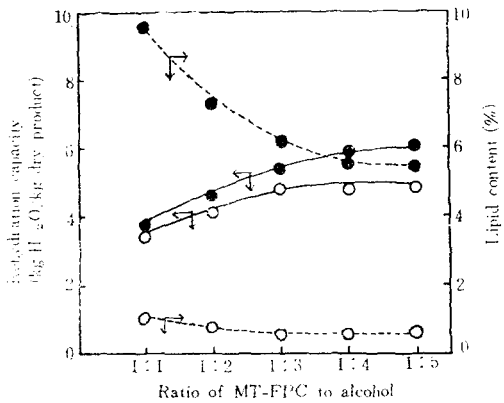

Fig. 4. Effect of the amount of 95% ethyl alcohol on the rehydration capacity and lipid content of meaty textured fish protein concentrate
—○—, filefish; —●—, sandfish

content decreased. However, when the amount of ethanol increased more than 3 volumes for filefish and 4 volumes for sandfish, the changes of rehydration capacity and lipid content of the product were not significant. Therefore, it appeared that the adequate amount of ethanol was 3 and 4 volumes for filefish and sandfish, respectively.

Suzuki *et al.*[7] reported that 3 volumes of ethanol were effective for processing of MT-FPC from Alaska pollack, while Lee and Kim[10] concluded that 4 volumes were adequate in the case of Alaska pollack and mackerel. Okazaki *et al.*[8] reported that 3 volumes of ethanol were needed to extract the lipid in sardine, while Lee *et al.*[9] reported that 10 volumes were reasonable for the processing FPC from sardine.

5. Effect of temperature of ethanol for soaking

The changes of rehydration capacity and lipid content of the product at various temperatures of ethanol are shown in Fig. 5. Minced meat was adjusted to pH 8.0 with sodium bicarbonate, and then the minced meat was kneaded with 1% sodium chloride and extruded into ethanol at various temperatures. The amount of ethanol was fixed at 3 and 4 volumes for filefish and sandfish, respectively.

As shown in Fig. 5, the rehydration capacity and lipid content of the product showed no significant changes with increasing temperature of ethanol. The temperature of ethanol was, therefore, adequate at

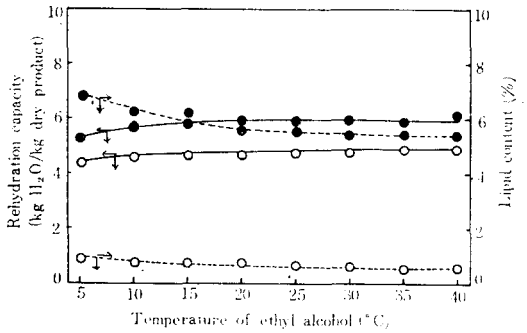

Fig. 5. Effect of the temperature of 95% ethyl alcohol for soaking on the rehydration capacity and lipid content of meaty textured fish protein concentrate
—○—, filefish; —●—, sandfish

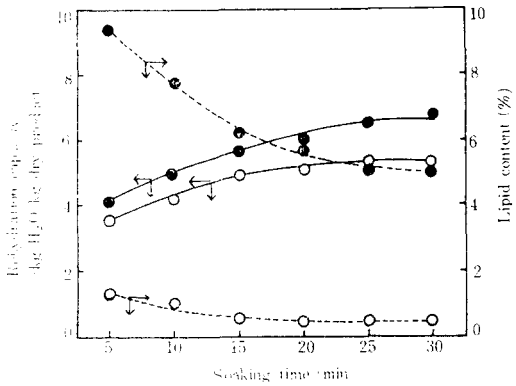

Fig. 6. Effect of soaking time in 95% boiling ethyl alcohol on the rehydration capacity and lipid content of meaty textured fish protein concentrate
—○—, filefish; —●—, sandfish

room temperature for processing MT-FPC from filefish and sandfish.

Suzuki *et al.*[7] reported that the temperature of ethanol was adequate at 5 to 10°C for processing of MT-FPC from Alaska pollack, but according to the reporting of Okazaki *et al.*[8], the ethanol temperature was suited at 25 to 30°C in the case of sardine. Lee and Kim[10] also reported that the temperature of ethanol was adequate at 25 to 30°C for producing of MT-FPC from Alaska pollack and mackerel.

The rehydration capacity of MT-FPC prepared from sandfish was higher than that of filefish under the same temperature conditions.

6. Effect of soaking time in boiling ethanol

The changes of rehydration capacity and lipid content of the product prepared at various soaking times in boiling ethanol are shown in Fig. 6. The rehydration capacity of the product prepared from filefish and sandfish increased with increasing of soaking time in boiling ethanol, while lipid content of the product decreased. However, as the rehydration capacity and lipid content above 15 min for filefish and 25 min for sandfish showed no significant changes.

It was, therefore, assumed that the soaking time in boiling ethanol was adequate for 15 and 25 min for filefish and sandfish, respectively. In case of lipid extraction with hot ethanol, Lee *et al.*[9] reported that 5 min were reasonable for the preparation of FPC from sardine by using 94% ethanol at 80°C. Okazaki *et al.*[8] also reported that the soaking time in ethanol of 80 to 85°C was needed 15 min for the extraction of lipid in processing MT-FPC from sardine.

7. Effect of the amount of boiling ethanol for soaking

As shown in Fig. 7, the rehydration capacity increased with increasing the amount of boiling ethanol until 2 and 4 volumes for filefish and sandfish, respectively. But in more volumes than that, the rehydration capacity and lipid content showed no significant changes. Therefore, it was considered that the amount of boiling ethanol for soaking was

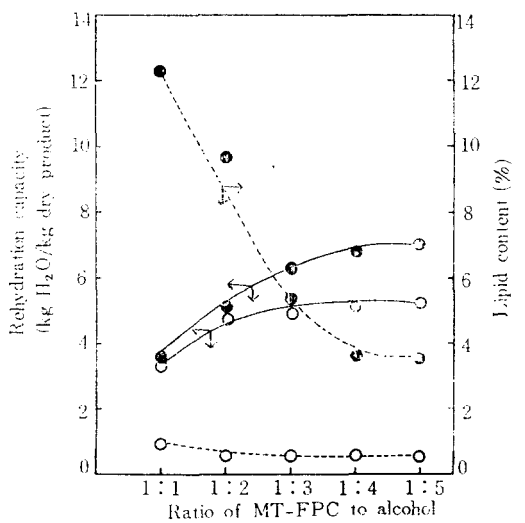

Fig. 7. Effect of the amount of 95% boiling ethyl alcohol on the rehydration capacity and lipid content of meaty textured fish protein concentrate
—○—, filefish; —●—, sandfish

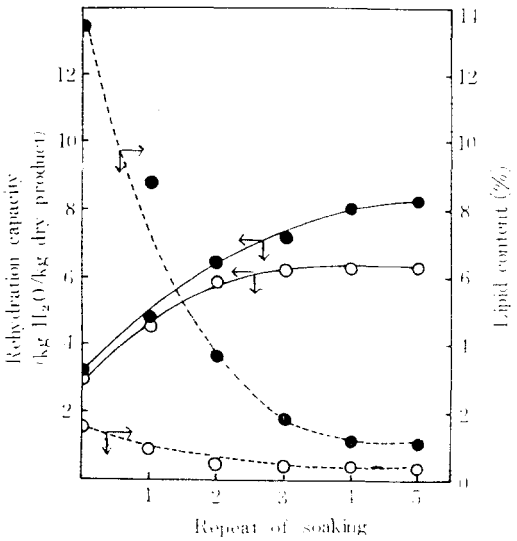

Fig. 8. Effect of repeats of soaking in 95% boiling ethyl alcohol on the rehydration capacity and lipid content of meaty textured fish protein concentrate
--○—, filefish; —●—, sandfish

2 and 4 volumes for filefish and sandfish, repectively. Okazaki *et al.*[8] reported that the amount of boiling ethanol was adequate 3 volumes for processing of MT-FPC from sandfish.

8. Effect of repeat of soaking in boiling ethanol

As shown in Fig. 8, the rehydration capacity increased and lipid content decreased with increasing repeat of soaking in boiling ethanol until 2 and 4 times for filefish and sandfish, respectively. But no significant changes were showed in more soaking repeat than that. Therefore, it was assumed that the repeat of soaking in boiling ethanol was adequate 2 and 4 times for filefish and sandfish, respectively.

Table 2. Chemical composition and yield of meaty textured fish protein concentrate (Unit : %)

	Filefish	Sandfish
Yield	13.7	12.5
Moisture	9.7	9.5
Protein	84.5	84.2
Lipid	0.2	1.1
Ash	4.4	4.3
Carbohydrate	1.0	0.8

Table 3. Amino acid composition of raw materials and meaty textured fish protein concentrate

(Unit : *g*/16*g* N, dry basis)

Amino acid	Filefish		Sandfish	
	Raw	MT-FPC	Raw	MT-FPC
Essential (A)				
Lysine	12.7	11.1	9.9	9.2
Threonine	5.7	5.6	5.2	5.1
Valine	4.2	3.3	3.5	3.3
Methionine	2.1	1.9	2.8	2.3
Isoleucine	5.0	5.3	4.0	4.3
Leucine	9.4	10.4	9.0	9.2
Phenylalanine	3.1	3.1	3.8	3.6
Histidine	2.5	2.1	1.6	1.5
Nonessential				
Arginine	5.5	5.2	4.4	4.4
Aspartic acid	12.3	12.5	13.0	12.9
Serine	4.8	5.0	5.0	5.4
Glutamic acid	18.0	18.2	20.6	20.7
Proline	2.6	3.3	4.0	3.9
Glycine	3.7	3.5	3.9	3.8
Alanine	4.5	4.6	4.6	4.9
Tyrosine	2.7	3.0	3.1	3.2
Total amino acid (B)	98.8	98.1	98.4	97.7
A/B(%)	45.2	43.6	40.4	39.4

Table 4. Comparison of essential amino acid contents of meaty textured fish protein concentrate to those of textured soybean protein(TSP), beef and FAO standard

(Unit : *g*/16*g* N)

Amino acid	MT-FPC		TSP [14]	Beef [14]	FAO Standard [14]
	Filefish	Sandfish			
Isoleucine	5.3	4.3	5.2	4.8	4.2
Leucine	10.4	9.2	7.5	8.1	6.8
Lysine	11.1	9.2	5.9	8.9	4.2
Phenylalanine	3.1	3.6	4.7	4.1	2.8
Methionine	1.9	2.3	1.1	2.7	2.2
Threonine	5.6	5.1	3.8	4.6	2.8
Valine	3.3	3.3	5.7	5.0	4.2
Tryptophane	n.d	n.d	1.4	1.2	1.4
Total	40.7	37.0	35.3	39.4	28.6

Okazaki *et al.*[8] reported that the repeat of soaking in boiling ethanol was adequate 2 times for processing of MT-FPC from sardine.

Chemical composition and yield of the product

Chemical composition and yield of MT-FPC of filefish and sandfish are shown in Table 2. The protein contents of of the product filefish and sandfish were 84.5% and 84.2%, respectively. Lipid content of the product from filefish was lower than that from sandfish, amounting to 0.2 and 1.1%, respectively.

The yield of the product of filefish and sandfish to the minced meat weight was 13.7 and 12.5%, respectively. The color of the product of filefish and sandfish was whitish and brownish, repectively.

Amino acid composition of the raw materials and the product

Amino acid composition of the raw materials and MT-FPC are shown in Table 3, and comparison of the essential amino acid of the product with those of textured soybean protein, beef and FAO standard are shown in Table 4. As shown in Table 3, the content of total amino acid of raw materials and the product showed no significant difference. Therefore, it seemed that the loss of amino acid on the processing is little, and the content of essential amino acid was approximately 40% to the contents of total amino acid. As shown in Table 4, the contents of total essential amino acid of both the MT-FPC were also slightly higher than that of textured soybean protein and FAO standard.

요 약

말쥐치(*Novodon modestus*) 및 도루묵(*Arctoscopus japonicus*)을 원료로써 축육과 유사한 어육단백질농축물을 가공하기 위한 최적조건을 검토하였다.

말쥐치를 원료로 하였을 때, 고기풀의 pH 8.0, 식염첨가량 1%, 고기풀에 대하여 3배량의 25°C 에탄올에 15분간 침지처리한 다음 다시 2배량의 비등 에탄올에 15분간 2회 침지처리하는 것이 좋았다.

도루묵의 경우는 pH 및 식염첨가량은 말쥐치와 같고 4배량의 25°C 에탄올에 15분간 침지처리하고, 다시 4배량의 비등 에탄올에 25분간 4회 침지처리하는 것이 좋았다.

이와같은 최적조건하에서 만든 말쥐치 및 도루묵의 축육과 비슷한 조직단백질 농축물 제품의 수분은 각각 9.7%, 9.5%, 단백질은 각각 84.5%, 84.2%, 지질은 각각 0.2%, 1.1%였으며, 수율은 각각 13.7%, 12.5%였다. 그리고 제품 중의 필수아미노산함량은 쇠고기 및 대두단백질과 비교하였을 때 큰 손색이 없었다.

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