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Studies on Processing and Utilization of Antarctic Krill (I)

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目　錄

Studies on the Proteases of Antarctic Krill *Euphausia superba*–Activities and Stability

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SUMMARY

Crude extract and purified krill proteases, tentatively called proteases A_1, A_2, B, C and D were used for this study. A_2, B, C and D belong to trypsin-like enzymes, while the substrate specificity of A_1 has not been fully characterized. The specific activity of the crude extract was an order of magnitude higher than samples from other sources. The purified proteases except for protease D, had lower proteolytic activity than the mammalian enzymes. The proteolytic activity decreased in the following order: D>C>A_1>B>A_2. Protease D had proteolytic activity in the same order of magnitude as those of bovine trypsin and chymotrypsin. On the other hand the esterase actvities of C and D were in the same order of magnitude as that of bovine trypsin, whereas A_2 and B had much lower esterase activities.

Optimal pH of the crude extract was 8 and optimal temperature around 50°C. The crude extract was labile at higher temperatures. The activity decreased remarkably when incubated at temperatures above 40° C for 10 min. However, it was stable if stored frozen, lyophilized or in saturated ammonium sulfate. Studies on stability of krill proteases revealed that the crude extract should be stored at -20° to -30° C, whereas proteases in either saturated ammonium sulfate solution or lyophilized form could be stored at 5°C. The latter also could be stored at 20° C with only minor loss of activity.

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INTRODUCTION

An increasing demands of the growing population in the world for improved diet would eventually result in a shortage of foods, more specifically proteins. Therefore, providing human being with high-quality protein foods is one of the main problems of today. According to estimations made by different investigators, the total resources of Antarctic krill in the South Ocean amounts to an astronomical figure of 0.6 to 2 billion tons. In addition, it has been reported that the biomass of the Antarctic krill is as high as 10 to 15 kg/m^3. High abundance and formation of massive concentrations point to strong possibilities of the commercial utilization of krill resources. The potential annual catch estimated by FAO is 50 to 70 million tons[1]. In view of such abundant krill resources and its strong possibility of serving as protein source for human consumption, our government had sent Hai-Kung Research Vessel to the Antarctic Ocean for exploration of resources in that area in December 1975 and brought back 136 tons of krill. The event, a milestone in the history of Chinese fisheries, thus initiated the active participation of Chinese in the exploitation of Antarctic resources.

In utilization of krill as a new source of portein food one faces the problem of rapid spoiling of krill resulting from blackening and autolysis presumably caused by tyrosinase and proteases, respectively[2,3]. It was reproted that within two hours on deck krill turned pale in color, lost transparency and became soft and fabby, with the cephalothorax turning dark. Judging from the unusual rapid autolysis of krill, it is suggested that krill may contain some highly active proteases. Studies on the krill proteases could provide useful information for preservation of fresh krill on the one hand and might make the enzyme practically applicable to food processing or medical field on the other hand. In this paper we present the proteolytic and esterase activities of purified proteases from krill as compared with that of some commercially available proteases. Stabilities of the crude proteases of krill under different storage conditions are also described.

MATERIALS and METHODS

Materials

Trypsin, chymotrypsin, papain, casein, hemoglobin, bovine serum albumin, benzoyl-L-arginine ethyl ester (BAEE) and p-toluenesulfonyl-L-arginine methyl ester (TAME) were purchased from Sigma Chemical Company. All other chemicals were reagent grade.

Antarctic Krill

Freshly frozen krill, *Euphausia superba*, which were captured in January 1976 at the Antarctic Ocean and stored frozen at-40°C was provided by Taiwan Fisheries Research Institute and stored at-30°C until use.

Extraction of Proteases

Preliminary experiment showed that 0.1M phosphate buffer, pH 7.0, was superior to other three extraction media tested for extraction of proteases from krill. Therefore phosphate buffer was employed. One hundred gram of frozen krill were suspended in 200 ml of 0.1M potassium phosphate buffer, pH 7.0 and homogenized in a Waring blendor. The insoluble material was removed by centrifugation at 7500×g for 20 min. The supernatant was dialyzed against the same buffer. All steps were performed at 5°C.

Assay of Proteolytic Activities

1. Casein as substrate: Caseinolytic activity was measured according to Kunitz method[4]. One unit of enzyme activity was defined as the amount of protease caused an increase in absorbance at 280 nm of 1.00 in 10 min. Specific activity was expressed as unit per mg protein.

2. Hemoglobin as substrate: The method described by Anson was used[5]. The denatured hemoglobin was digested for 10 min at 37°C, the reaction was stopped by the addition of 5% trichloroacetic acid, and the nondigested hemoglobin was removed by filtration. The amount of split products remaining in solution was determined spectrophotometrically at 280 nm. Definition of

units and specific activity was the same as that for caseinolytic assay.

3. Bovine serum albumin as substrate: Denatured bovine serum albumin was used as substrate. 1 g of bovine serum albumin was dissolved in 100 ml of 0.1M potassium phosphate buffer, pH 8.0 and heated in a boiling water bath for 15 min. The assay procedure was essentially the same as that of hemoglobinolytic assay.

Assay of Trypsin Esterase Activities.

1. BAEE as substrate[6]: 2.8 ml of 1 mM BAEE in 50 mM Tris-HCl, pH 8.0 containing 0.02 M $CaCl_2$ was measured into a cuvette. 0.2 ml of properly diluted enzyme solution was added at zero time and mixed immediately. Absorbance at 253 nm was taken at 30-second intervals. One unit of BAEE activity was defined as the amount of trypsin resulted in an absorbance increase of 1.00 per 10 min. Specific activity was expressed as unit per mg protein.

2. TAME as substrate[7]: 2.6 ml of 46 mM Tris-HCl, pH 8.1 containing 11.5 mM $CaCl_2$ was measured into a cuvette followed by 0.3 ml of 10 mM TAME. 0.1 ml of properly diluted enzyme solution was added at zero time and mixed immediately. Absorbance at 247 nm was taken at 30-second intervals. One unit of TAME activity was defined as the amount of trypsin resulted in an absorbance increase of 1.00 per 10 min. Specific activity was expressed as unit per mg protein.

Protein Determination

Protein was determined by the Lowry method[8] using bovine serum albumin as a standard.

RESULTS and DISCUSSION

Specific Activity of the Crude Extract of Krill

A comparison of the specific activity of the crude extract of krill with that of some aquatic organisms is shown in Table 1. The specific activity of the crude extract of krill was one order of magnitude higher than that of the

Table I. Protease Activities in Some Aquatic Organisms

Speceis	*Euphausia superba* (krill)	*penacus japonicus* (tiger shrimp)	*Macrobrachium rosenbergii* (giant freshwater prawn)		*Cyprinus carpio* (LINNE) (carp)
	whole krill	muscle	cephaloth-orax	abdomen	muscle
Specific activity (Δ 280nm/10min /mg protein)	3.83×10^{-1}	1.73×10^{-2}*	3.09×10^{-2}	4.20×10^{-3}	3.93×10^{-2}**

* Iwata, K., et al. Bull. Jap. Soc. Sci. Fisheries. 40, 201-209 (1974)

** Iwata, K., et al. Bull. Jap. Soc. Sci. Fisheries. 38, 1325-1337 (1973)

three samples from other sources.

Optimal pH and Temperature of the Crude Extract

The pH optimum was 8 as shown in Fig. 1. However the hemoglobinolytic activity distributed over a wide range of pH with a shoulder around pH 5.5-

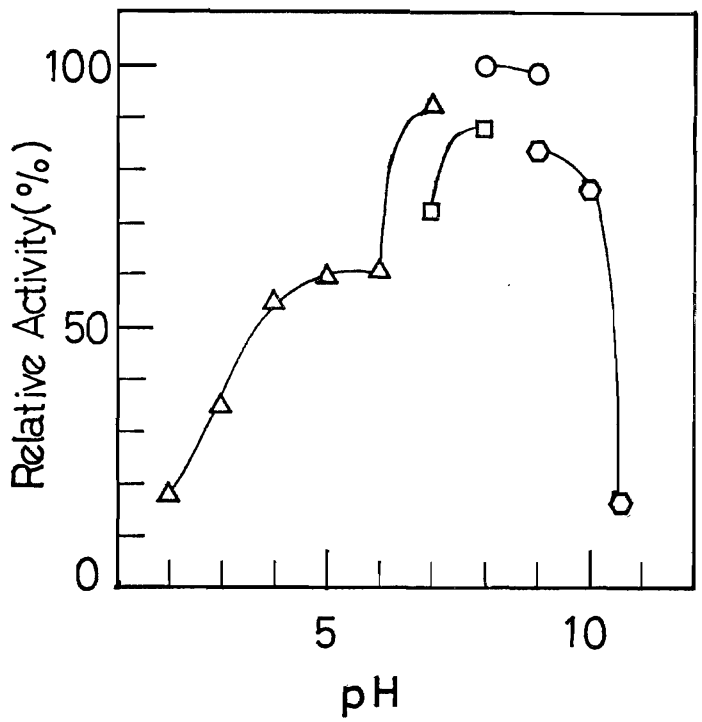

Fig. 1. pH-Activity Profile of the Crude Extract of Krill
—△— Citrate-phosphate buffer, —□— phosphate buffer,
—○— Tris-HCl buffer, —⬡— glycine-NaOH buffer.

6.0. The result seemed to indicate that the crude extract contained both acidic, neutral and alkaline proteases. The data presented in Fig. 2 indicated that the optimal temperature was about 50°C. It is worth noting that the crude extract showed 5% of its maximal caseinolytic activity at 0-5°C. This might account for the rapid autolysis occurred in thawing the frozen krill.

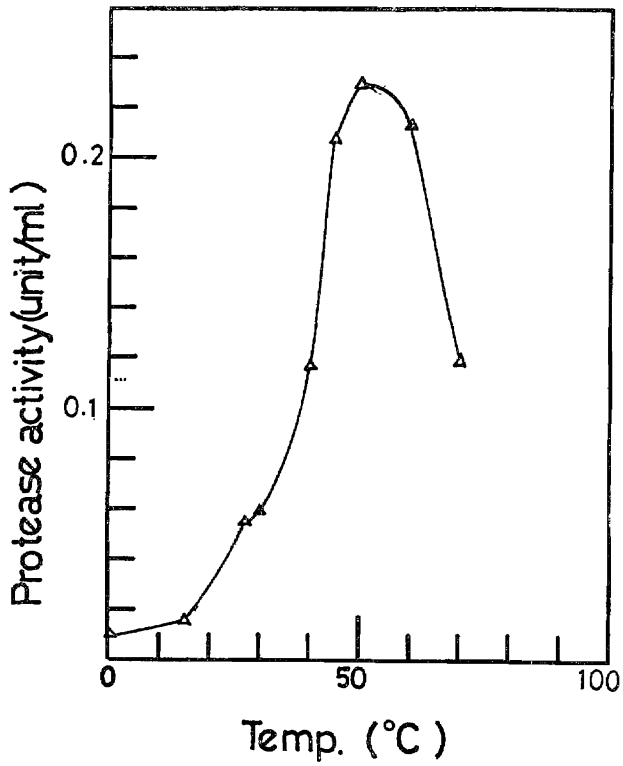

Fig. 2. Temperature-Activity Profile of the Crude Extract of Krill

Proteolytic Activity of Purified Krill Proteases

The proteolytic activity of the crude extract of krill was separated into five proteolytic enzymes, called proteases A_1, A_2, B, C, and D. A_1, B, C, and D were purified to homogeneity, although A_2 was only partially purified. A_2, B, C and D were identified as trypsin-like enzymes, while A_1 has not been fully characterized[9]. The five purified proteases were examined for their specific activity toward three natural protein substrates—casein, hemoglobin and bovine serum albumin. The proteolytic activity of four commercially available proteases which are commonly used in food manufacture and medical field were also determined for comparison. The results shown in Table II

Table Ⅱ. Comparison of the Activities of Purified Krill Proteaes with Four Selected Proteases

Substrate	Specific Activity (unit/mg protein)								
	Krill proteases					Bovine trypsin	Bovine chymo-trypsin	Hog pepsin	Papain
	A_1	A_2	B	C	D				
Casein	2.56	0.84	2.00	4.08	9.18	11.85	16.89	—	2.24
Hemoglobin	10.36	—	5.40	—	13.03	45.61	20.53	54.34	1.50
Bovine serum albumin	3.70	—	—	—	6.32	3.31	1.87	11.99	1.86

indicated that all of the purified krill proteases except for protease D had lower proteolytic activity than the mammalian enzymes. Protease D had activity in the same order of magnitude as those of bovine trypsin and chymotrypsin. The caseinolytic activity of the purified krill proteases decreased in the following order: $D>C>A_1>B>A_2$.

Esterase Activities of Purified Krill Proteases

Since krill proteases A_2, B, C and D were identified as trypsin-like enzymes, their activity toward trypsin specific substrates, BAEE and TAME, were compared with that of bovine trypsin. The results are shown in Table III. The esterase activities of C and D were in the same order of magnitude as that of bovine trypsin, whereas proteases A_2 and B had much lower esterase

Table Ⅲ. Esterase Activities of Purified Krill Protease and Bovine Trypsin

Substrate	Specific Activity (unit/mg protein)				
	Krill Proteases				Bovine
	A_2	B	C	D	Trypsin
BAEE	4.35	2.34	182.2	137.7	63.1
TAME	8.70	7.25	132.7	173.5	340

activities. The lower esterase activity of A_2 cannot be simply explained by the presence of impurity. A_2 and B also had lower proteolytic activities as shown in Table II. Further work is needed to be done in order to clarify this point.

Even the purified krill proteases showed lower proteolytic activity than the four commercial proteases, it is worth considering the practical applications of the krill proteases in food processing and medical field because krill extract showed high specific activity and the resources of Antarctic krill are tremendously abundant.

Stability of the Crude Proteases of Krill

1. In liquid form: The crude proteases were labile at higher temperatures. The activity decreased remarkably when incubated at temperature above 40°C for 10 min as shown in Fig. 3. Fig. 4 shows the caseinolytic activities of

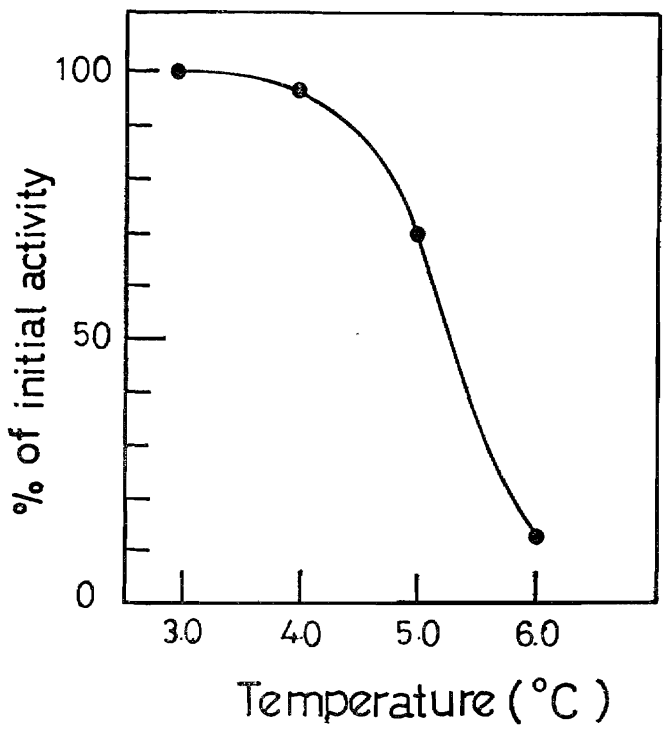

Fig. 3. Thermostability of the Crude Extract of Krill

The crude extract was preincubated at various temperatures for exactly 10 min, cooled to 0°C, and assayed for caseinolytic activity.

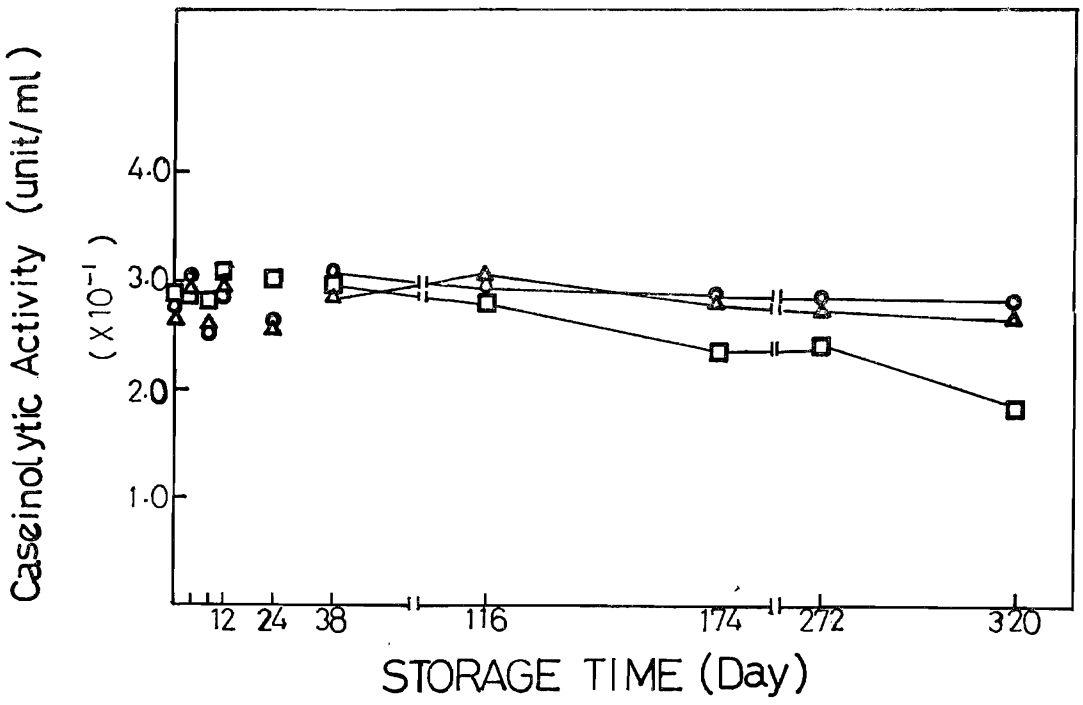

Fig. 4. Stability of the Crude Extract of Krill

—□— 5°C, —△— -20°C, —○— -30°C.

the crude extract after storage at -30°, -20° and 5°C for various time intervals. The loss of activity was only 10% after 320 days of storage at -30° and -20°C, whereas 36% loss was observed for the sample stored at 5°C. The results showed that the crude extract was quite stable at -30° to -20°C.

2. Lyophilized crude proteases: Dialyzed crude extract was lyophilized and stored at 20°, 5° and -20°C. The caseinolytic activities of each sample assayed after different periods of storage are shown in Fig. 5. The results indicated that lyophilized crude extract had 84%, 95% and 98% of activities left after storage for 320 days at 20°, 5° and -20°C, respectively.

3. Crude enzymes saturated with ammonium sulfate: The crude extract was fractionated with ammonium sulfate to obtain three ammonium sulfate

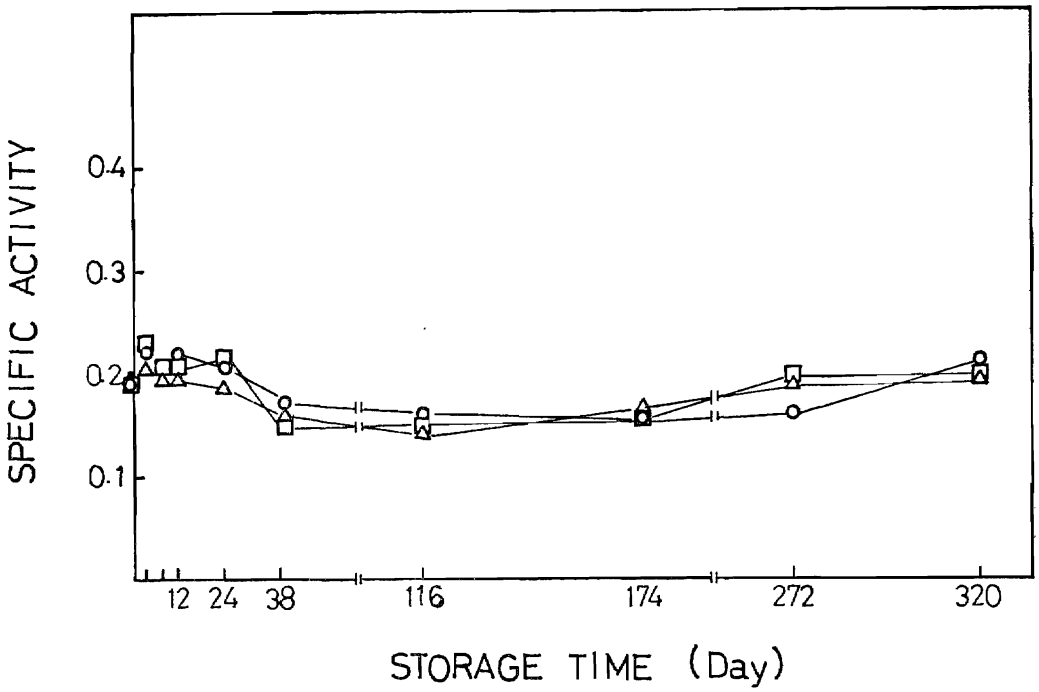

Fig. 5. Stability of the Lyophilized Crude Krill Proteases

—□— 20°C, —△— 5°C, —○— -20°C.

fractions, 0-50%, 50-75% and >75%. Each fraction was divided into two parts and stored at 5° and -20°C. An aliquot of each sample was taken and the specific activity determined after different periods of storage. As shown in Fig. 6, 81% activity of 0-50% faction and 92% activity of 50-75% fraction survived from 320 day storage at 5°C, whereas almost insignificant loss of activity was observed for samples stored at -20°C.

4. Lyophilized ammonium sulfate fractions: Both 0-50%, 50-75% and >75% ammonium sulfate fractions were divided into three parts, stored at 20°, 5° and -20°C, and assayed for caseinolytic activity after different periods of storage. The results are shown in Fig. 7. The 50-75% fraction was more stable than the 0-50% fraction. After storage at 20°C for 320 days, the former had 83% activity survived, whereas the latter had only 67% activity left.

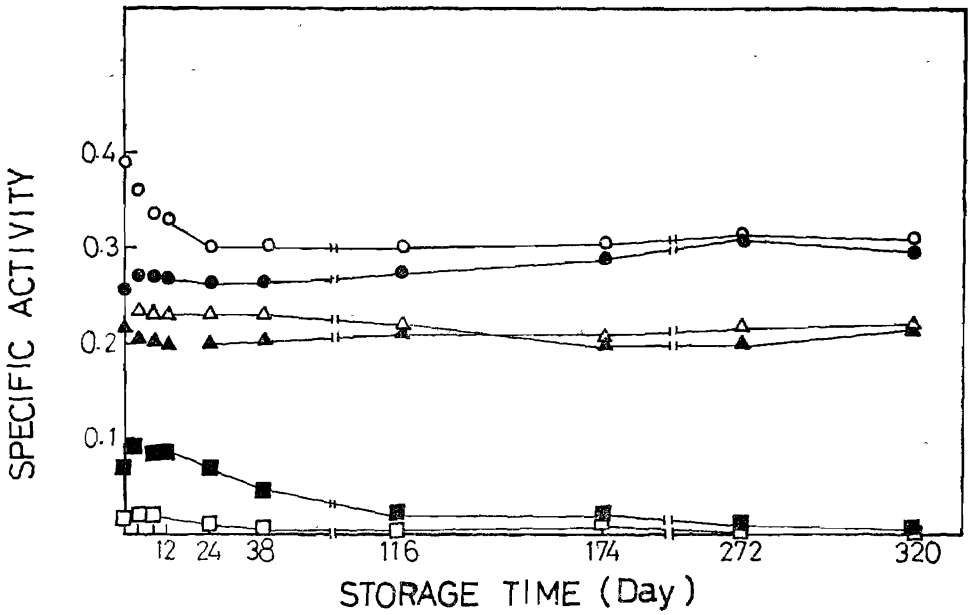

Fig. 6. Stability of the Crude Krill Proteases Saturated with Ammonium Sulfate

	5° C	-20° C
0-50% ammonium sulfate fraction:	—○—	—●—
50-75% ammonium sulfate fraction:	—△—	—▲—
> 75% ammonium sulfate fraction:	—□—	—■—

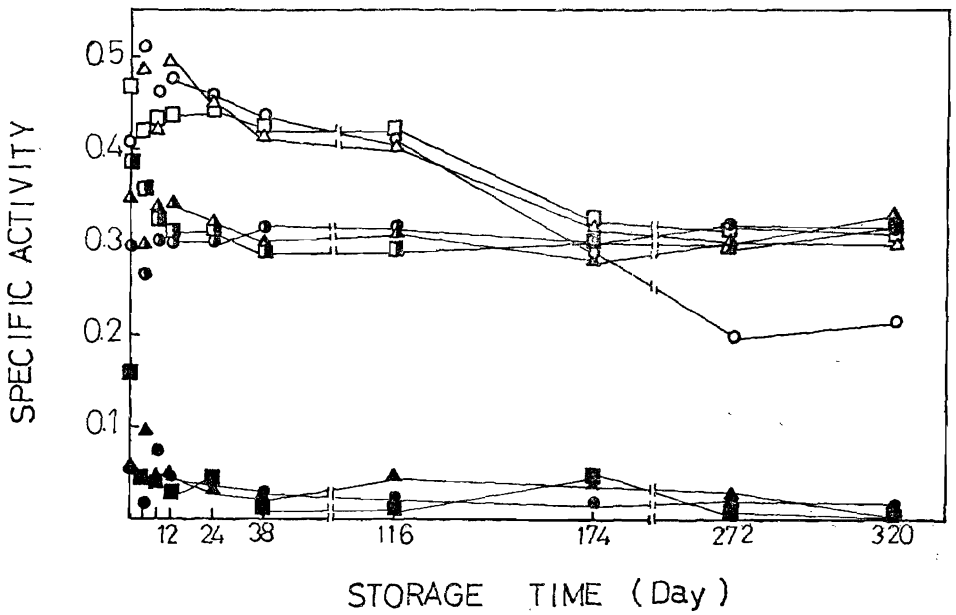

Fig. 7. Stability of the Lyophilized Ammonium Sulfate Fractions of Krill Proteases

	-20° C	5° C	20° C
0-50% ammonium sulfate fraction:	—○—	—△—	—□—
50-75% ammonium salfate fraction:	—◑—	—◭—	—◨—
> 75% ammonium sulfate fraction:	—●—	—▲—	—■—

The following conclusion can be drawn from the stability experiments. Krill proteases in liquid form should be stored at -20° to -30°C, while that in saturated ammonium sulfate solution and in lyophilized form could be stored at 5°C. The latter also could be stored at 20°C with minor loss of activity.

ACKNOWLEDGEMENTS

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南極蝦蛋白酶之研究

——活性及安定性——

陳慶三・高淑文・顏聰榮

摘　　要

試驗2％氯化鈉、2％氯化鉀、水及0.1M磷酸緩衝液（pH 7.0）等四種溶液的抽出效果顯示0.1M磷酸緩衝液最適於自南極蝦抽取蛋白酶。粗酵素經純化後獲得五種蛋白酶，命名爲 A_1、A_2、B、C 和 D。A_1、B、C 及 D等經鑑定爲均質，A_5 之純度估計約80％以上。依其基質特異性將 A_2、B、C及D歸類爲胰蛋白酶。A_1 之特異性尚未充分瞭解。

D之活性與胰蛋白酶及胰凝乳蛋白酶大約相等。A_1、A_2、B、C 等活性稍低於此兩種市販胰臟蛋白酶。對 BAEE 及 TAME 的活性測定得到相似的結果。

粗蛋白酶的最適 pH 是 8 等電點偏於酸性，最適溫度爲 50°C 差右在 0～5°C南極蝦蛋白酶仍有 5％活性。蛋白酶粗抽出液在高溫不安定，在 40°C 以上保溫10分鐘後，活性即顯著下降。但是粗蛋白酶在低溫或以硫酸銨飽和或以乾燥狀態保存，都具有很高的穩定性。粗蛋白酶溶液貯藏在 5°C 經過 321 天後，活性尚有64％，在 −20°C及−30°C 殘存活性均爲 90％ 。凍結乾燥後貯藏在20°C、5°C及−20°C經過321天殘存活性分別爲84％、95％及98％。貯藏於硫銨飽和液中之蛋白酶，經過 321 天，其在−20°C者，活性幾乎沒有損失，而在5°C者仍有81％殘存活性。貯藏實驗獲得以下結論：蛋白酶溶液的最適貯藏條件是−20°C及−30°C，乾燥蛋白酶可以貯藏在20°C，蛋白酶於硫酸銨飽和液中，可以貯藏在5°C。

Freezing Preservation of Fresh Antarctic Krill (*Euphausia superba*)

Shann-Tzong JIANG*, Mao-Song CHEN** and Shyh-Shiuan CHANG**

ABSTRACT

It is well known that the frozen raw krill exudes a lot of drip and develops darkening discoloration during thawing. In order to reduce drip loss and prevent the development of darkening discoloration of frozen krill on thawing, some special pretreatments were employed and the following results were obtained.

For frozen-thawed Antarctic krill, pretreatments with the mixture of 3% NaCl and 1.0% sodium erythorbate or 0.2% polyphosphate-2DK (50% Na-polyphosphate, 50% Na-pyrophosphate) and 1.0% sodium erythorbate for 10 minutes at solution temperature below 5°C showed less drip exudation on thawing at both 5°C and 25°C than those treated otherwise and no darkening discoloration was observed until the samples were spoiled.

SUMMARY

Experiments were carried out to find some better pretreatments for preventing the development of darkening discoloration and reducing the drip loss from frozen krill. The following results were obtained.

1). When frozen raw krill was thawed at 5°C and 25°C of air temperature for 24 hours, about 20% and 33% of drip exuded and 30.0mg and 46.7mg of

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total nitrogen was lost with drip, respectively, from 100g of frozen krill. In the former case black spots appeared at 10th hour and the spots spread to whole head after 24 hours storage, while by thawing at 25°C the black spots were observed at 4th hour and spread to head, legs and tail after 24 hours.

2). About 100g of frozen krill samples were immersed in either 0.5% or 1.0% Na-erythorbate solution for 1 hour, and then stored at 5°C and 25°C of air temperature for 4 days and 1 day, respectively. In no case was darkening discoloration observed, although the samples were spoiled.

3). Krill samples were incubated at 5°C, 20°C and 40°C for 6 hours and the rate of autolysis was measured. The decrease in speed of autolysis was in proportion to the decrease in storage temperature.

4). A number of substances were examined for their inhibitory effects on the autolysis of krill at 40°C. NaCl, NaH_2PO_4, polyphosphate-2DK, polyphosphate-2A, citric acid and Na-citrate showed remarkable inhibitory effect.

5). The frozen-thawed krill was immersed in a solution containing either 0.2% polyphosphate-2DK and 1.0% Na-erythorbate or 3% NaCl and 1.0% Na-erythorbate for 10 minutes at solution temperature below 5°C, then dripped and frozen quickly at body temperature below -18°C. When the frozen samples were thawed again at 25°C and 5°C of air temperature, drip loss from frozen krill was reduced from 21.0% to below 8% and from 15% to below 5%, respectively. No darkening discoloration was observed after 1 day and 4 days storage, respectively, while the samples spoiled.

INTRODUCTION

Antarctic krill, *Euphausia superba*, is a small crustacean belonging to the order Euphausiaceae. It is herbivorous, representing the first trophic level in Antarctic food chains. It forms the main diet of baleen whales, and is also a prey for other animals such as smaller humpback, sei, minke whales crabeater seals, penguins and petrels.[1] Adult krill attains a length of 40-50mm and swarm in large numbers in the surface layers of the Antarctic waters during southern summer months. The shortage of provisions all over

the world and human's demand for high-quality proteins have caused world-wide interest in the exploitation and ultilization of Antarctic krill. Tentative estimation shows that from 50-70 million tons of krill could be harvested annually.[2]

Although studies on the exploitation and ultilization of krill have made progress, but the krill still can not be processed efficiently on board so far, presumably due to problems of processing equipments, labor, fresh water...etc. Since krill can only be captured from November to the following February, a successful freezing preservation technique during the harvest season is definitelv needed to keep the market supply year round. However, it has been reported that the frozen krill exudes much drip and develops darkening discoloration on thawing. The darkening discoloration and drip loss would severely deteriorate the krill. Krill with such defects will hardly be accepted by the public.

According to the investigation by M. YANASE,[3] the frozen krill had only about 40% of edible portion, the remainder were about 30% of drip and 30% of crust portion. Thus, the major problems confronting the krill processing industry have been the difficulty in prevention of the development of darkening discoloration and reduction of the drip loss from frozen krill during thawing.

The objective of this study, therefore, was to develop some practical methods to prevent the blackening and drip loss.

At the present moment, the precooking freezing method has been exclusively employed for preventing the frozen krill from the darkening discoloration during defrosting. However, preliminary works suggested that the yields of crude proteins, crude fats and carbohydrates of the product decreased, resulting from precooking treatment.[4,5] In addition, the double denaturation resulting from cooking and freezing would reduce the ultilization value of krill.

The mechanism of the development of darkening discoloration in Antarctic krill has not been fully understood. It, however, is suggested that the mechanism is similar to that occurred in shrimp or prawn.[6] Namely, the

existence of an enzyme tyrosinase, and oxygen is responsible for the darkening discoloration which is a consequence of melanin formation. In the studies of lobster,[7] it was found that the tyrosinase activity was higher in blood than in other organs. However, the content of free tyrosine was higher in liver, gonad and stomach than in blood.

With respect to drip loss from frozen fish, it is well known that the drip loss is caused by the denaturation of muscle proteins and the histological damage of muscle during freezing and frozen storage. For the frozen krill,[6] the drip loss may be attributed to the higher content of water soluble constituents, high autolysis enzyme activity (especially, the proteases) and poor freezing tolerance. Based on the above mentions, it seems likely that the darkening discoloration and much drip loss of frozen krill on thawing may be prevented by some special pretreatments, such as rinsing with water to diminish blood and visceral residue and/or treating with cryoprotective reagents and antioxidant solutions. This study was based on this conjecture. The frozen krill was performed with the pretreatments of a mixture of 3% NaCl and 1.0% sodium erythorbate or 0.2% polyphosphate-2DK (sodium polyphosphate 50%, sodium pyrophosphate 50%) and 1.0% sodium erythorbate solution and did demonstrate an efficient results.

MATERIALS AND EXPERIMENTAL METHODS

All Antarctic krill used in this study were fished from the Antarctic Oceans. They were frozen in an air-blast freezer (air temp. : -40°C, wind velocity 3.0m/sec) for 8-12 hours at the body temperature below -35°C and stored at the same temperature until use. The proximate composition of raw frozen and precooked frozen samples were analyzed. The results were shown in Table 1.

Table 1. Proximate composition of raw frozen and precooked frozen Antarctic krill.

constituents \ samples	raw frozen	precooked frozen*
moisture	81.3%	84.1%
crude proteins	11.1%	11.3%
crude fats	3.8%	1.8%
carbohydrates	1.9%	0.8%
ash	1.9%	2.0%

* The precooked frozen samples were that fresh krill boiled at 95~100°C of sea water for 5 minutes and frozen in the same manner as that for raw frozen samples.

Experiment 1. Determination of drip loss from frozen krill on thawing:

About 400 grams of samples were weighed, thawed at 5°C and 25°C in air for 24 hours. Then, the drip loss from the frozen krill was determined by percentage ratio of the weight of drip to the weight of sample. The pH value of drip and development of darkening discoloration were also examined by a pH meter and organoleptic test.

Experiment 2. Experiments for preventing the darkening discoloration:

After the pretreatments (see Table 2), the samples were stored at 5°C and 25°C of air temperature for 96 and 24 hours, respectively. Then, they were examined for the formation of black spots. Deterioration of organoleptic quality during storage was also investigated.

Table 2. Conditions of pretreament in the test for preventing the darkening discoloration.

wt. of sample (g)	code of treatment	conditions of pretreatment
100	G-I	soaked in 0.5% sodium erythorbate at 25°C for 1 hour.
100	G-II	soaked in 1.0% sodium erythorbate at 25°C for 1 hour.
100	G-III	soaked in 0.5% sodium ascorbate at 25°C for 1 hour.
100	G-IV	soaked in 1.0% sodium ascorbate at 25°C for 1 hour.
100	G-V	soaked in 0.01% butylated hydroxyanisole (BHA) solution at 25°C for 1 hour
100	G-VI	no treatment.

Experiment 3. Effect of the variation of storage temperature on the autolysis of krill:

After being thawed by tap water to 0°C of body temperature, every 10 grams of samples was put into 50ml volumetric flask, 25ml of phosphate buffer solution (0.1M, pH 7.6) were added, and the mixture homogenized. These samples were incubated at 40°C, 20°C and 5°C, respectively, for examination of autolysis.

At an interval of one hour each, the sample was taken out of the incubator. 10ml of 20% trichloroacetic acid (T.C.A) solution was added to stop the autolysis reaction and made up to 50ml volume with phosphate buffer (0.1M, pH 7.6). It was allowed to stand at room temperature (about 25°C) for 30 minutes and centrifuged (5,000 r.p.m., 10 minutes). The supernatants were filtered by using Toyo filter paper No. 5C, and the filtrates were collected and diluted to twenty-five folds of the original volume. The T.C.A. soluble constituents were compared by measuring the absorbance at 660nm, according to the Folin method cited by KUWANO.[5]

Experiment 4. Inhibitory effect of various cryoprotective substances on the autolysis of krill:

Every 10 grams of krill which was thawed by tap water to 0°C of body temperature was put into 50ml volumetric flask, 30ml of phosphate buffer (0.1M, pH 7.6) was added and the mixture homogenized. Cryoprotective substances (listed in Table 3) were put into the homogenizer and made up to 50ml volume with phosphate buffer solution.

Table 3. Kinds and concentrations of cryoprotective substances for test of inhibitory effect on autolysis.

wt. of sample (g)	cryoprotective substance		
10	added phosphoric acid	0.005M	0.01M
10	added $NaH_2PO_4 \cdot 2H_2O$	0.005M	0.01M
10	added $Na_2HPO_4 \cdot 2H_2O$	0.005M	0.01M
10	added citric acid	0.005M	0.01M
10	added sodium citrate	0.005M	0.01M
10	added polyphosphate-2A*	0.1%	0.2%
10	added polyphosphate-2DK	0.1%	0.2%
10	added NaCl	0.2%	0.5%
10	added meaton-E**	0.2%	0.3%
10	added sugar	3.0%	5.0%

* The constituents of polyphosphate-2A was as follows:

Na-phosphate	60%	K-metaphosphate	14%
Na-metaphosphate	22%		
Na-pyrophosphate	2%	K-pyrophosphate	2%

** 40% Na-polyphosphate, 60% Na-pyrophosphate.

All of these resulting solutions were incubated at 40°C for 6 hours. 15ml of 20% T.C.A. solution was added to each solution to stop the autolysis reaction. They were allowed to stand at room temperature for 30 minutes and centrifuged. The supernatants were filtrated using Toyo filter paper No.

5C and the filtrates were collected and diluted to twenty-five folds of the original volume. The T.C.A. soluble constituents were measured for their absorbance at 660nm.[5] The result was shown in percentage relative to the control group (=100%) for its content of amino acid residues.

Experiment 5. The combined effect of various cryoprotective substances and antioxidant on the reduction of the drip loss and prevention of the development of darkening discoloration of frozen krill:

Five hundred grams of frozen krill were weighed, thawed in tap water to 0°C of body temperature, and then treated as follows (Table 4):

Table 4. Pretreatment conditions used to test the combined effect of various cryoprotective substances on reducing drip loss and preventing darkening discoloration of frozen krill.

code of samples	pretreatment condition*
G-I	no treatment
G-II	soaked in 0.02M NaH_2PO_4 solution for 10 minutes at solution temperature below 5°C.
G-III	soaked in 0.2% polyphosphate-2A for 10 minutes at solution temperature below 5°C.
G-IV	soaked in 0.2% polyphosphate-2DK for 10 minutes at solution temperature below 5°C.
G-V	soaked in 0.02M citric acid for 10 minutes at solution temperature below 5°C.
G-VI	soaked in 3% NaCl solution for 10 minutes at solution temperature below 5°C.
G-VII	soaked in a solution containing 3% NaCl, 0.02M citric acid and 0.2% polyphospnate-2A for 10 minutes at solution temperature below 5°C.
G-VIII	soaked in a solution containing 3% NaCl, 0.02M citric acid and 0.2% polyphosphate-2DK for 10 minutes at solution temperature below 5°C.
G-IX	soaked in a solution containg 3% NaCl, 0.02M citric acid and 0.02M $NaH_2PO_4 \cdot 2H_2O$ for 10 minutes at solution temperature below 5°C.

* Except for G-I, in which 1.0% of sodium erythorbate was added to prevent the development of darkening discoloration.

After the pretreatments, they were placed in different P.E. box and frozen to below -18°C of body temperature by using an air-blast freezer (air temperature: -40°C, wind velocity: 3.0 m/sec), then thawed at 5°C and 25°C of air temperature. The organoleptic evaluation of developing darkening discoloration was conducted for 4 days (at 5°C) and 1 day (at 25°C). The quantity of drip loss from frozen krill was also measured until the body temperature reached 5°C.

RESULTS AND DISCUSSION

1. *Effect of thawing temperature on the quality of frozen-thawed krill on thawing*:

About 400 grams of frozen krill was placed at 5°C and 25°C of air temperature for 24 hours, and the drip loss from frozen krill, pH value of drip and the development of darkening discoloration were examined. The results are shown in Table 5. The quantity of drip loss from frozen krill was considerably large on thawing at 5°C and 25°C of air temperature. About 20% and 33% of drip loss were observed on thawing at 5°C and 25°C of air temperature, respectively. In addition, one hundred grams of frozen krill had 30.0mg and 46.7mg of total nitrogen loss with drip on thawing at 5°C and 25°C of air temperature respectively. From these results, it is clear that the weight of frozen raw krill was remarkably reduced as a result of drip loss on thawing, and the nutrition and flavor elements had also been lost concomitantly with drip. The nutritive value and flavor did lose in spite of these treatments and the quality of frozen raw krill was deteriorated.

From the results of the development of darkening discoloration in the sample thawed at 5°C of air temperature it was observed that after 10 hours, black spots appeared and extended to all over the head after 24 hours. While in the sample thawed at 25°C of air temperature, the black spots appeared after 4 hours and extended to head, legs and tail after 6 hours and remarkably extended to all over the body after 10 hours. It was also known that the deterioration in freshness of the sample thawed at 5°C, from the results of pH determination, was slower than those of the sample thawed at 25°C.

Table 5. The drip loss, pH of drip, and organoleptic estimation of developing melanosis of frozen krill during thawing at 5°C and 25°C.

thawing temp. (°C)	5°C			25°C		
kinds of measurement	drip loss (%)	pH of drip*	developing** melanosis	drip loss (%)	pH of drip*	developing** melanosis
thawing time (hr)						
0	0	—	5	0	—	5
2	0	—	5	2.8	—	5
4	0	—	5	10.5	7.45	4
6	0	—	5	16.7	7.41	2
8	0.9	—	5	21.6	7.66	2
10	2.6	7.40	4	25.8	7.71	1
24	20.0	7.62	3	32.9	7.88	1
wt. of sample (g)	416.8			409.5		
total nitrogen loss with drip from 100g of frozen krill. (mg)	30.0			46.7		

* The pH of frozen raw krill was 7.40.

** The scores express the degree of intensity of black spots as follows:

5: no blackening spots was observed.
4: blackening spots occurred slightly at the head.
3: blackening spots were observed in head.
2: blackening spots extended to the leg, body and tail.
1: developed melanosis severely.

The results obtained from these experiments suggested that the quality of the samples thawed at 5°C was superior to the samples thawed at 25°C. Especially in case of thawing a large amount of sample, the surface portion of frozen krill had already deteriorated, while the internal portion still did not defrost completely.

2. Effect of various antioxidants on the prevention of development of darkening discolorution of frozen krill:

The inhibitory effects of two kinds of water-soluble antioxidants and B.H.A. (oil-soluble antioxidant) on the development of darkening discoloration were investigated by organoleptic estimation. The results are presented in Table 6. Being stored at 5°C, the treatments with 0.5% and 1.0% of sodium erythorbate prevented the development of darkening discoloration for as long as 4 days, while the treatments with 0.5% and 1.0% sodium ascorbate could only retard the development of black spots for 2 and 3 days, respectively. The 0.01% B.H.A. solution treatment had the black spots appeared after 2 days, on the contrary, the darkening discoloration occurred in the control group as early as 6th hour after experiment started. At 25°C, the treatments with 0.5% and 1.0% sodium erythorbate effectively prevented the development of darkening discoloration for as long as 24 hours, while the 0.5% and 1.0% sodium ascorbate treatment had black spots appeared after 24 hours. The 0.01% B.H.A. had blackening spots shown after 10 hours, while the control group had black spots occurred after 4 hours storage.

It was known from these experiments that for preventing the development of darkening discoloration, the treatments with 0.5% and 1.0% sodium erythorbate were the most effective, 0.5% and 1.0% sodium ascorbate were effective, and 0.01% B.H.A. was less effective.

3. Effect of storage temperature on the autolysis:

Although the krill was caught at very low temperature in Antarctic Oceans, the extent of autolysis developed very rapidly to cause a severe drip loss during thawing.[6] In order to investigate the effect of storage temperature on autolysis of Antarctic krill, the autolysis of krill samples at 5°C, 20°C and

Table 6. Effect of various antioxidants on preventing the development of darkening discoloration of krlll during storage at 5°C and 25°C of air temperature.

treatments**		G-Ⅰ		G-Ⅱ		G-Ⅲ		G-Ⅳ		G-Ⅴ		G-Ⅵ	
storage time (hr)	storage temp. (°C)	DM*	freshness	DM*	freshness	DM*	freshness	DM*	freshness	DM*	freshness	DM*	freshness
0	25	5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	5	fresh
2		5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	5	fresh
4		5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	4	fresh
6		5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	3	fresh
8		5	deteriorated	5	deteriorated	5	deteriorated	5	deteriorated	5	deteriorated	3	deteriorated
10		5	deteriorated	5	deteriorated	5	deteriorated	5	deteriorated	4	deteriorated	2	deteriorated
24		5	spoiled	5	spoiled	3	spoiled	3	spoiled	3	spoiled	1	spoiled
0	5	5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	5	fresh
2		5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	5	fresh
4		5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	5	fresh
6		5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	5	fresh
8		5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	4	fresh
10		5	fresh	5	fresh	5	fresh	5	fresh	5	fresh	4	fresh
24		5	deteriorated	5	deteriorated	5	deteriorated	5	deteriorated	5	deteriorated	3	deteriorated
48		5	deteriorated	5	deteriorated	4	deteriorated	5	deteriorated	4	deteriorated	2	deteriorated
72		5	deteriorated	5	deteriorated	4	deteriorated	4	deteriorated	3	deteriorated	1	deteriorated
96		5	spoiled	5	spoiled	3	spoiled	3	spoiled	2	spoiled	1	spoiled

* DM: Degree of melanosis, the scores express as the footnote in Table 5.

** The samples were soaked in various solutions shown as follows for 1 hour, then removed and stored at 5°C and 25°C.

G-Ⅰ: 0.5% sodium erythorbate solution.
G-Ⅱ: 1.0% sodium erythorbate solution.
G-Ⅲ: 0.5% sodium ascorbate solution.
G-Ⅵ: 1.0% sodium ascorbate solution.
G-Ⅴ: 0.01% B.H.A. solution.
G-Ⅵ: no treatment.

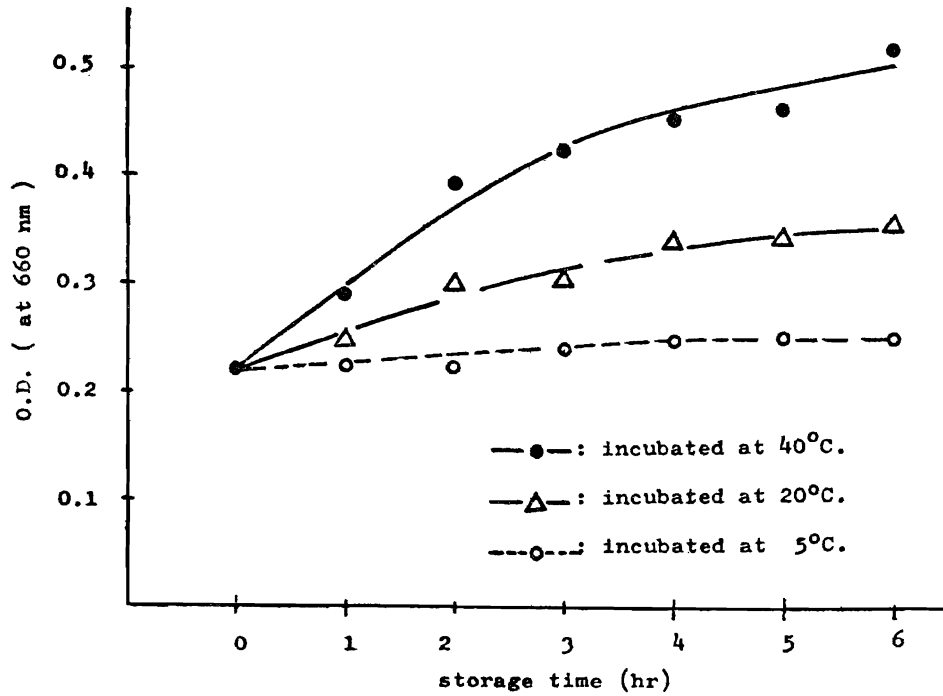

Fig. 1. Effect of the storage temperature on the extent of autolysis of Antarctic krill.

40°C was compared by determining the content of T.C.A. soluble elements. The results are shown in Fig. 1. The krill autolyzed most rapidly under appropriate temperature (such as 40°C). At 40°C, the content of T.C.A. soluble elements increased faster than those at 20°C and 5°C. The extent of autolysis was retarded by decreasing the incubation temperature. These studies suggested that, even at very low temperature, 5°C as in the Antarctic Oceans, the autolysis would occur slowly. The freezing process, therefore, becomes a necessity.

4. Effect of various cryoprotective reagents on inhibiting the autolysis of krill:

According to Fig. 1, the extent of autolysis proceeding decreased in proportion to the decrease of storage temperature, thus frozen storage can inhibit the autolysis to some degree. The activity of autolysis enzymes of krill, however, was strong, it still proceeds even under frozen storage, consequently causing a severe drip loss during thawing. If, therefore, some pretreatments are employed to inhibit the proceeding of autolysis and prevent

Table 7. Effect of various cryoprotective reagents on inhibiting the autolysis of Antarctic krill at 40°C for 6 hours (pH 7.6).

cryoprotective substance	concentration	quantity of T.C.A. soluble elements (%)*	concentration	quantity of T.C.A. soluble elements (%)*
blank	—	100	—	100
H_3PO_4	0.005M	83.9	0.01M	61.0
$NaH_2PO_4 \cdot 2H_2O$	0.005M	77.8	0.01M	54.2
$Na_2HPO_4 \cdot 2H_2O$	0.005M	69.3	0.01M	63.7
polyphosphate-2A	0.1 %	70.1	0.2 %	61.0
polyphosphate-2DK	0.1 %	64.7	0.2 %	58.5
citric acid	0.005M	76.1	0.01M	63.1
sodium citrate	0.005M	70.1	0.01M	66.1
NaCl	0.2 %	69.3	0.5 %	48.6
meaton-E	0.2 %	66.8	0.3 %	95.5
sugar	3.0 %	63.1	5.0 %	127.0

* The percentage values were relative to the value of blank sample (=100%).

the muscle proteins denaturation during frozen storage, the quantity of drip loss from frozen krill will be reduced. According to the conjecture mentioned above, some cryoprotective reagents[8] such as NaH_2PO_4, Na-polyphosphate, Na-pyrophosphate, citric acid, Na-citrate, NaCl,[9,10] and sugar[10,11], which were reported to reduce the drip loss, were tested for their inhibitory effect on autolysis of krill. The rseults are shown in Table 7. The inhibitory effect on autolysis was compared by the percentage of the content of T.C.A. soluble elements (mainly, amino acids such as tyrosine, tryptophan, etc.) related to non-added group (=100). From Table 7, the content of T.C.A. soluble elements of samples with 0.5% NaCl, 0.01M $NaH_2PO_4 \cdot 2H_2O$, 0.2% polyphosphate-2DK added were 48.6%, 54.2% and 58.5%, respectively, related to the blank group and these inhibitors mentioned above appeared to be the most effective. Those samples with 0.2% polyphosphate -2A, 0.01M citric acid, 0.01M sodium citrate, and 3% sugar added were 61.0%, 63.1%, 66.1% and 63.1%, respectively, relative to the blank group and these inhibitors mentioned above were moderately effective. From these experiments, it is suggested that if krill kept in contact with those inhibitors shown above, or those inhibitors were added to krill, then hold at subzero temperatures, the proceeding of autolysis would be retarded and the drip loss on thawing reduced. Thus, the following experiments were carried out based on this hypothesis.

5. *Effect of various combinations of cryoprotective reagents and antioxidant on the reduction of drip loss and prevention of darkening discoloration of frozen krill during thawing*:

According to the results shown in Table 7, it seems that NaCl, $NaH_2PO_4 \cdot 2H_2O$, polyphosphate-2DK had remarkable effect on inhibiting the autolysis, the polyphosphate-2A, citric acid and sugar had moderate effect. For the purpose of investigating the practical inhibitory effect of various inhibitors shown above on drip loss from frozen krill, frozen raw krill was thawed by tap water to 0°C of body temperature, pretreated with various combinations of cryoprotective reagents and antioxidant, and subsequently frozen by using an air-blast freezer (air temperature: -40°C, wind velocity: 3.0 m/sec) at body temperature below -18°C and stored at -20°C of air temperature.

Table 8a. Effect of various combinations of cryoprotective reagents and antioxidant on the reduction of drip loss and prevention of developing darkening discoloration of frozen krill during thawing at 25°C.

code of samples*		G-Ⅰ	G-Ⅱ	G-Ⅲ	G-Ⅳ	G-Ⅴ	G-Ⅵ	G-Ⅶ	G-Ⅷ	G-Ⅸ
drip loss. % (w/w)		21.0	11.9	16.0	7.1	14.2	8.3	14.4	14.8	15.4
thawing time (hr)		organoleptic quality								
0	color	pink	pink	pink	pink	pink	pink	pink	pink	pink
	texture	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
	flavor	desirable	desirable	desirable	desirable	desirable	desirable	desirable	desirable	desirable
4	color	pink	pink	pink	pink	pink	pink	pink	pink	pink
	texture	acceptable	acceptable	acceptable	acceptable	fairly acceptable	acceptable	fairly acceptable	fairly acceptable	fairly acceptable
	flavor	desirable	desirable	desirable	desirable	desirable	desirable	desirable	desirable	desirable
8	color	blackening slightly	pink	pink	pink	pink	pink	pink	pink	pink
	texture	fairly acceptable	acceptable	fairly acceptable	acceptable	fairly acceptable	acceptable	fairly acceptable	fairly acceptable	fairly acceptable
	flavor	fairly desirable	desirable	fairly desirable	desirable	fairly desirable	desirable	fairly desirable	fairly desirable	fairly desirable
10	color	blackening	pink	pink	pink	pink	pink	pink	pink	pink
	texture	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable
	flavor	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable
24	color	blackening	pink	pink	pink	pink	pink	pink	pink	pink
	texture	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled
	flavor	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled

Table 8b. Effect of various combinations of cryoprotective reagents and antioxidant on the reduction of drip loss and prevention of developing darkening discoloration of frozen krill during thawing at 5°C.

code of samples		G-Ⅰ	G-Ⅱ	G-Ⅲ	G-Ⅳ	G-Ⅴ	G-Ⅵ	G-Ⅶ	G-Ⅷ	G-Ⅸ
drip loss. % (w/w)		15.0	6.9	10.5	2.1	5.0	4.4	10.6	7.6	9.4
thawing time (hr)		organoleptic quality								
0	color	pink	pink	pink	pink	pink	pink	pink	pink	pink
	texture	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
	flavor	desirable	desirable	desirable	desirable	desirable	desirable	desirable	desirable	desirable
24	color	pink	pink	pink	pink	pink	pink	pink	pink	pink
	texture	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable	acceptable
	flavor	desirable	desirable	desirable	desirable	desirable	desirable	desirable	desirable	desirable
48	color	blackening slightly	pink	pink	pink	pink	pink	pink	pink	pink
	texture	fairly acceptable	acceptable	fairly acceptable	acceptable	fairly acceptahle	acceptable	fairly acceptable	fairly acceptable	fairly acceptable
	flavor	fairly desirable	desirable	fairly desirable	desirable	fairly desirable	desirable	fairly desirable	fairly desirable	fairly desirable
72	color	blackening slightly	pink	ping	pink	pink	pink	pink	pink	pink
	texture	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable	fairly acceptable
	flavor	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable	fairly desirable
96	calor	blackening	pink	pink	pink	pink	pink	pink	pink	pink
	texture	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled
	flavor	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled	spoiled

Thawing was performed at 5°C and 25°C of air temperature on the next day and the quantity of drip loss and organoleptic quality were determined. The results are shown in Table 8a, 8b. Among those thawed at 25°C, drip loss from G-IV (0.2% polyphosphate-2DK and 1.0% Na-erythorbate solution immersion pretreatment) and G-VI (3% NaCl and 1.0% Na-erythorbate solution immersion pretreatment, so-called brining pretreatment) were 7.1% and 8.3%, respectively. In contrast to this, non-treated samples exuded 21.0% drip loss. Among those thawed at 5°C, drip loss from G-IV, G-VI, G-V and G-II were 2.1%, 4.4%, 5.0% and 6.9%, respectively. In a striking contrast with this, non-treated samples exuded 15.0% drip loss. As to the effect on reduction of drip loss from frozen krill, pretreatment with a mixture of 3.0% NaCl and 1.0% Na-erythorbate or that of 0.2% polyphosphate-2DK and 1.0% Na-erythorbate solution at solution temperature below 5°C for 10 minutes showed less drip exudation on thawing at both 5°C and 25°C than those treated otherwise.

As also shown in Table 8a and 8b, thawing at 25°C, organoleptic estimation showed at G-IV, G-II and G-VI were the best in color, texture and flavor for 8 hours storage. After 24 hours storage, most of them were spoiled, but every group, except G-I, maintained the original pink color. For those thawed at 5°C, organoleptic estimation revealed that G-II, G-IV and G-VI were also the best in color, texture and flavor for 2 days storage. Most of them were spoiled, but every group except G-I, which developed severe darkening discoloration, still maintained the original pink color after 4 days storage.

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南極蝦之凍結貯藏研究

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摘　　要

凍藏南極磷蝦在解凍時易生大量滴液流失及黑變現象，影響及其商品價值，本項研究係探討凍結前處理對減輕滴液流失及防止黑變現象之效果，其結果如下。

凍結——解凍之南極磷蝦，以 3％ NaCl 和 1.0％ 異抗壞血酸鈉或0.2％重合磷酸鹽—2DK和1.0％異抗壞血酸鈉之混合溶液在液溫 5 °C以下實施10分鐘之浸漬前處理，再實施急速凍結，次日取出在 5 °C及 25° C 之空氣中行自然解凍，則其滴液流失量分別由未經任何處理者之15％及21％降至 5 ％及 8 ％以下，且分別放置 4 天及 1 天，其蝦體雖已腐敗但仍無黑變之跡象。

南極蝦乾製品製造貯藏試驗

A Study on the Processing and Storage of Dried Krill.

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SUMMARY

The purpose of this study was to find out proper processing methods and optimal storage conditions of the dried krill. The experimental sample used in this study was frozen raw krill. The frozen raw krill were thawed in some kinds of immersion solutions, then dried by sunlight, hot-air, or cold-air to produce the dried krills, which were subjected to storage test.

The sample was thawed in pure water, 3% NaCl solution, 3% NaCl solution mixed up with 1% sodium erythorbate, stationary air, or forced air, then added with antioxidants (butylated hydroxyanisol or sodium erythorbate), or taste blender (sorbitol), or antiseptic (sorbic acid) in further processing experiments to observe their preventive effects on the discoloration and deterioration of the dried krill during storage. The drying methods used were sun drying, hot-air drying and cold-air drying. The products were sealed in polyethylene bags and stored at room temperature or in a freezer to proceed the storage test. The results were as follows:

(1) With the sun drying method, the frozen raw krill were boiled and dried after having been thawed. The color of the dried products was better than that without boiling.

(2) The optimal miosture content of the dried krill was between 20% and 30%.

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The packaging materials must be able to prevent the penetration of air. When the dried krill were stored at lower temperature, the changes in pH, V.B.N., color and odor were very little, and it was likely able to keep their quality and appearance in better condition.

(3) The preventive effect of B.H.A. on the discoloration of the dried krill was very good. The one added with 0.02% B.H.A. was better than that added with 0.01% B.H.A. The immersion solution consisted of 3% sorbitol and 1% sodium erythorbate also had considerable effect of color preservation.

(4) When 0.1% to 0.2% sorbic acid was added to the dried krill, the growth of molds or bacteria was effectively inhibited.

(5) The cold-air dried krill had more proper moisture content and their appearance and fragility were considerably better than those of other products.

前　　言

南極蝦是一種大型的浮游生物，體長約4～6公分，形狀很像櫻蝦，外殼很薄，肉質柔軟[1]。其自家消化酵素及黑變酵素之活性甚强，漁獲後如不立卽加工處理，1～2小時後卽有液化及黑變現象產生[2][3]。由於南極蝦具有此等特性，故如何在船上或陸上施行適當的加工處理，成爲急待解決的問題。

據陳[4]之調查，一般蝦類乾製品如蝦米、蝦皮、蝦脯等，其乾燥方式，除基隆、蘇澳地區的大型加工廠有使用熱風乾燥機外，一般均採用天日乾燥法。此因天日乾燥法具有無需機械設備，不必耗損燃料，而可大量處理等優點；而冷、熱風乾燥法則有需昂貴的設備費，燃料費及維護費，無法做大量處理等缺點，故天日乾燥法仍普遍被採行。

雖然冷、熱風乾燥機有如上述之缺點，但對於在南極海域作業之船隻言，欲實施天日乾燥時，則因漁船面積、外界氣溫等之限制而無可行性；且將來民間若組織船團從事南極蝦漁業，屆時漁獲量必然甚豐，其中一部份勢必要在船上加工，一部份則需凍藏回國再行加工。在船上若能以冷、熱風乾燥機實施乾燥，則有減輕重量，增加積載量，減少運費，降低成本等利點；在陸上則以天日乾燥法做大量處理，亦可降低成本，此等處理方式，將是可行的途徑。

本試驗係以上述三種乾燥方法對生鮮凍結南極蝦施行乾燥處理，添加抗氧化劑或防腐劑以防止製品之色澤變化及品質低落，研究貯藏條件對製品品質的影響，以瞭解最適當的乾燥方法及貯藏條件，做爲日後南極蝦加工的參考。

材料及方法

一、實驗用南極蝦：係海功號試驗船於民國65年12月至66年3月首航南極海域時所漁獲，以生鮮狀態凍藏於－20°C 以下之冷凍庫內之南極蝦。

二、加工方法：

實驗Ⅰ、天日乾燥法

1）取生鮮凍結南極蝦，稱重後置於3％食鹽水中行浸漬式解凍，待完全解凍後稱重，直接舖在乾燥棚上行天日乾燥。本法所得製品爲生乾品A。

2）取生鮮凍結南極蝦，稱重後以風速 3.87m/sec 之强風行强制式送風解凍2小時，然後舖於乾燥棚上行天日乾燥。本法所得製品爲生乾品B。

3）取生鮮凍結南極蝦，稱重後浸於3％食鹽水中解凍，次投入95～100°C的3％食鹽水中煮熟5分鐘[2]，取出水冷、滴乾、稱重，然後舖在乾燥棚上行天日乾燥。如此所得製品爲煮乾品。

實驗Ⅱ、熱風乾燥法

將生鮮凍結南極蝦置於含1％異抗壞血酸鈉（Sodium erythorbate）的3％食鹽水中解凍，於部份解凍時分成五組，分別投入於含有 0,1,2,3,4% 山梨醇（Sorbitol）的水溶液中，以95～100°C加熱5分鐘，取出滴乾，置於熱風乾燥機中，先用 140°C熱風乾燥2小時，次以 100～105°C繼續乾燥之。所得製品以聚乙烯袋密封，置於室內（20～30°C）及冰櫃（－18～－22°C）中供貯藏試驗之用。

實驗Ⅲ、冷風乾燥法

取生鮮凍結南極蝦，分成五組，稱重後置於室溫空氣中解凍2小時。將蝦體重5倍的3％食鹽水預先加熱至90°C，先加入或不加入 B.H.A（Butylated hydroxyanisol），次投入原料，以95～100°C煮熟5分鐘，取出滴乾、稱重，以噴霧器噴灑山梨酸酒精溶液（Sorbic acid-alcohol solution），置入冷風乾燥機中，以風速 1.8～1.9m/sec 的 15～25°C 冷風乾燥至水分約20～30% 時，取出密封於聚乙烯袋中，於室內（15～25°C）中進行貯藏試驗。本實驗中 B.H.A. 和山梨酸之用量如下所示：

組　別	B.H.A.（對煮液用水量）	山梨酸（對煮熟蝦體重）
對照組	0％	0％
第Ⅰ組	0.01%	0.1%
第Ⅱ組	0.02%	0.1%
第Ⅲ組	0.01%	0.2%
第Ⅳ組	0.02%	0.2%

三、測定項目及方法

1）水分、粗灰分、粗蛋白、粗脂肪：依常法測定。

2）pH：稱取粉碎製品5g於燒杯中，加45ml蒸餾水，攪拌後靜置30分鐘，以HM-5A型 pH meter 測定之。

3）揮發性鹽基態氮（V.B.N.）：採 Conway 氏微量擴散法。

4）色澤（Color）：將製品粉碎，用 ND-68 型 Color and Color Difference Meter 測定其 L、a、b 值（均取正值）。

5）生菌數（Total bacterial count）：採混釋平板法[5]。

6）脆度（Fragility）：採官能檢查，每次檢查20隻乾蝦，按衣卷[6]建議之等級區分評定：（其方法如下）

部 位	頭 胸 部	尾 腹 部
第1級	幾乎保持原狀。	僅尾部缺失程度。
第2級	有部份缺失。	顯然有缺失，但似成小片狀。
第3級	幾乎沒有或折斷。	極大部份折斷而缺失。

7) 嗅味（Odor）：採官能檢查，結果分爲下列四級表示：

第1級：有濃厚蝦乾香味。

第2級：略有蝦乾香味，具本身特殊刺激臭，無其他異臭。

第3級：無蝦乾香味，略有油燒、變敗等異臭。

第4級：有强烈之油燒、變敗臭、刺激臭等濃厚異臭。

結果與討論

實驗I、天日乾燥法

一、加工過程中原料重量、乾燥溫度及時間、外觀等之變化情形

Table 1. The yield, temperature, and appearance of three kinds of sundried krill.

product	wt. of raw material (g)	wt. of product (g)	yield (%)	drying temp. (°C)	drying time (hr.)	appearance
raw-dried A	4,450	760	17.10	29-45	10.5	crude, dark red
raw-dried B	4,800	820	17.10	29-50	13.0	crude, dark brown
boil-dried	4,650	1,060	22.79	29-45	9.5	imperfect, red

如 Table 1 所示，原料在解凍後，其形態及色澤雖良好，但生乾品A及B之外觀粗糙，色澤變暗紅，有缺少肉質之感；煮乾品之色澤鮮紅，但頭殼因煮熟處理而易致脫落。推其原因爲：生乾品由於照射的光線太强，溫度甚高，時間又長，促進其黑變酵素作用及自家消化酵素作用，而引起强烈的油燒現象，致蝦體顏色變暗；煮乾品則由於酵素活性因加熱而受破壞，且游離出還原蝦紅素（Astaxanthin），致蝦體呈鮮紅色，但營養成分溶失頗多，形態亦欠完整。

二、製品的一般成分與貯藏中品質之變化

由 Table 2 得知，貯藏至第12天時，煮乾品之 V.B.N. 值由 8.08mg% 增加爲 28.34mg%：生乾品A及B則分別由 26.94mg% 及 45.99mg% 陡增至 131.25mg% 及 116.42mg%，且有異臭，顯見煮熟處理不但能得到較好品質之製品，且能使製品維持較好的品質而耐長期之貯藏。

Table 2. Chemical compositions of three kinds of sun-dried krill.

item	raw-dried A	raw-dried B	boil-dried
moisture (%)	11.86	13.08	11.87
crude ash (%)	19.94	9.99	9.70
crude protein (%)	48.13	55.36	56.73
crude fat (%)	12.31	16.09	13.93
V.B.N. (mg%)	26.94	45.99	8.08
pH	6.88	6.83	7.69
V.B.N.* (mg %)	131.25	116.42	28.34
pH*	6.95	6.89	7.68

* After 12-day storage at room temperature

實驗Ⅱ、熱風乾燥法

一、製品的一般成分與脆度

Table 3. Chemical compositions of hot-air dried krill.

group*	moisture (%)	crude ash (%)	crude protein (%)	crude fat (%)
Ⅰ-1	44.08	5.06	40.29	10.34
Ⅰ-2	22.95	7.43	56.83	13.28
Ⅰ-3	3.89	9.98	70.52	14.44
Ⅱ-1	23.16	6.91	56.75	11.23
Ⅱ-2	5.74	7.24	69.52	14.97
Ⅱ-3	4.62	8.15	70.60	15.76
Ⅲ-1	27.11	7.39	53.22	9.79
Ⅲ-2	19.47	8.20	60.89	10.04
Ⅲ-3	7.90	9.87	66.02	14.45
Ⅳ-1	40.27	6.21	43.10	8.31
Ⅳ-2	35.88	8.10	45.41	8.98
Ⅳ-3	3.14	7.19	68.63	14.36
Ⅴ-1	30.69	6.27	50.07	11.23
Ⅴ-2	14.10	6.68	59.41	16.31
Ⅴ-3	9.75	7.60	68.42	12.61

* The thawed krill in groups I, II, III, IV and V were boiled, respectively, in 0, 1, 2, 3 and 4% sorbitol solutions before hot-air drying. The sub-groups 1, 2 and 3 represent the products of 6.5, 7.5 and 8.5 hours of hot-air drying, respectively.

Table 3 爲製品之一般成分分析。第Ⅰ、Ⅱ、Ⅲ、Ⅳ和Ⅴ組之解凍南極蝦分別在 0,1,2,3,4% 山梨醇水溶液中煮熟，然後以熱風乾燥之。各組後面之 1,2,3, 係代表以熱風乾燥法分別經 6.5,7.5,8.5 小時乾燥所得之製品。由表中得知：隨乾燥時間之經過，水分卽漸減，粗蛋白、粗脂肪、粗灰分則因水分之減少而相對地增加。

Table 4. The fragility of hot-air dried krill. (no. of dried krill: 20)

group*	cephalothorax			telson		
	1**	2**	3**	1**	2**	3**
Ⅰ-1	4	10	6	4	9	7
Ⅰ-2	2	11	7	7	4	9
Ⅰ-3	1	11	8	6	7	7
Ⅱ-1	3	10	7	9	6	5
Ⅱ-2	3	7	10	6	5	9
Ⅱ-3	2	8	10	5	7	8
Ⅲ-1	5	7	8	7	6	7
Ⅲ-2	6	10	4	9	6	5
Ⅲ-3	6	7	7	10	6	4
Ⅳ-1	5	9	6	16	4	0
Ⅳ-2	2	11	7	9	6	5
Ⅳ-3	4	9	7	8	8	4
Ⅴ-1	2	8	10	11	8	1
Ⅴ-2	3	9	8	11	8	1
Ⅴ-3	3	13	4	6	5	9

* See the footnote of Table 3.

** Grade 1: little destruction; Grade 2: some destruction; Grade 3: severe destruction.

Table 4 表示製品的脆度。由表中得知：乾燥時間愈長及水分愈低之製品愈不易保持蝦體之完整性。就蝦體部位言，頭胸部之完整性顯然較尾腹部爲差，亦卽尾腹部在加工過程中較不易斷裂，頭胸部則否。各種蝦類亦均具有此種現象。

二、製品貯藏中之品質變化情形

Table 5 爲製品在室溫貯藏時嗅味之變化情形。製品水分超過40%者，於第 7 天或第14天時卽產生濃厚之異臭；水分20～40%者於第35天時始有濃厚之異臭產生；水分10%以下者至第35天時仍無異臭產生。相反地，貯於-18° C以下冰櫃中者，其嗅味殆無變化，且第35天時水分越高者反而有類似熟成之香味產生，其原因有待進一步之研究。

Table 5. Change in odor*** of hot-air dried krill during storage at 20~30°C and -18~-22°C for 35 days.

group*	0 day		7 days		14 days		21 days		28 days		35 days	
	A**	B**	A**	B**	A**	B**	A**	B**	A**	B**	A**	B**
Ⅰ-1	3	3	4	3	4	3	4	3	4	3	4	3
Ⅰ-2	2	2	3	2	3	2	4	2	4	2	4	2
Ⅰ-3	1	1	1	1	1	1	2	1	2	1	2	1
Ⅱ-1	2	2	2	2	3	2	4	2	4	2	4	2
Ⅱ-2	1	1	2	1	2	1	2	1	3	1	3	1
Ⅱ-3	1	1	2	1	2	1	2	1	2	1	2	1
Ⅲ-1	2	2	3	2	3	2	4	2	4	2	4	2
Ⅲ-2	2	2	3	2	3	2	4	2	4	2	4	2
Ⅲ-3	1	1	2	1	2	1	2	1	2	1	2	1
Ⅳ-1	2	2	3	2	4	2	4	2	4	2	4	2
Ⅳ-2	2	2	3	2	4	2	4	2	4	2	4	2
Ⅳ-3	1	1	1	1	1	1	2	1	2	1	2	1
Ⅴ-1	2	2	3	2	3	2	3	2	3	2	4	2
Ⅴ-2	2	2	2	2	3	2	3	2	3	2	3	2
Ⅴ-3	1	1	2	1	2	1	2	1	2	1	2	1

* See the footnote of Table 3.

** A: stored at 20~30°C; B: stored at -18~-22°C.

*** Odor grade: 1, excellent; 2, good; 3, light rancidity and off-flavor; 4, severe rancidity and off-flavor.

Table 6 爲製品在室溫貯藏時 V.B.N. 的變化情形，顯示其值有漸增之傾向。水分越高者，其V.B.N.值均較水分低者爲大，但水分在10%以下者則無多大變化。故知若能控制製品之水分在10%以下時卽有耐藏之效果，而水分較高者則宜在低溫下貯藏。

Table 6. Changes in V.B.N. of hot-air dried krill during storage at 20～30°C for 35 days. (unit: mg%)

group*	0 day	7 days	14 days	35 days
I-1	170.01	193.36	257.42	—
I-2	14.97	20.95	46.69	—
I-3	19.76	—	25.74	134.39
II-1	30.53	—	—	—
II-2	36.52	—	44.89	111.35
II-3	19.76	—	25.14	31.13
III-1	23.35	159.24	—	—
III-2	18.85	—	27.54	—
III-3	—	—	23.94	19.46
IV-1	173.01	146.67	256.22	—
IV-2	23.34	—	83.21	—
IV-3	14.37	14.97	19.76	17.06
V-1	53.28	—	—	—
V-2	20.36	—	22.15	—
V-3	10.78	—	19.76	57.71

* See the footnote of Table 3.

三、異抗壞血酸鈉和山梨醇對製品之保色效果

由 Table 7a, 7b 可知製品貯於室內（20～30°C）及冰櫃（-18～-22°C）中時色澤之變化情形。貯於室內者，各組之白色度（L值），黃色度（b值）均有漸減之傾向，紅色度（a值）亦有減少之傾向，然第IV組（3%山梨醇添加組）之a值於貯藏期間甚爲穩定，且較其他各組有較高值；由 Table 7c 的官能檢查亦顯示相同的結果，即第IV組者於第35天時與第0天時之a值殆無顯著之變化，而其他各組則因生黴致呈灰綠色使色澤變暗。相反地，貯於-18～-22°C中者，於貯藏期間，各組之 L, b 值雖有減少之傾向，然與貯於 20～30°C 者比較，則有較高的L值及較低的b值。其a值雖亦有減少之傾向，但第35天時反而略有增加，且較後者有較高值。此外，第IV組之a值亦較其他各組有較高值， Table 7c 亦顯示相同的結果，即其色澤較爲鮮紅。

由上述貯藏試驗結果推知，製品在－18～20°C貯藏時，對色澤之保持效果較在20～30°C貯藏時爲佳。此外，異抗壞血酸鈉和山梨醇之使用對色澤亦有良好的保持效果，其使用量分別爲1%及3%時最爲適當。推測其原因爲：山梨醇除了可做爲甜味劑外，尚有封鎖微量金屬離子之功用，而阻止由金屬離子催化產生之變色，故亦有保色效果[7]；異抗壞血酸鈉因係一種抗氧化劑，故能阻止因油脂氧化而產生之褐變，

Table 7a. Changes in color of hot-air dried krill during storage at 20~30°C for 35 days.

group*	0 day			7 days			14 days			35 days		
	L	a	b	L	a	b	L	a	b	L	a	b
I-1	44.1	19.6	17.6	34.2	15.2	13.9	34.9	14.7	14.3	29.7	13.2	11.5
I-2	44.2	19.8	17.0	37.0	13.1	14.4	38.1	12.0	15.0	35.8	9.3	12.4
I-3	51.4	20.1	16.7	41.0	13.2	14.2	42.0	12.9	14.5	38.4	12.1	13.9
II-1	44.5	10.2	16.3	36.7	13.0	14.4	—	—	—	33.2	6.4	9.6
II-2	48.8	17.6	13.9	39.8	13.5	14.4	41.0	12.0	15.1	37.6	12.3	14.0
II-3	49.6	17.6	14.7	40.4	14.7	14.2	40.6	13.3	14.9	37.7	12.3	13.2
III-1	42.9	20.2	15.9	35.7	14.8	13.9	—	—	—	34.2	12.2	11.6
III-2	43.9	18.0	15.0	36.2	13.9	13.9	37.8	11.6	14.7	36.1	9.2	11.4
III-3	46.5	17.6	13.6	39.7	13.2	14.0	39.8	12.9	14.9	38.2	11.0	14.3
IV-1	43.8	19.7	15.8	34.7	16.4	13.9	37.0	16.1	14.7	32.6	16.3	12.6
IV-2	43.4	19.2	15.5	34.6	16.3	13.5	35.9	16.1	14.6	32.5	16.1	11.3
IV-3	48.8	17.0	14.8	39.7	16.4	13.2	36.8	16.2	14.7	37.9	16.0	13.6
V-1	43.9	18.5	15.6	35.4	14.7	13.9	—	—	—	34.8	11.7	12.2
V-2	46.2	17.2	14.7	38.4	13.0	13.6	39.8	12.7	13.9	36.6	10.2	13.7
V-3	47.8	17.5	14.7	39.8	12.9	14.5	40.2	11.0	15.1	36.9	10.2	14.1

* See the footnote of Table 3.

Table 7b. Changes in color of hot-air dried krill during storage at −18~−22°C for 35 days.

group*	0 day			7 days			14 days			35 days		
	L	a	b	L	a	b	L	a	b	L	a	b
I-1	44.1	19.6	17.6	37.1	14.8	14.4	37.2	14.6	14.6	35.8	15.6	14.1
I-2	44.2	19.8	17.0	35.1	13.1	13.0	35.0	13.7	14.0	33.4	12.9	12.2
I-3	51.4	20.1	16.7	41.7	11.5	13.8	43.2	12.3	14.1	39.6	12.1	12.2
II-1	44.5	10.2	16.3	36.4	14.3	14.1	35.2	14.3	14.0	35.5	14.5	13.7
II-2	48.8	17.6	13.9	39.1	13.6	12.8	40.1	13.0	13.1	37.8	13.6	12.4
II-3	49.6	17.6	14.7	41.0	12.9	13.6	41.0	13.0	13.6	38.9	12.4	12.4
III-1	42.9	20.2	15.9	36.6	15.6	14.6	36.6	15.2	14.3	34.1	14.5	13.0
III-2	43.9	18.0	15.0	36.7	13.9	13.7	35.0	13.6	13.6	32.4	14.2	12.4
III-3	46.5	17.6	13.6	40.8	13.5	13.8	40.1	13.5	13.4	38.6	13.8	12.7
IV-1	43.8	19.7	15.8	37.6	15.1	14.5	37.1	15.7	15.0	34.7	16.0	13.4
IV-2	43.5	19.2	15.5	36.8	15.1	14.6	37.0	15.2	14.6	33.1	15.7	12.9
IV-3	48.8	17.0	14.8	40.9	12.5	13.9	42.0	12.5	13.9	38.9	12.4	12.5
V-1	43.9	18.5	15.6	36.9	13.4	14.3	36.3	14.5	14.2	35.2	13.7	12.7
V-2	46.2	17.2	14.7	35.8	13.4	12.0	38.0	12.4	13.5	36.3	12.9	12.4
V-3	47.8	17.5	14.7	39.1	12.8	13.2	39.0	12.3	13.5	37.3	13.1	12.5

* See the footnote of Table 3.

Table 7c. Changes in color and appearance** of hot-air dried krill estimated by organoleptic method during storage at 20～30°C for 28 days.

group*	20～30°C					−18～22°C
	0 day	7 days	14 days	21 days	28 days	0～28 days
Ⅰ-1	A	A	A	B,M	B,M	A
Ⅰ-2	A	A	B	B,M	B,M	A
Ⅰ-3	B	B	B	B	B	B
Ⅱ-1	A	A	B,M	B,M	B,M	B
Ⅱ-2	A	A	B	B	B	A
Ⅱ-3	A	B	B	B	B	A
Ⅲ-1	A	A	A,M	A,M	A,M	A
Ⅲ-2	A	A	B,M	B,M	B,M	A
Ⅲ-3	B	B	B	B	B	B
Ⅵ-1	A	A	A	A,M	A,M	A
Ⅵ-2	A	A	A,M	A,M	A,M	A
Ⅵ-3	B	B	B	B	B	B
Ⅴ-1	A	A	A	B,M	B,M	A
Ⅴ-2	A	B	B	B	B	A
Ⅴ-3	B	B	B	B	B	B

* See the footnote of Table 3.

** Symbol A: light red; B: dark red; M: molded.

故具保色效果。總之，原料若先在含 1 %異抗壞血酸鈉的 3 %食鹽水中浸漬解凍，然後在含 3 %山梨醇的 3 %食鹽水煮液中煮熟時，將使製品具有較佳之色澤。

四、解凍方法之檢討

因原料係呈凍結狀態者，於加工前勢必須先行解凍處理，然解凍時因蝦體內之可溶性營養成分隨滴出液流失，對製品之品質具有不良影響。本實驗之解凍溫度爲20～22° C，原料重 10,740g，解凍後重9,000g，故其流失率爲 16.20%。然依筆者等[8] 之另一解凍試驗得知，在 25° C之水溫中解凍時，重量均減少，但在10° C以下之水溫中解凍時，重量却增加；此外，若以 3 %食鹽水，內含0.5%異抗壞血酸鈉，使其水溫降至 10° C 以下以解凍凍藏之南極蝦時，其全氮素之流失量可由 46.7mg% (22～25° C空氣解凍) 及 30mg% (5～10° C空氣解凍) 降至 22.2mg%。故爲減少解凍過程中重量及營養成分之流失起見，浸漬解凍之水溫宜在 10° C 以下。

Table 8. Changes in moisture of cold-air dried krill during storage at 15~25°C for 35 days.

group*	0 day	7 days	14 days	21 days	28 days	35 days
control-1	17.57	14.97	17.79	16.75	17.62	17.10
control-2	16.40	13.17	15.07	15.28	16.66	15.50
I-1	18.45	12.64	16.29	15.30	17.56	16.76
I-2	14.15	13.14	13.49	14.42	15.24	14.50
II-1	40.15	44.73	44.67	43.68	45.39	44.16
II-2	22.80	21.20	21.50	21.17	21.80	20.28
III-1	44.56	39.36	41.52	41.96	41.94	41.49
III-2	22.61	21.60	21.35	22.52	21.49	21.52
VI-1	22.78	21.65	23.20	21.60	22.40	23.68
VI-2	14.64	14.09	12.34	12.98	13.52	14.21

* The thawed krill in groups I, II, III, IV and the control were boiled in 3% NaCl solution containing 0.01%, 0.02%, 0.01%, 0.02% and 0% B.H.A., respectively, and the boiled krill were then sprayed with 0.1%, 0.1%, 0.2%, 0.2% and 0% sorbic acid solution in alcohol, respectively. The sub-groups 1 and 2 represent the products of 20 and 28 hours of cold-air drying, respectively.

Table 9. Changes in pH of cold-air dried krill during storage at 15~25°C for 35 days.

group*	0 day	7 days	14 days	21 days	28 days	35 days
control-1	7.42	7.34	7.30	7.22	7.17	7.08
control-2	7.45	7.36	7.30	7.26	7.16	7.05
I-1	7.33	7.28	7.16	7.25	7.23	7.10
I-2	7.28	7.28	7.28	7.24	7.20	7.23
II-1	7.45	7.36	7.50	7.42	7.74	7.63
II-2	7.28	7.29	7.39	7.24	7.20	7.09
III-1	7.37	7.30	7.35	7.23	7.17	7.10
III-2	7.22	7.23	7.21	7.19	7.13	7.10
VI-1	7.17	7.18	7.11	7.12	7.09	7.04
VI-2	7.21	7.21	7.10	7.17	7.11	7.06

* See the footnote of Table 8.

實驗Ⅲ、冷風乾燥法

一、製品貯藏中水分、pH、V.B.N. 之變化情形

Table 8 係表示將製品密封於聚乙烯袋中在15～25°C貯藏時，各種製品之水分變化均極少。

製品在15～25°C貯藏時之 pH 變化則如 Table 9 所示。由此表得知：第Ⅱ-1組的pH值在貯藏期間顯然較其他製品者爲高且有漸增之傾向，然其他製品者則有減少之傾向。第Ⅱ-1組製品之pH值在第21天時爲7.42，第28天時則升至7.74，第35天時雖略有減低，但仍有7.63，顯示該組製品於第28天時其品質已下降；官能檢查亦覺出此時該製品已有異臭產生，其他製品則無。

Table 10. Changes in V.B.N. of cold-air dried krill during storage at 15～25°C for 35 days.

group*	0 day	7 days	14 days	21 days	28 days	35 days
control-1	7.87	8.87	11.64	12.99	15.01	19.34
control-2	6.12	9.15	10.44	12.83	13.78	17.02
Ⅰ-1	6.89	9.48	10.74	12.78	25.49	18.10
Ⅰ-2	6.92	8.25	10.60	10.79	13.56	17.35
Ⅱ-1	10.22	12.62	25.09	52.79	105.99	122.08
Ⅱ-2	11.85	12.53	13.60	17.70	18.44	22.09
Ⅲ-1	10.75	12.47	13.51	16.94	19.03	27.96
Ⅲ-2	10.28	11.95	13.93	15.80	18.31	21.13
Ⅵ-1	12.09	13.43	13.87	14.99	17.94	22.44
Ⅵ-2	8.89	8.87	10.32	10.90	14.30	17.62

* See the footnote of Table 8.

Table 10 爲製品在35天貯藏期間 V.B.N. 的變化情形。各組的 V.B.N. 值在貯藏期間均有漸增之傾向，除第Ⅱ-1組外，其他製品於第35天時仍低於 30mg%；而第Ⅱ-1組在第 21、28、35 天時分別爲52.79、105.99、122.08mg%，顯示該製品在第28天時品質已顯著下降，此結果與 Table 9 及官能檢查所示者相符合，故V.B.N.值之變化可作爲此等製品品質變化之指標[9]。

二、B.H.A. 對蝦體之保色效果

製品在15～25°C貯藏時之色澤變化如 Table 11 所示。各組之 L, a, b 值於第14天時均顯著減少，但此後直到第35天時則無多大變化。與對照組作比較，其他各組均有較佳的紅色（a 值），且B.H.A.之添加量0.02%者較0.01%者有較高的 a 值，顯示 B.H.A. 具有良好的保色效果。

Table 11. Changes in color of cold-air dried krill during storage at 15~25°C for 35 days.

group*	0 day			7 days			21 adys			35 days		
	L	a	b	L	a	b	L	a	b	L	a	b
control-1	40.5	16.5	15.4	40.4	16.9	17.4	34.8	11.9	13.8	36.2	11.3	14.7
control-2	40.6	15.4	15.1	47.0	16.7	17.0	36.3	10.3	13.7	37.6	10.7	15.0
Ⅰ-1	39.0	16.7	14.4	44.9	19.5	16.2	32.2	14.6	12.2	34.3	14.6	13.3
Ⅰ-2	39.0	16.1	14.1	44.8	18.9	16.1	33.7	14.1	12.0	34.0	14.9	13.0
Ⅱ-1	34.1	16.9	13.0	35.9	18.2	12.0	28.5	13.4	9.5	28.9	14.7	10.9
Ⅱ-2	37.5	16.1	14.0	40.5	18.1	13.6	30.9	14.0	11.2	30.0	15.1	11.9
Ⅲ-1	34.6	15.2	13.1	36.6	17.7	12.6	30.1	13.2	10.7	29.8	14.2	12.0
Ⅲ-2	38.1	14.6	14.5	39.2	17.3	14.0	31.3	13.6	11.6	31.4	14.7	12.7
Ⅵ-1	37.8	14.5	14.3	40.9	19.0	14.4	30.4	14.0	10.8	29.8	14.9	11.9
Ⅵ-2	40.3	14.1	14.2	43.4	19.4	15.1	33.7	14.7	12.1	33.9	14.7	12.6

* See the footnote of Table 8.

三、山梨酸對製品之保藏效果

Table 12. Changes in aerobic plate count of cold-air dried krill during storage at 15~25°C for 35 days. (no./g of product)

group*	7 days	21 days	35 days
control-1	2.5×10^{2}	5.0×10^{2}	2.8×10^{5}
control-2	1.5×10^{2}	—	3.0×10^{3}
Ⅰ-1	1.0×10^{3}	—	2.0×10^{2}
Ⅰ-2	8.0×10^{2}	5.0×10^{3}	5.0×10^{2}
Ⅱ-1	—	5.0×10^{2}	9.5×10^{2}
Ⅱ-2	5.0×10^{3}	3.9×10^{4}	1.5×10^{3}
Ⅲ-1	5.0×10^{1}	8.6×10^{3}	2.8×10^{4}
Ⅲ-2	4.0×10^{3}	2.5×10^{2}	1.0×10^{3}
Ⅵ-1	—	—	1.0×10^{2}
Ⅵ-2	—	2.5×10^{2}	1.0×10^{3}

* See the footnote of Table 8.

Table 12 爲製品在15～25° C貯藏時生菌數之增加情形。隨時間之經過，各組之生菌數有漸增之傾向，但於35天之貯藏期間中，各區均無黴菌生長，顯示山梨酸爲一種有效的黴菌抑制劑。就製品之水分相近者作比較，山梨酸添加量越多者，其生菌數則較少，且各組生菌數之增加並不顯著。故添加0.1～0.2%山梨酸於製品時，對細菌亦有良好的抑制效果。

四、製品之脆度

由 Table 13 得知，製品之形態已較用熱風乾燥者爲完整，顯示冷風乾燥法對製品之形態有良好的保持效果。

Table 13. The fragility of cold-air dried krill. (no. of krill: 20)

group*	cephalothorax			telson		
	1**	2**	3**	1**	2**	3**
control-1	11	5	4	16	3	1
control-2	10	6	4	14	4	2
I-1	13	4	3	12	5	3
I-2	12	5	3	10	8	2
II-1	13	5	2	14	4	2
II-2	14	5	1	14	4	2
III-1	13	4	3	17	2	1
III-2	12	5	3	13	6	1
VI-1	12	6	2	16	4	0
VI-2	15	3	2	12	8	0

* See the footnote of Table 8.

** Grade 1: little destruction; Grade 2: some destruction; Grade 3: severe destruction.

結　　論

由於南極蝦的自家消化酵素與黑變原因酵素之活性甚强，爲防止製造過程中蝦肉之液化與蝦體之黑變，則適當的煮熟處理及抗氧化劑或防腐劑之添加等 ， 對製品之品質具有良好的保持效果，將是有效的方法。

於南極海域剛漁獲後之南極蝦，如能採用一貫作業之方式處理，亦即先在含 1 %異抗壞血酸鈉及 3 % 山梨醇的 3 %食鹽水溶液中浸漬10分鐘，次經連續式煮蝦鍋，以95～100° C的 3 %食鹽（或潔淨海水）或另添加 0.01～0.02% B.H.A. 的 3 %食鹽水或潔淨海水中煮熟 5 分鐘，再經連續式之冷風或熱風乾燥機以15～25° C或100～105° C風速 1.9m/sec 之空氣乾燥，於製品水分在20～30%時噴灑製品重0.1～0.2% 之山梨酸酒精溶液，最後用密封性良好的 pE 塑膠袋包裝，貯於 0～5° C低溫處，則可長期保持製品之形

態、色澤、臭味等品質，且使 V.B.N. 值保持在較低值，並能有效抑制黴菌或細菌之增殖。如此所得之南極蝦乾製品，將可降低成本，增加積載量，從而促進南極蝦漁業之發展。

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摘　　要

就生鮮凍結的南極蝦施以不同的前處理，然後以天日、熱風、冷風等三種方法實施乾燥以試製乾製品，並進行貯藏試驗。其結果如下：

(1) 就天日乾燥法言，生鮮凍結的南極蝦宜在解凍後煮熟再行日乾，如此之製品將保有較好的色澤。

(2) 南極蝦乾製品所含水分宜在20～30%，包裝材料應能阻止外界空氣之滲透。製品若貯於低溫時，其 pH、V.B.N、色澤、嗅味等變化很少，且可保持其品質和外觀於較佳狀態。

(3) B.H.A. 製品具有良好的保色效果，其添加量0.02%者比0.01%者效果爲佳。以含 3 %山梨醇和 1 %異抗壞血酸鈉的 3 %食鹽水溶液浸漬解凍，對製品亦有相當的保色效果。

(4) 添加0.1～0.2%山梨酸於製品時，可有效地抑制黴菌或細菌的增殖。

(5) 以冷風乾燥法進行乾燥時，可得含適當水分的製品，且其形態亦相當完整。

南極蝦油製造試驗

Studies on the Manufacture and Storage of the Krill Sauce

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ABSTRACT

Fresh and frozen Antarctic krill were used as raw materials for sauce manufacture. The krill sauce was made by adding various amounts of salt. The quality of the manufactured sauce was inquired. In addition, the sauce quality after storage was also studied in this experiment.

Antarctic krill with 15, 20, 25, 30% salt added were autolyzed by their intrinsic proteolytic enzymes under room temperature. After filtration, the yield of krill sauce products ranged from 68.1 to 77%.

The amino-N of krill sauce was about 30% of total-N. The krill sauce produced with 30% salt concentration was most lowest in transmittance (330 nm), VBN, total-N and amino-N. It was observed that the above parameters were increased as the salt concentration decreased. The colour of krill sauce darkened by boiling process, and so did VBN increase from 58.30 mg% to 64.11 mg%. At a storage temperature of 5±2°C for 104 days, the VBN and transmittance remained almost unchanged. However, the VBN increased and transmittance decreased as the storage went on at higher temperatures (i.e. 30±4°C).

In a storage experiment, the 0.025% butyl p-hydroxybenzoate and 3% ethyl alcohol were added respectively. After storing for 114 days, there was no antiseptic effect by these two chemicals from the view point of the increase in VBN. The addition of sodium bisulfite or BHA (butylated hydroxyanisol) could improve the colour of krill

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sauce after storage. But the increase in VBN after 10-week storage was further promoted owing to the addition of sodium bisulfite, and the VBN was doubled as compared to the control.

前　　言

我國所產的蝦油，係由小蝦或雜魚製成，因氣味特殊，爲部份人士所嗜食，此種蝦油皆經自然醱酵而成[1]，製法極爲簡單。

南極蝦體小，且其蛋白質分解酵素活性甚强[2][3]，形成利用上及加工上的一大瓶頸。但其氨基酸的組成極爲平衡[4]，其中甘氨酸含量特多，無論就營養上或食味上而言，確是一種良好的食物，自亦可做上述蝦油製造之原料。

爲利用南極蝦天生的體型小，酵素活性强的缺點，藉以製成蝦油，以嘗試做南極蝦利用途徑的一個方法，並研討成品在貯藏中的變化情形，以供加工及利用上的參考，特實施此項試驗。茲將試驗結果報告如下：

材料與方法

一、試驗材料

本試驗所用試料係海功號試驗船於1977年1月24日至2月7日，在恩得比東北外緣附近海域（65°28′S，58°17′E）所漁獲者，就地加工蝦油或經－40°C的管棚式凍結室或－35°C的接觸式凍結室凍結8小時，貯於－36°C冷凍庫內保藏，回港後於5月15日卸下，改放陸上冷凍庫（－17±2°C）中。供試時未待解凍，即用鐵榔頭予以打碎，秤取需要量使用，所用南極蝦之一般成份請見前報[5]。

二、蝦油製法

南極蝦油的製法係將南極蝦分別用不同重量的食鹽（高級精鹽，NaCl 99.5% 以上）摻和，放入20 l容塑膠桶中，施蓋，俟完全解凍後再將塑膠桶橫倒滾動，使食鹽與南極蝦混合均勻，即放置於常溫下靠自然醱酵，醱酵完成後，用尼龍布粗濾，未消化物再加以壓榨，務使液體部份完全分離，最後將濾液再用濾紙（Toyo No. 2）過濾即得成品。

在船上製造者，係將捕獲之南極蝦用海水洗淨後，立即處理之，此種南極蝦鮮度良好，大部份是活生的。用鹽醃漬放置第二甲板上（在南極海上室溫爲 5°C 左右，隨着回航室溫漸趨增高），携回分離蝦油。

三、分析方法

南極蝦油之分析依下列方法實施：

1). 水分、粗蛋白、粗脂肪、粗灰分：均依常法測定。

2). 揮發性鹽基態氮（V B N）：採用微量擴散法（Conway 法）。

3). 胺基態氮：採用 Formol 滴定法。

4). 鹽　　分：採用硝酸銀滴定法。

5). pH：用 TOA pH meter, HM-5A（玻璃電極）測定。

6). 透 光 率：將南極蝦油用蒸餾水稀釋 100 倍後，用 Spectronic 20 或 Hitachi 60-100 UV-Vis_S 光電比色計測定，最大吸收波長爲 330 nm。馬祖產蝦油以相同方法測定之最大吸收波長爲 307 nm。

7). 消化率(%)$=\frac{\text{胺基態氮(g)}}{\text{全氮(g)}}\times 100$

結果及討論

1. 熟成期間之成份變化

使用凍結南極蝦 10kg 兩份，分別加食鹽 3 及 2 kg，混合均勻後放置常溫任其醱酵，每隔一定時日，採樣測定各種成份與項目，結果列於 Table 1。

在爲時 27 天的熟成期間中，所分離的蝦油，其各種成份包括 pH，VBN，AN 及比重均有增加，但變化幅度並不很大，就 30% NaCl 與 20% NaCl 區的相異而言，前者的 Amino N, pH,及 VBN 均較低，證明鹽分有抑制魚體自家消化及延遲腐敗作用的功能，此和一般鹽藏法的基本觀念[6] 並無不同。

比重亦以 30% NaCl 區爲高，由於該區的 TN 在 1,602～1,690 mg% 間，較 20% NaCl 區的 1,760～2,020 mg% 爲低，推測其高低差異並非由可溶性氮所形成，而是溶解的食鹽量不同所致。

比重的相異既以食鹽的溶解量不同爲主要原因，則高比重區的 30% NaCl 區鹽分含量自亦較高，設消化程度相同時，該南極蝦油的含氮因受到鹽分含量影響，其呈值顯然較低，方爲合理。但筆者等，將全氮及胺基態氮分別除以比重後的數值比較，則 20% NaCl 區的含氮量仍然較高，足證 NaCl 過多，蛋白質變性度較高，溶解度減低，且其自家消化亦會受阻。

2. 用鹽量對於南極蝦油成份品質之影響

依照前述方法，用冷凍南極蝦分別加15，20，25，30%等不同量的食鹽，醃漬後，第一次於第45天及第51天，第二次於第97天分離蝦油及蝦醬（殘渣）並加以分析，結果列於 Table 2。

由Table 2 可知，南極蝦油的收率以用鹽少者爲高，此和前節的結果相同，證明食鹽有抑制消化的功能。至於消化率雖均在34%上下，但T N及A N均隨着用鹽量的增多而減低。因此，用鹽量較低的15%及20%區，蝦油收率既高，而T N及A N含量亦較豐富，故蝦油中T N及A N絕對量仍以低鹽量區爲佳，只是低鹽區的V B N含量較高爲其缺點。由此可見，如欲速釀南極蝦油，用鹽量不能太多，惟所得蝦油不耐久藏爲其缺點。否則如以久藏爲目的時，用鹽量應酌予提高，如用鹽量爲30%區，在第97天時，其品質尙稱相當穩定，其V B N仍保持在第45天的水準，惟經品評結果被認爲味道過鹹爲其缺點。反之，15%區的V B N含量則由 73.72 mg% 升高到 92.06 mg%。其餘 25% 及 20% 區的V B N變化情形均較微。由以上試驗結果衡量，南極蝦油製造時的用鹽量以20%或以上爲適當。

Table 1. Chemical and physical disposition change of krill sauce after different salting days.

salting days	conc. NaCl	pH	specific gravity	V B N	total N	amino N	amino N	digestibility	max. absorption	trans-mittance (330nm)
	%			mg%	mg%	mg/100ml	mg/100g	%	nm	%
4	30	6.46	1.1998	43.46	1.602	574	479	29.9	330	54.9
8	30	6.55	1.1916	50.64	1.669	608	510	30.1	330	55.2
12	30	6.50	1.1954	54.88	1.660	634	530	31.9	330	54.9
17	30	6.55	1.2027	46.26	1.690	657	546	32.3	328	55.7
20	30	6.52	1.2107	47.86	1.690	670	553	32.7	330	54.9
23	30	—	1.2029	49.39	1.690	678	564	33.3	—	—
27	30	—	1.2102	48.48	1.690	654	540	31.9	—	—
4	20	6.58	1.1357	46.16	1.943	669	589	30.3	334	64.9
8	20	6.58	1.1519	53.16	1.887	662	575	30.5	334	60.7
12	20	6.58	1.1752	58.48	1.760	692	589	33.5	334	64.1
17	20	6.67	1.1716	64.41	2.020	730	623	30.8	330	61.0
20	20	6.64	1.1897	49.58	2.020	746	627	31.0	330	58.8
23	20	—	1.1795	55.18	2.020	722	612	30.2	—	—
27	20	—	1.1842	50.74	2.020	782	660	32.6	—	—

Table 2. Chemical and physical disposition of krill sauce under different NaCl concentrations.

salting days	NaCl conc.	yield of sauce	weight of residue	moisture of residue	specific gravity	V B N	total N	amino N	amino N	diges-tibility	max. absorption	trans-mittance (330nm)
	%	%	kg	%		mg%	mg%	mg/100ml	mg/100g	%	nm	%
45	30	68.1	4.20	48.86	1.2129	47.60	1.514	673	555	36.7	331	39.3
	25	75.6	3.10	52.61	1.2025	51.40	1.602	672	559	34.5	335	39.1
	20	77.5	2.30	52.60	1.1842	58.02	1.786	714	603	33.8	331	44.1
	15	77.0	2.30	53.87	1.1608	73.72	1.829	724	624	34.1	330	46.9
51	30*	70.8	3.65	47.05	1.2121	99.00	1.620	601	496	30.6	330	60.8
	30**	63.1	4.60	62.30	1.2051	42.52	1.470	544	451	30.7	331	58.2
	25**	70.0	3.65	64.57	1.1942	44.52	1.480	524	439	29.7	330	56.5
	20**	77.7	2.50	56.28	1.1780	51.23	1.530	552	469	30.7	330	52.7
97	30	62.69	3.80	47.14	1.2120	42.10	1.442	478	556	38.5	330	58.7
	25	67.60	3.40	51.98	1.2038	60.40	1.562	519	625	40.0	330	61.9
	20	70.62	2.70	51.55	1.1850	66.61	1.795	576	683	38.0	330	68.6
	15	—	2.45	50.94	1.1655	92.06	1.872	655	763	40.7	330	70.2

* 1% (on krill weight) of $NaHSO_3$ was added.

** 0.02% (on krill weight) of BHA was added.

另外在用鹽量30%區同時添加 1% $NaHSO_3$，在30%，25%及15%區各添加 0.02% BHA，於第51天測定各項成份結果，確認添加 $NaHSO_3$ 者顏色較鮮紅，但VBN含量大爲增加，達 99 mg%，高居各區之首位。BHA係先用少量酒精溶解後添加，除成品之透明度較未添加區略好，紅色度增加及VBN含量稍低外，TN及AN含量亦均較低，消化率較未添加區稍差。總之，於南極蝦油釀造時添加適量BHA，有改善色澤之效，惟南極蝦自體消化略受到阻礙，使熟成時間加長。用BHA、BHT等酚系抗氧化劑於蝦類加工品，可防止蝦殼色素或紅皮魚類及鮭等肌肉色素的褪色等，已分別有報告。

3. 南極蝦油在貯藏中之品質變化

一般蝦油在貯藏中會發生顏色暗化及異臭，終至腐敗，而嚴重地影響成品的品質。爲明瞭南極蝦油在貯藏中的品質變化，於南極海上將剛漁獲之南極蝦，立刻加 30% 的 NaCl，置15±10°C處熟成100天後，予以分離蝦油，並取其中一部份再加熱至沸騰，放冷後密閉於玻璃瓶內，以比較貯藏中品質變化情形。

所得生南極蝦油及熟南極蝦油之一般成份分析結果列於Table 3。

Table 3. Chemical composition of fresh and boiled krill sauce.

krill sauce	moisture	crude protein	crude fat	crude ash	salinity	pH	VBN	transmittance (330nm)
	%	%	%	%	%		mg%	%
boiled	64.66	9.79	0.130	22.78	24.31	5.97	64.11	46.5
fresh	65.10	9.23	0.126	22.90	24.51	6.01	58.30	63.5

由此結果獲知，南極蝦油經煮熟後因蒸發致水分略減，以及透光度顯著降低，顏色暗化，似爲Maillard反應所致。VBN則因加熱而由 58.30mg% 增至64.11 mg%，此和fish soluble經 90～95°C，15分鐘之加熱後，VBN增加 1.5倍[8]比較，增加幅度並不算很高，其餘各成份都無明顯變化。

次將以上二種南極蝦油分別置於低溫（5±2°C）及常溫（30±4°C）等恒溫庫內，定期測定透光度及VBN變化情形，結果分別列於 Table 4 及Table 5。南極蝦油之吸收光譜如 Fig. 1，於 330nm 處有最大吸收，和筆者的另一試驗[9]，就南極蝦之水解物測定之吸收光譜極爲相似。

由Table 4 可見，在爲期104～117天的貯藏期間中，貯於低溫者無論生或熟南極蝦油，某透光率變化極微，幾乎保持原來的程度，至於貯存在常溫者，透光度隨着貯藏日數之增加而逐漸減低，即次第暗化，在117 天期間內透光率之減少，無論生或熟南極蝦油幾達40%之多。因此爲保持蝦油固有顏色與透明度，將蝦油貯藏於 5°C溫度下，即可充分地達到目的。

至於 pH在貯藏期間中殊少變化，均略呈酸性，與VBN在室溫下稍有增加（Table 5）之現象相比，兩者間顯然無相關關係存在。因此尚無法由 pH判斷新鮮度之變化情形。

4. 各種防腐劑對於南極蝦油之防腐效果

以醬油一般習用之防腐劑[10]，如對經苯甲酸丁酯（Butyl p-hydroxybenzoate），酒精等，以及在上面已有試用之 $NaHSO_3$ 及BHA，分別添加於南極蝦油中密封，置於常溫下，由VBN及透光率之變化來判斷是否有防腐效果，結果如Table 6 及Table 7。

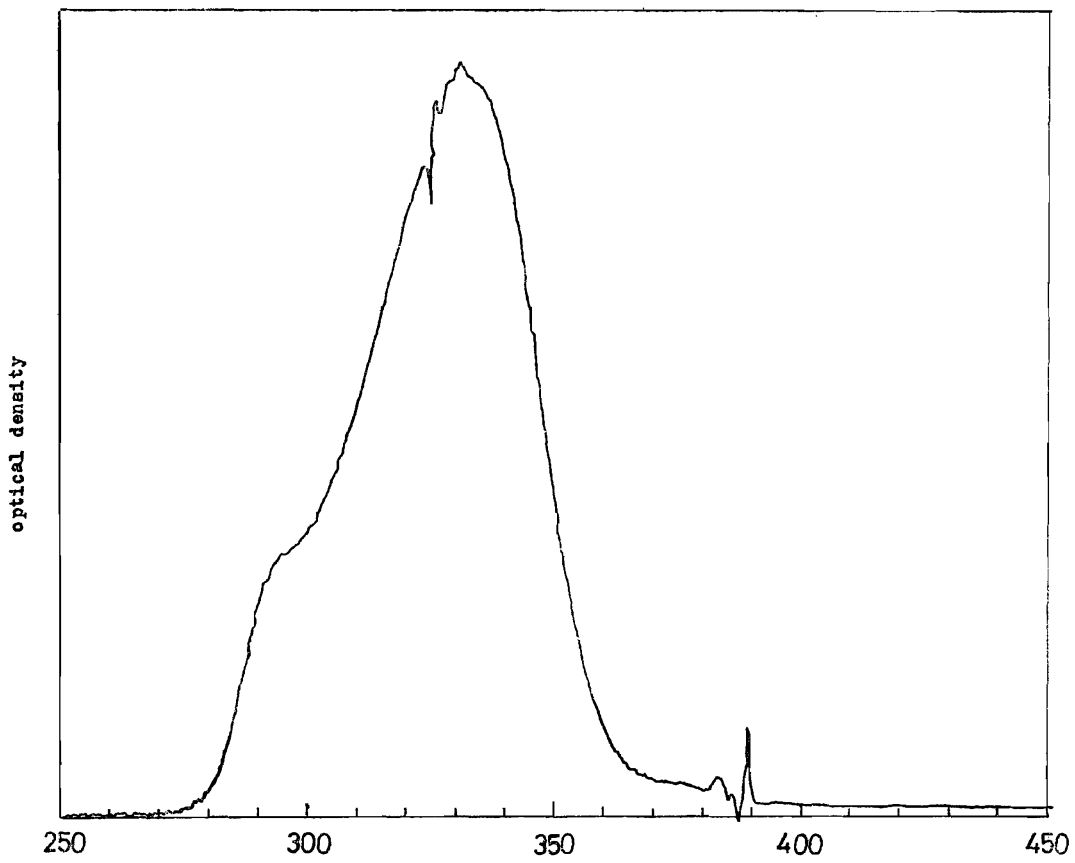

Fig 1. Absorption spectra of Antarctic krill sauce.

Table 4. Transmittance change (330 nm) of krill sauce during storage at low temperature and room temperature for 117 days.

storage time (day)	5 ±2° C		30±4° C	
	fresh	boiled	fresh	boiled
0	63.5	46.5	63.5	46.5
15	64.8	51.5	62.3	49.0
21	62.5	50.0	60.1	45.3
32	64.7	49.4	55.9	43.0
45	60.5	47.5	53.0	41.2
54	63.0	50.1	50.2	39.0
64	63.0	51.1	50.3	38.7
76	60.5	49.0	44.3	33.8
92	60.0	48.6	42.0	31.8
104	61.7	50.0	40.2	32.3
117	65.8	50.1	38.7	29.8

Table 5. VBN change of krill sauce during storage at low temperature and room temperature for 104 days.

storage time (day)	5 ±2° C		30±4° C	
	fresh	boiled	fresh	boiled
0	58.30	64.11	58.30	64.11
15	57.88	64.70	63.40	70.66
21	58.24	64.76	65.20	72.12
32	59.25	71.97	65.74	72.12
45	62.49	70.42	68.47	72.94
54	64.93	70.31	70.29	73.01
64	54.98	62.30	65.09	70.45
76	53.12	60.31	67.71	71.20
92	57.47	62.21	71.92	72.64
104	56.17	61.58	67.46	71.39

Table 6. Comparison of VBN change of krill sauce between different antiseptics or antioxidants added.

expt no.	kinds and conc. of additives	NaCl conc.	weeks of storage at room temperature									
			1	2	3	4	5	6	7	8	9	10
1	butyl P-hydroxybenzoate 0.25g/L	28.79	46.00	47.12	48.48	50.32	49.57	50.62	53.37	52.11	56.91	58.25
2*	bitto	28.20	60.11	71.02	64.18	70.21	65.14	69.31	75.13	73.33	76.43	90.13
3	ethyl alcohol 3%	27.73	45.56	45.81	49.42	52.90	51.82	50.88	55.91	55.11	59.99	59.17
4*	ditto	27.61	44.94	50.49	57.98	67.97	65.91	72.81	73.43	73.51	75.53	76.45
5	none	28.63	44.95	47.49	50.19	54.59	53.83	50.69	59.52	58.12	60.75	61.53
6*	none	29.09	52.55	67.00	65.39	71.62	62.04	70.47	72.18	73.18	75.02	76.64
7	$NaHSO_3$ 1%	27.81	95.24	84.16	98.57	104.43	106.36	103.51	104.98	107.21	115.12	120.34
8	BHA 0.02%	28.23	38.17	42.30	43.80	49.87	43.13	50.79	54.60	57.60	57.36	59.12
9	ditto	26.26	38.38	45.06	48.31	43.20	41.24	49.45	67.71	68.72	70.26	70.76
10	ditto	22.77	46.62	44.63	49.94	47.30	52.45	52.11	53.84	55.21	60.50	59.67
average storage temperature			15.±.5	17.3±.8	19.3±.7	19.6±.4	18.9±.4	19.4±1.0	20.5±.5	20.3±.9	23.0±.7	23.1±.1

* Boiled krill sauce.

Table 7. Comparison of transmittance change (330 nm) of krill sauce between different antiseptics and antioxidants added.

expt no.	kinds and conc. of additives	NaCl conc.	weeks of storage at room temperature									
			1	2	3	4	5	6	7	8	9	10
1	butyl P-hydroxybenzoate 0.25g/L	28.79	28.3	26.1	27.6	26.9	26.4	24.1	25.7	25.3	24.9	24.7
2*	ditto	28.20	31.0	30.2	29.4	28.4	30.3	28.0	22.0	27.4	27.2	27.0
3	ethyl alcohol 3%	27.73	29.6	26.8	28.0	26.5	27.2	25.9	25.7	25.5	25.5	25.1
4*	ditto	27.61	32.0	29.9	29.2	29.1	30.3	28.0	27.9	28.2	28.0	27.9
5	none	28.63	27.5	25.9	24.8	26.0	26.3	26.1	25.5	25.3	25.4	24.3
6*	none	29.09	30.9	28.4	27.9	27.9	29.5	27.9	26.7	28.0	27.9	27.2
7	$NaHSO_3$ 1%	27.81	25.4	25.5	21.9	24.5	24.8	24.5	24.2	24.0	24.0	24.0
8	BHA 0.02%	28.23	26.1	26.5	25.1	25.9	25.2	26.1	25.5	25.5	25.1	23.8
9	ditto	26.26	27.9	27.9	25.7	26.5	26.2	25.5	24.7	24.8	25.0	24.6
10	ditt	22.77	29.7	31.9	28.8	28.2	28.6	27.9	28.0	28.2	27.9	27.9

* Boiled krill sauce.

一般而言，經過煮熟之南極蝦油，其V B N含量恒高於生南極蝦油，此和上面的試驗結果相同，至V B N生成量最高者爲添加 1 % NaH SO_3 區，在第 1 週卽有 95.24 mg%，至第10週則已達 120 mg%。此種情形已見於前項試驗，故添加 $NaHSO_3$ 於南極蝦油中，固能防止色澤之暗化，保持固有之蝦紅色，惟相反地有促進V B N之生成，咸屬不宜。而一般醬油習用之防腐劑，如對羥苯甲酸丁酯及酒精等，在本試驗中由V B N生成量而言，無論對於生或熟南極蝦油均無效果。至於添加B H A，係爲防止蝦紅色的褪色，其本身並無防腐效果，故V B N生成量未比對照區少，乃係意料中之事。因此，欲保持南極蝦油品質，仍以貯藏在 5 °C 左右之低溫處爲佳。

5. 南極蝦油與馬祖蝦油之比較

本省常見的蝦油，以馬祖產者最富代表性，且爲一般人熟悉及嗜好，因此以馬祖蝦油做比較之對象，較易明瞭品質之良窳。

本試驗用於做比較對象之馬祖特級蝦油（馬祖南竿鄉復興村99號，合記蝦油廠出品）購於馬祖，惟製造日期及方法均不明，玆將該蝦油於不同時間之分析結果列於Table 8 。

Table 8. Proximate analysis of shrimp sauce maufactured in Ma-Tzu.

date of analysis	moisture	pH	total N	amino N	V B N	transmittance (307 nm)
	%		%	mg%	mg%	%
March 27, 1978	69.12	5.90	1.49	571.64	181.71	52.25
April 24, 1978	67.40	6.28	1.47	577.50	188.79	50.60
May 29, 1978	67.49	6.48	1.49	671.31	190.29	48.64
June 27, 1978	67.07	6.49	1.47	584.70	190.94	48.01

由分析結果獲知其鹽分爲 25.58%，由此推之，其用鹽量亦約在25%之譜。與在南極洋所製之南極蝦油（Table 3）比較，則南極蝦油製造時用鹽量稍高（30%），故其水分含量相對地較低。雖然如此，南極蝦油的全氮量（1.48%，換算粗蛋白爲9.23%）仍不低於馬祖蝦油，胺基態氮含量亦有同樣現象。表示南極蝦油的品質並不比馬祖蝦油爲遜，此外其 pH及V B N含量雖與貯藏期間長短有關，惟在商店出售狀態下所購得的馬祖蝦油，應可代表平常出售時的品質。如斯者，其 pH及V B N均過高，尤以V B N爲甚，達 181～190 mg% 。據推測，當以製造時之原料不新鮮或製造後貯藏時間過久所致。南極蝦油與馬祖蝦油經輔仁大學食品營養系品評結果，以前者較後者爲優，其原因似爲V B N過高，使味道、嗅氣均受到不良影響，或成份上有某種不同所致，則尚待進一步的研究。

據阿部[11]分析其所製南極蝦油結果，確認有次黃嘌呤（Hypoxanthine），次黃嘌呤核苷（Inosine）及尿酸（Uric acid）等存在。次黃嘌呤核苷量隨着貯藏期間之增加而減少。至於次黃嘌呤量則愈趨增加，而雖然爲數極少，亦發現有一磷酸腺苷（Adenylic acid）存在。足見蝦油，包括南極蝦油，在貯藏中隨着貯藏日數之增加，會生成各種不好的成份，使品質劣化。像馬祖蝦油及本所自製南極蝦油之品質劣化，不外乎屬於此種變化的範疇內。

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摘　　要

利用南極蝦的强力蛋白質分解酵素活性，在南極海上，將剛漁獲的南極蝦以及經冷凍貯藏的南極蝦做爲原料，加10～30%的食鹽，於常溫下試製南極蝦油，並觀察貯藏中的品質變化情形，得到以下之結果：

1. 南極蝦於常溫下加20～30%食鹽醃漬後，第4日起所分離南極蝦油之全氮與胺基態氮含量之比約爲100：30，已趨於穩定，以後殊少變化。

2. 加15，20，25及30%等不同食鹽量製成的南極蝦油，收率最高者達77%（用鹽量15～20%），隨着用鹽量的增高而減少，最少者爲68.1%（用鹽量30%）。

3. 加30%食鹽製成的南極蝦油，其ＶＢＮ、總氮、胺基態氮、透光度（330 nm）等均較用鹽量少者低。

4. 南極蝦油製成後，經煮沸則透光率（330 nm）減低，顏色暗化，ＶＢＮ由58.30 mg% 增至64.11 mg%。生或熟南極蝦油分別在低溫（5±2°C）及常溫（30±4°C）貯藏104天，結果ＶＢＮ及透光率在低溫均幾無變化，貯藏於常溫者ＶＢＮ略有增加，透光率却減低。

5. 由VBN生成量判斷生或熱南極蝦油添加藥劑保存10週之效能，獲知加 0.25 g/l 對羥苯甲酸丁酯及 3 %酒精等均無明顯效果，加 $NaHSO_3$ 反而促進 VBN 之生成，其在第10週時 VBN 生成量爲 120.34mg%， 高出各種生南極蝦油 1 倍之多。

6. 南極蝦油的全氮和胺基態氮含量略高於坊間所售一種馬祖蝦油，並具較低的 pH及VBN值，實際品評結果，亦得較高評價。

南極蝦罐頭製造試驗

Experiments on Canning of Antarctic Krill

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SUMMARY

The main material of the canned product was frozen raw Antarctic krill, which had gone through the process of thawing, boiling, dripping, frying, canning and adding dressing. The process was completed when the filled cans were vacuum sealed, sterilized and cooled.

1. Yield of canned Antarctic krill—70%.
2. Appropriate time for pre-boiling—1～2 minutes.
3. Optimum time for dripping water—40 minutes.
4. Frying conditions—180°C for 3 minutes.
5. To stuff 130 gram of fried krill in a C-enameled Tuna No. 2 Can, filled with 10 ml dressing.
6. Sterilization—0.7kg/cm^2 for 40 minutes.
7. To improve the quality of the canned Antarctic krill, added 0.20～0.25% citric acid in the pre-boiling NaCl solution (2.5%).
8. Poor freshness of the Antarctic krill will not only give the krill bitter taste after they are canned, but also affect the quality of the canned products.

前　　言

民國六十五年，我國水產試驗所海功號試驗船，首次航向南極，在海功號全體同仁的共同努力下，捕獲了一百多噸南極蝦，使國人嚐到了南極蝦的鮮美味道，也使我國漁業發展史上邁向一個嶄新的里程。

南極蝦生長在廣大的南極海域中，據保守估計[1]，每年可有 5,000～7,000 萬噸的漁獲量，這個數字

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接近目前世界的總漁獲量；另據估計，南極蝦每年可漁獲 1～5 億噸之多。由此可知開發南極蘊藏豐富的南極蝦資源，正是解決世界糧食危機最有效的方法之一。

南極蝦有很高的營養價值[2, 3, 4]，它包括豐富的蛋白質和易爲人體消化吸收的脂肪，而且蛋白質中的氨基酸組成非常良好，此外亦含有鈣、磷、鎂、鐵等礦物質，以及維生素A、B_2、B_6，泛酸(pantothenic acid)、菸鹼酸 (nicotinic acid)、葉酸 (folic acid)、生物素 (biotin) 和維生素 B_{12} 等。目前南極蝦製品有冷凍品 (可製成燒賣、餃子等)、乾蝦、濃縮蛋白、蝦醬油和南極蝦蛋白糊 (paste) 等。加工方法不斷在改進，加工方式亦不斷在創新。

本試驗係利用南極蝦特殊的風味與特性，探討製造罐頭的可行性，藉以提高南極蝦的經濟價值，並爲南極蝦的加工發展一條可行的途徑。

材料與方法

一、試驗材料

1. 南極蝦 (*Euphausia superba*)：本試驗所用之南極蝦係海功號試驗船第一次南極之行 (65年12～66年3月) 所捕獲者，於66年9月以生鮮凍結狀態運至本分所。體長爲 3～6cm，重量爲 0.3～1.2 g。其一般成分如 Table 1。

Table 1. Chemical composition of frozen Antarctic krill.

moisture (%)	81.3
crude protein (%)	11.1
pure protein (%)	5.1
hot water soluble-N (%)	1.1
crude fat (%)	3.8
ash (%)	1.9
pH	7.4
V.B.N. (mg%)	20.4

註：本表取材自江善宗等[5]之試驗報告。

2. 沙拉油：益華沙拉油。
3. 鹽：再精製細鹽。
4. 味晶：味全公司出品。
5. 檸檬酸：三福公司出品，工業級。
6. 空罐：鮪二號塗漆罐。
7. 蒜頭、葱、辣椒……等：均購自菜市場。

二、試驗方法

1. 南極蝦罐頭製法：

本試驗係以生鮮凍結南極蝦爲原料，在空氣中解凍2小時，以原料蝦10倍的水量進行水煮，煮液中並添加2.5%食鹽及0.2%檸檬酸，經沸水煮1～2分鐘後，撈起滴乾約40分鐘。然後以180°C左右的沙拉油炸3分鐘，油滴乾後立即裝罐，裝罐時以鮪二號塗漆罐每罐裝130 g，另加調味液10 ml。調味液配方如Table 2。然後經眞空捲封，以 0.7 kg/cm² 殺菌40分鐘，最後以清水冷却即得本製品。

Table 2. The composition of dressing for canned Antarctic krill.

wine (rice wine)	1,200ml
black pepper	18 g
monosodium glutamate	60 g
salt	30 g
garlic	360 g
scallion	600 g
red pepper	12 g
water	1,800ml

調味液配法：將紅辣椒（12 g）、葱（600 g）和蒜頭（360 g）等切碎，與味晶（60 g），鹽（30 g）、胡椒（18 g）、米酒（600 ml）等置鍋中，加入水 1,800 ml，以大火煮開，再以文火煮約30分鐘，熄火再添加米酒 600 ml，製成調味液 1,000 ml（但葱、蒜頭等仍含有相當量的調味液，未完全搾出）。

2. 檢驗方法：

(1) 開罐檢查

將製品置恒溫箱（37°±1°C），貯存二週後，開罐檢查其眞空度，風味、色澤、肉質、固形量，嗜好性和罐壁等事項[6]。

(2) 品　評

由本分所5位同仁共同品評之。

結果與討論

一、南極蝦罐頭開罐檢查

依第 II、1 節南極蝦罐頭製法所製造之南極蝦罐頭，經過一個月貯藏後，開罐檢查，其結果如Table 3。

Table 3. Examination of canned Antarctic krill.

items	result
net weight	140 g
drained weight	136 g
can vacuum	25cmHg
flavor	good
color	good
preference	good
blackening	negative

本開罐檢查除由本分所 5 位同仁品評外，並承蒙輔仁大學食品營養系16位同學參與品評工作，其結果一併列入本表中。由本表知，南極蝦罐頭是受人們歡迎的罐頭之一。

二、製成率試驗

南極蝦罐頭製成率，經以生鮮凍結南極蝦爲 100% 計算水煮後剩87%，油炸後剩70%，故南極蝦罐頭製成率約爲70%。

三、油炸溫度與時間之探討

油炸時的溫度與時間對品質有很大的影響，若溫度太低則達不到油炸的效果，溫度過高則有燒焦之虞。經多次油炸試驗，發現180° C是油炸最適宜的溫度，當油炸至南極蝦開始「起爆」時卽爲油炸終點，大約 3 分鐘，此時製品的風味，色澤均呈最佳狀態。

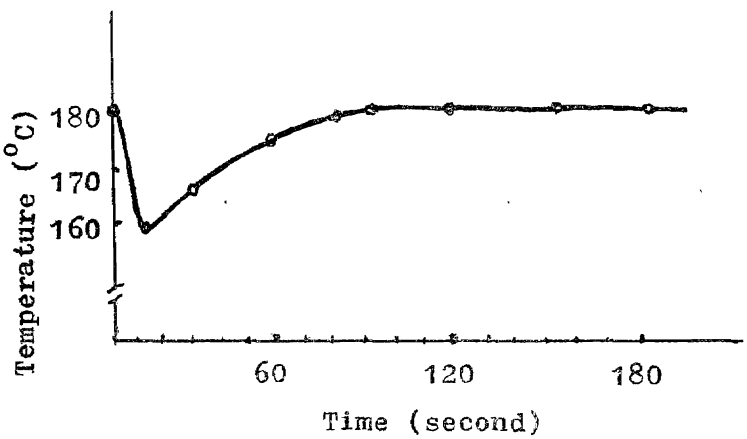

Fig 1. Temperature curve of oil during frying.

四、水煮後滴乾與日乾對罐頭品質之影響

將水煮後之南極蝦，在油炸前以自然滴乾和日乾二方式分別試驗。自然滴乾者經油炸，製成罐頭後，品質相當良好，但經日乾二日製成罐頭後者品質不良。

本試驗最初係爲了增加蝦的酥度而有此構想，即將南極蝦水煮後放置於有紗窗的晒棚中，經過二天日晒。結果顯示，雖然晒後水分減少，可縮短油炸時間，但油炸後色澤及風味均較差，因此南極蝦水煮後仍以自然滴乾爲宜，滴乾時間約40分鐘左右即可。

五、加熱殺菌試驗

由於南極蝦個體小，且在製罐前經過180° C，3分鐘的油炸，南極蝦中所含細菌幾乎可說已經完全被殺滅。本試驗以 0.7 kg/cm², 40 分鐘殺菌條件進行殺菌，其殺菌熱穿透曲線如 Fig 2。殺菌後罐頭經37° ±1° C保溫貯存二週後，未發生膨罐現象，且色澤、風味均相當良好。

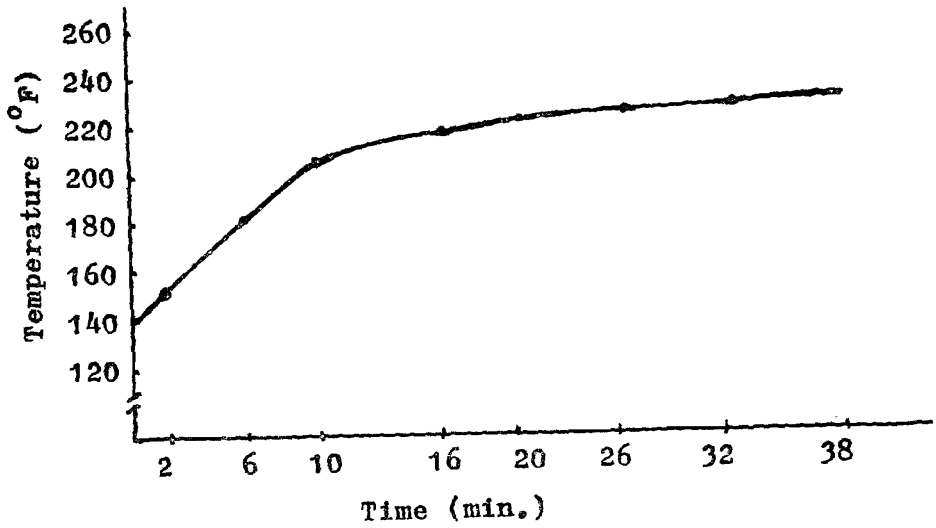

Fig 2. Heat penetration curve of canned Antarctic krill during sterilization.

六、檸檬酸對南極蝦罐頭品質之影響

根據研究報告[7]指出，南極蝦的不快味道，主要係二甲硫（Dimethyl sulfide, DMS）的成分。當原料新鮮時，南極蝦內含有很多 Dimethyl-β-propiothetin （DMPT），而二甲硫成分很少。隨著原料鮮度逐漸下降，蝦中的 DMPT 逐漸轉變成二甲硫，因此南極蝦中二甲硫的含量逐漸增多。

又當南極蝦在鹼性時，DMPT 很容易分解成二甲硫，因此本試驗乃針對此項原因，擬以檸檬酸來調節南極蝦的 pH值，希望藉 pH值的調節，使得 DMPT 不分解或分解較慢，以確保南極蝦罐頭的品質。

本試驗係在水煮時，分別在水溶液中添加 0.10%、0.15%、0.20% 和 0.25% 等四種不同濃度的檸檬酸，其試驗結果 Table 4 。

Table 4. Effect of citric acid in pre-boiling solution on the quality of canned krill.

concentration in pre-boiling solution		after boiling		flavor	color
citric acid	NaCl	pH	yield* of krill		
0.10%	2.5%	6.0	53%	fair	flat
0.15%	2.5%	5.8	47%	good	fair
0.20%	2.5%	5.5	45%	good	good
0.25%	2.5%	5.1	42%	good	good

* For the sake of having inferior quality of krill, the yield of krill after boiling was lower than that described in this paper.

由本試驗結果知，添加0.20%和0.25%檸檬酸者色澤最佳，且無不快臭味，而四者之中以添加0.10%檸檬酸者風味、色澤均較差。

由本試驗亦可發現，檸檬酸濃度愈高，水煮後步留愈少，亦即表示水煮時脫水率較高，這對油炸時縮短油炸時間當然有所裨益。

七、南極蝦鮮度對罐頭品質之影響

由於南極蝦本身酵素很强，自家消化作用很快，因此很容易腐敗，而且容易產生黑變。當南極蝦鮮度良好時，其 pH值較低，當 pH值在7.40～7.45之間時，南極蝦即開始有產生黑變的徵兆。而隨著 pH值的逐漸增高，黑變的程度亦愈顯著。

本試驗以新鮮原料、將近黑變原料和輕微黑變原料製罐時，發現新鮮原料製成者，味道鮮美，幾乎沒有不快味道；將近黑變原料製成者，略帶苦味，且有不快味道；而以輕微黑變原料製成者，發現苦味很重，且色澤，風味均不佳（如 Table 5 ）。本試驗係水煮，油炸後之南極蝦，不經調味製成者。

Table 5. Effect of freshness of Antarctic krill on the quality of canned product.*

grade of freshness*		A	B	C
organoleptic quality	color	brick red	pale brick red	pale brown
	flavor	good	fair, bitter	bitter
Blackening		negative	negative	positive

* A: fresh; B: right before blackening; C: slightly blackened.

八、南極蝦水煮罐頭製造試驗

本試驗係以南極蝦爲主要原料，將凍結南極蝦在空氣中解凍二小時（不完全解凍）後，用添加0.20%檸檬酸、2.5%食鹽的水溶液進行預煮（水爲蝦量的10倍），然後撈起，滴乾，不經過油炸卽以鮪二號塗漆罐每罐裝 150 g，另注入 50 ml 調味液，經過眞空捲封，以 0.7 kg/cm² 殺菌60分鐘，冷却後卽得本製品。調味液如 Table 6。

Table 6. The composition of dressing for canned Antarctic krill.

ingredient	dressing (1)	dressing (2)	dressing (3)
water	100ml	100ml	100ml
sodium chloride	10 g	10 g	10 g
monosodium glutamate	10 g	10 g	10 g
dried, fermented black bean	30 g	30 g	—
ginger	20 g	—	20 g

將上述三種調味液原料，以大火煮開，次以文火煮30分鐘，再以水補足蒸發水分，煮開，然後過濾備用。

本罐頭開罐結果，三種調味液之罐頭均帶苦味，由此可知，苦味來源不是豆豉或薑，而可能係南極蝦原料鮮度較差之故。此時蝦的 pH已達 7.4 左右。本試驗將來擬以新鮮原料繼續試驗。

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摘　　要

南極蝦罐頭係以生鮮凍結南極蝦爲主要原料，經過解凍、水煮、滴乾、油炸、裝罐和添加調味料等過程，然後眞空捲封、殺菌、冷却後完成之。

1. 南極蝦罐頭製成率約爲70%。
2. 水煮時以沸水煮 1～2 分鐘爲宜。
3. 滴乾時間以40分鐘爲宜。
4. 油炸以180°C，3分鐘爲宜。
5. 裝罐以鮪二號塗漆罐，每罐裝 130 g，另加調味液 10 ml。
6. 殺菌以 0.7kg/cm²，40分鐘行之。
7. 水煮用食鹽溶液（2.5%）中添加 0.20～0.25% 檸檬酸可增進南極蝦罐頭品質。
8. 鮮度差的南極蝦製成罐頭後有苦味，且製品品質不良。

謝　　辭

本研究承蒙臺灣省水產試驗所高雄分所賴分所長永順多方關照與指導，總所提供南極蝦原料，以及本分所同仁通力合作，得以順利完成，謹此致謝。

南極蝦對生長中白老鼠之營養生理影響

Effects of Antarctic Krill on the Nutritional Physiology in the Growing Rat

蔡　敬　民

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ABSTRACT

Freeze dried Antarctic krill contained about 94 ppm iron and 82 ppm copper. However, those iron and coppor could not be absorbed, utilized and accumulated in the liver. It caused severe anemia if iron and copper were not supplemented in the Antarctic krill diet. Vitamin E in the Antarctic krill was available to prevent the decrease of hemoglobin and hematocrit which might happen due to vitamin E deficiency.

Ingestion of Antarctic krill, instead of pork, could prevent the elevation of serum cholesterol. Antarctic krill diet without the additions of iron and copper, however, promoted serum cholesterol. Chlorella in the diets decreased serum cholesterol and liver lipids. Lactose in the diet also could decrease liver lipids. A trend, to increase liver iron and decrease liver copper was observed due to the addition of lactose in the diet. However, hemoglobin and hematocrit were not influenced significantly by lactose.

緒　　言

臺灣是個多山的海島，農耕地及畜牧地極爲有限，要有效地突破食物生產的瓶頸，勢必須開發新的漁業資源，而南極蝦漁業是公認最具開發價值的新目標，我國政府也注意到它的重要性，因此有「海功號」先後二次研究試探性的遠赴南極海，並且在國內掀起了對南極蝦之研究熱潮。

關於南極蝦的營養價值研究，以往大部分學者僅止於化學分析的工作（1,2,3,4,5），然而化學成分

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之多寡並不能代表它的生物利用價值之高低。近年來開始有 Arai 等 (6)， Matsumoto 等 (7) ，孫氏 (8) 和蔡氏 (9) 等從事南極蝦蛋白質之動物實驗。本實驗目的在於觀察南極蝦所含之鐵，銅和維生素E，是否可供身體所吸收利用，及成爲食物中供給鐵、銅和維生素E之一來源，並同時比較南極蝦油與猪油對血清膽固醇之影響，以及添加乳糖和綠藻等，對白老鼠之影響。

材料與方法

本實驗共採用10種飼料，其成分如表一所示。60 隻剛斷奶的白老鼠 (Wistar rats) ，體重約爲42～45克，逢機取樣地 (Randomly) 平均分配到10個飼料組，即每組有 6 隻，個別分開飼養在不銹鋼的籠子裏。所有之白老鼠第一、二週各別飼以 6 克之試驗飼料，其後每兩週增加 2 克飼料，即第九、十週飼以16克飼料，但最初三天之飼料，以 1 ： 1 混加原母鼠所食之飼料，使逐漸適應新的試驗飼料。此外每天並供以不限量之蒸餾水，共飼養10週。動物室保持20±2° C及各12小時之明暗，每週秤一次體重。

飼養滿10週之最後一天不供應飼料，隔天每隻白老鼠分別以乙醚麻醉，由尾巴取血，以 Cyanmethemoglobin method (10) 測定血紅素，以 Heparinized micro-hematocrit capillary tubes 來測定血球比容，然後以眞空試管由心臟抽血 (Cardiac puncture) ，以 Scarcy and Begquist method (11) 測定血清膽固醇，並取下肝臟，以乙醚抽出法來測定粗脂肪，並以原子吸光分光分析法 (12) 測定鐵和銅。所有結果以統計方法作 Standard deviation, F test 和 Duncan multiple range test (13, 14, 15).

結果與討論

經本實驗分析結果顯示冷凍乾燥南極蝦本身約含有 94ppm 的鐵和 82ppm 的銅 (表一註脚) ，因此若在飼料中混加30%之冷凍乾燥南極蝦，則飼料中所含鐵與銅之量，似應可避免貧血之發生 (16) 。然而本實驗發現，飼料中僅加30%之冷凍乾燥南極蝦，而不再添加鐵與銅者 (飼料 1) ，會導致嚴重貧血，其嚴重程度與不添加鐵與銅之酪蛋白飼料組 (飼料 7) 並無差異。亦即顯示，南極蝦所含之鐵與銅，幾乎完全不能被白老鼠所吸收利用。

在酪蛋白飼料中不添加維生素E者 (飼料 8) ，會導致其血紅素與血球比容，較添加維生素E者 (飼料 9) 爲低 ($P<0.05$) ， 但南極蝦飼料不添加維生素E者 (飼料 2) 與添加者 (飼料 3) 相比，其血紅素與血球比容並無顯著之差異。此結果顯示，南極蝦所含之維生素E可被吸收利用，且飼料中如混加30%之冷凍乾燥南極蝦時，其所含之維生素E足以防止紅血球之細胞膜的氧化與破損。綠藻曾被發現可以增高血紅素之含量 (17) ，但本實驗 (飼料 6 和10) 並沒發現有此現象。

本實驗發現飼料中缺少鐵和銅 (飼料 1 和 7) ，會提高血清膽固醇。1973年 Klevay (18) 解釋增加飼料中鋅與銅之比率，會導致提高血清膽固醇，但還未被證實，且爲何會引起血清膽固醇之增加，目前也不清楚。把南極蝦所含之油抽取出來，而以猪油代替 (飼料 4) ，則發現血清膽固醇因而提高。沒抽掉蝦油之控制組 (飼料 3) 與混加沙拉油的酪蛋白控制組 (飼料 9) ，其血清膽固醇之量，並沒顯著的差異。由於沙拉油是常用食油中最不增加血清膽固醇者之一 (19) ，因此結果顯示，如以南極蝦來取代其他動物

表一 試驗飼料之組成成份表一

Table 1. Composition of the Experimental Diets

Ingredients, %	Diet Number									
	1	2	3	4	5	6	7	8	9	10
Wheat powder	21	21	21	21	21	21	21	21	21	21
Corn starch[a]	21	21	21	21	15	19	27	27	27	25
Sucrose[b]	20.5	20.5	20.5	20.5	14.5	20.5	20.5	20.5	20.5	20.5
Mineral mixture[c]	5	5	5	5	5	5	5	5	5	5
Vitamin mixture[d]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Antarctic krill[e]	30	30	30	—	30	30	—	—	—	—
Defatted Antarctic krill[f]	—	—	—	26	—	—	—	—	—	—
Casein[g]	—	—	—	—	—	—	20	20	20	20
Lard	—	—	—	4	—	—	—	—	—	—
Salad oil	—	—	—	—	—	—	4	4	4	4
Lactose	—	—	—	—	12	—	—	—	—	—
Chlorella[h]	—	—	—	—	—	2	—	—	—	2
$FeSO_4 \cdot 7H_2O$	—	0.0155	0.0155	0.0155	0.0155	0.0155	—	0.0155	0.0155	0.0155
$CuSO_4$	—	0.00126	0.00126	0.00126	0.00126	0.00126	—	0.00126	0.00126	0.00129
Tocopherol acetate	0.02	—	0.02	0.02	0.02	0.02	0.02	—	0.02	0.02
Alphacel[i]										

表一（續）

a . ICN Pharmaceuticals, Inc., Cleveland, Ohio, U.S.A.

b . Superior white fine granulated sugar, Taiwan Sugar Co.

c . Mineral mixture contained the following ingredients per 100g: KH_2PO_4, 38.9g; $CaCO_3$, 38.14g; Nacl, 13.93g; $MgSO_4$, 5.73g; $MnSO_4 \cdot H_2O$, 0.401g; KI, 0.079g; $ZnSO_4 \cdot 7H_2O$, 0.0548g; $CoCl_2 \cdot 6H_2O$, 0.023g and alphacel to make up 100g.

d . Vitamin mixture contained the following ingredients per gram: Vitamin A, 2000 IU; Vitamin D, 200 IU; Menadione, 0.5mg; Choline, 200mg; p-Aminobenzoic acid, 10mg; Inositol, 10mg; Niacin, 4mg; Calcium D-pantothenate, 4mg; Riboflavin, 0.8mg; Thiamine-HCl, 0.5mg; Pyridoxine•HCl, 0.5mg; Folic acid, 0.2mg; Biotin, 0.04mg; Vitamin B_{12}, 0.003mg and Glucose to make up 1g.

e . Freeze dried Antarctic krill powder. Antarctic krills were obtained from Taiwan Fisheries Research Institute and freeze dried by Dragon Gate Food Corporation, then powdered by hardware blender. By analyses, krill powder contained 3% moisture, 66.2% crude protein, 13.4% crude fat, 94ppm Fe and 82ppm Cu.

f . Defatted with n-hexane.

g . Casein from milk, Sigma Chemical Co., St. Louis, Mo., U.S.A. By analyses, casein powder contained 9% moisture, 89% crude protein and 0.07% crude fat.

h . Yung Chien Chlorella Co., Chia-I, Taiwan.

i . Alphacel, non-nutritive bulk, was added to make up 100%. ICN Pharmaceuticals, Inc., Cleveland, Ohio.

表二　白老鼠的血液及肝臟分析結果

Table 2. Analyses of blood and liver in the growing rat.

Diet #	Tissue[a]					
	Hemoglobin g/100 ml	Hematocrit %	Serum Cholesterol mg/100 ml	Liver Lipids %	Liver Iron[b] ppm	Liver Copper[b] ppm
1	5.9±0.7	21±4	78±12	15.5±2.5	149±14	7.9±1.6
2	14.1±0.9	42±3	69± 8	16.5±2.0	288±35	13.6±2.1
3	14.5±0.6	44±5	69± 6	16.2±3.3	310±33	14.6±1.8
4	14.1±0.7	45±2	80± 4	16.0±3.7	300±34	14.0±0.9
5	15.2±0.8	45±3	73± 6	12.6±2.3	345±22	12.8±1.6
6	15.0±0.8	47±2	58±10	13.5±2.4	323±43	14.5±1.7
7	5.8±0.9	23±2	83± 7	13.0±2.8	164±35	7.5±1.6
8	12.9±0.7	37±3	71± 5	13.5±1.6	310±27	13.8±3.5
9	14.5±0.6	48±3	71± 6	12.2±1.2	292±26	14.0±2.2
10	15.2±0.6	49±2	63± 7	10.8±1.2	320±40	13.8±2.0

a. Each value is the mean of 6 observations ± S.D.

b. Values are expressed as concentration per unit of dry tissues.

性食物時，不但可獲得高品質之蛋白質（9），又能降低血清膽固醇。由於如大量開發時，南極蝦之成本又很低廉，所以南極蝦漁業之推展極具營養及經濟價值。

本實驗結果亦發現，在飼料中加入綠藻（飼料6和10），可降低（$P<0.05$）血清膽固醇與肝脂肪之含量，這可能是由於綠藻之細胞壁與小腸腔中之膽汁結合（20,21）而降低油脂與膽固醇之消化吸收率。南極蝦飼料組（飼料1～6）比酪蛋白飼料組（飼料7～10），其肝脂肪之含量較高（$P<0.05$），理由尚不清楚，有待進一步研究。適量之乳糖能降低體脂肪（21,22），本實驗發現12%之乳糖（飼料5）可降低（$P<0.05$）肝脂肪。

不添加鐵與銅之南極蝦（飼料1）和酪蛋白（飼料7）飼料組，顯示其肝臟之含鐵與銅之量，皆非常顯著地下降（$P<0.01$），12%之乳糖（飼料5）使肝臟中之鐵稍微升高（$P<0.10$），而銅略下降（$P<0.10$），但沒顯著地影響到血紅素與血球比容。

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摘　　要

冷凍乾燥南極蝦本身雖含有 94ppm 鐵及 82ppm 銅，但無法被白老鼠吸收利用，也不貯存於肝臟內，倘在飼料內不添加鐵與銅，則會導致嚴重之貧血。南極蝦可提供維生素E，因此能避免因缺少維生素E而使血紅素及血球比容下降。

南極蝦油所含之脂肪酸可能比猪油所含者較短鏈且不飽和，因此食用南極蝦以取代猪肉，可防止血清膽固醇之大量升高。但含南極蝦之飼料，若不添加鐵與銅，仍會導致較高之血清膽固醇。在南極蝦飼料中若加點綠藻，亦會降低血清膽固醇及肝脂肪，如加入適量的乳糖，則可降低肝脂肪，但使肝鐵微升，而肝銅略降，却沒顯著影響到血紅素與血球比容。

冷凍乾燥及熱風乾燥南極蝦之蛋白質利用率

A Study on PER of Freeze Dried and Hot-air Dried Antarctic Krill, *Euphausia superba*, in the Growing Rat

蔡　敬　民

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ABSTRACT

The purposes of this trial were to determine the protein efficiency ratio of Antarctic krill, *Euphausia superba* and to compare the processing effects of freeze dried and hot-air dried methods on the nutritional value of its protein.

The growth rate and PER value of the rats fed freeze dried Antarctic krill diet was much higher ($P<0.01$) than those of the rats fed casein diet. However, the growth rate and PER value of the rats fed hot-air dried Antarctic krill diet were slightly lower ($P<0.10$) than those of the rats fed casein diet.

The finding of this study indicates that the biological quality of Antarctic krill protein is higher than that of casein which is regarded as a very high quality protein and is frequently used as a control protein for PER studies. Its quality, however, can be interfered due to the methods of processing. It is worthy of further studies to improve the technique of processing which coss less and can preserve higher protein quality of Antarctic krill.

緒　　言

南極磷蝦 (*Euphausia superba*) 是體長約 4～6 公分，夜間可發出磷光的一種節足動物 (Arthropoda)，盛產於南極海及附近之海面。據估計 (1) 其總資源爲 11.5～50 億公噸，目前全世界

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之總漁產量僅約7千萬公噸，其所提供的動物性蛋白質，也祇佔全人類食用者之10%，因此南極磷蝦如能全面開發，必能提供大量物美價廉的動物性蛋白質，極具經濟及營養價值。

1977年3月底，「海功號」捕獲136噸回國，引起國內各界人士對南極磷蝦的普遍重視，也開始從事加工、營養及酵素等各方面之研究。據瞭解，蘇俄、日本等國早在幾年前已開始從事南極磷蝦的研究工作，但在營養價值上，大多僅止於各項營養成分之化學分析（2,3,4,5,6）。至於其在動物體內營養上之有效性，根據資料顯示，日本 Arai 等（7）於1976年曾進行日晒乾燥南極磷蝦之PER實驗，1977年 Matsumoto等（8）將濃縮的南極磷蝦蛋白質加入小麥麵筋，作蛋白質之互補作用的動物實驗及最近在臺灣亦有孫氏（9）的PER及NPU實驗。本實驗之目的，乃在測定南極磷蝦的蛋白質被利用之生物效率，同時比較冷凍乾燥法與熱風乾燥法對它的影響。

材料與方法

本實驗共採用30隻剛斷奶的白老鼠（Wistar rats），體重約爲42～45克，逢機取樣地（Randomly）平均分配到三組，每組各有10隻，個別分開飼養在不銹鋼的籠子裏，飼以如表一之3種不同飼料。飼料之配製採用A.O.A.C.（10）的方法，其成分如表一所列。

表一　試驗飼料的組成份

Table 1. Composition of the Experimental Diets.

Ingredients, %	Diet number		
	1[a]	2[b]	3[c]
Casein[d]	11.2	—	—
Freeze dried Antarctic Krill powder[e]	—	15.1	—
Hot-air dried Antarctic Krill powder[f]	—	—	18.7
Corn starch[g]	46.0	44.9	41.3
Sucrose[h]	25.0	25.0	25.0
Corn oil[i]	8.0	6.0	6.0
Mineral mixture[j]	5.0	5.0	5.0
Vitamin mixture[k]	1.0	1.0	1.0
Alphacel[l]	3.8	3.0	3.0

a. By analyses, diet 1 contained 10.17% crude protein and 8.11% crude fat.

b. By analyses, diet 2 contained 10.02% crude protein and 8.03% crude fat.

c. By analyses, diet 3 contained 10.06% crude protein and 8.28% crude fat.

d. Casein from milk, Sigma Chemical Co., St. Louis, Mo., U.S.A. By analyses, casein powder contained 9% moisture, 89% crude protein and 0.07% crude fat.

e. Antarctic Krills were obtained from Taiwan Fisheries Research Institute and freeze

dried by Dragon Gate Food Corporation, then powdered by a hardware blender. By analyses, freeze dried Antarctic Krill powder contained 3% moisture, 66.2% crude protein and 13.4% crude fat.

f. Hot-air dried Antarctic Krill powder was provided by Taiwan Fisheries Research Institute. Antarctic Krills were cooked in boiling water until krills floated out. Then they were drip dried under shade and hot-air dried at 140°C for 90 minutes, and powdered by a hardware blender. By analyses, hot-air dried Antarctic Krill powder contained 9.5% moisture, 53.4% crude protein, and 12.5% crude fat.

g. ICN Pharmaceuticals, Inc., Cleveland, Ohio, U.S.A.

h. Superior white fine granulated sugar, Taiwan Sugar Co.

i. Mazola Pure Corn Oil, Best Foods, A division of CPC International Inc., Englewood Cliffs, N.J., U.S.A.

j. Mineral mixture contained the following ingredients per 100g: KH_2PO_4, 38.9g; $CaCO_3$, 38.14g; NaCl, 13.93g; $MgSO_4$ anhyd., 5.73g; $FeSO_4 \cdot 7H_2O$, 2.7g; $MnSO_4 \cdot H_2O$, 0.401g; KI, 0.079g; $ZnSO_4 \cdot 7H_2O$, 0.0548g; $CuSO_4 \cdot 5H_2O$, 0.0477g; $CoCl_2 \cdot 6H_2O$, 0.023g and alphacel to make up 100g.

k. Vitamin mixture contained the following ingredients per gram: Vitamin A, 2000 IU; Vitamin D, 200 IU; Vitamin E, 10 IU; Menadione, 0.5 mg; Choline, 200 mg; p-Aminobenzoic acid, 10 mg; Inositol, 10 mg; Niacin, 4 mg; Calcium D-pantothenate, 4 mg; Riboflavin, 0.8 mg; Thiamine ·HCl, 0.5 mg; Pyridoxine ·HCl, 0.5 mg; Foltc acid, 0.2 mg; Biotin, 0.04 mg; Vitamin B_{12}, 0.003 mg and Glucose to make up 1 g.

1. Alphacel, Non Nutritive Bulk; ICN Pharmaceuticals, Inc., Cleveland, Ohio, U.S.A.

所有之白老鼠，第一週各別飼以6克的試驗飼料，第二週飼以8克，第三、四週10克。但最初三天之飼料，以1：1混加原母鼠所食之飼料，使逐漸適應試驗飼料。此外每天並供以不限量之蒸餾水，共飼養28天。動物室保持20±2°C及12小時之明暗，每4天秤一次體重，其結果作Standard deviation, F test 和 Duncan multiple range test[11, 12, 13].

結果與討論

本實驗共分成3組，分別飼以酪蛋白、冷凍乾燥和熱風乾燥南極磷蝦爲蛋白質來源之3種不同飼料（表一），其體重增加的情形，如表二所示。

由於動物細胞利用胺基酸之速率有一極限，加上游離的必需胺基酸停留在細胞內有時間限制[14, 15]，它們會逐漸轉化成其他胺基酸，或產生脫氨作用，而供熱能或其他用途，因此爲了避免蛋白質中之限制胺基酸（Limiting amino acids）的攝食量達到動物之需要量，導致無法清楚地觀察不同蛋白質中胺基酸之平衡程度，本實驗採用低蛋白飼料（表一）及定量之分別飼養法。

表二　白老鼠體重增加之平均值(克)[a]

Table 2. The means of weight gain in the growing rat (g)[a].

Days	Treatments		
	Casein (Control)	Freeze dried Antarctic Krill	Hot-air dried Antarctic Krill
4	5.1±0.6	5.9±0.8[b]	4.8±0.8
8	12.1±0.8	13.7±0.6[b]	11.5±1.0
12	21.5±1.1	24.9±1.6[b]	21.0±1.7
16	33.4±1.3	37.8±2.4[b]	32.6±2.5
20	45.9±2.2	50.4±3.1[b]	43.9±3.3
24	55.8±2.4	62.9±1.8[b]	52.0±2.8[c]
28	63.0±2.7	69.1±2.2[b]	60.5±2.4[c]

a. Each data is the mean of 10 replications±S.D.

b. $P<0.01$ vs control.

c. $P<0.10$ vs control.

結果（表二）顯示，飼以冷凍乾燥南極磷蝦的白老鼠，其生長率比飼以酪蛋白者有很顯著（$P<0.01$）的增加。致於飼以熱風乾燥南極磷蝦的白老鼠，其初期之生長率，較之飼以酪蛋白者並沒有任何顯著的不同（$P>0.10$），但到了最後一週，可能其攝食量較其需要量略低，因此可較顯著地看出，飼以熱風乾燥南極磷蝦的白老鼠，比飼以酪蛋白（飼料所含之熱量相同）者，其生長率略爲緩慢（$P<0.10$）。

本實驗蛋白質之有效被利用率（PER），如表三所示。冷凍乾燥南極磷蝦之PER，顯著地（$P<0.01$）高於熱風乾燥南極磷蝦及酪蛋白，而酪白微高於（$P<0.10$），熱風乾燥南極磷蝦。

表三　蛋白質之有效被利用率（時間28天）

Table 3. Protein efficiency ratio in 28 days.

Treatments	# of rats	Gain/4 wk(g)	Total protein intake (g)	PER[a]
Casein (Control)	10	63.0±2.7	24.2	2.60±0.11
Freeze dried Antarctic krill	10	69.1±2.2	23.9	2.89±0.09[b]
Hot-air dried Antarctic krill	10	60.5±2.4	24.0	2.52±0.10[c]

a. Protein efficiency ratio.

b. $P<0.01$ vs control.

c. $P<0.10$ vs control.

本實驗結果顯示，南極磷蝦的蛋白質，其品質及可被利用性極高，甚至高過一般被認爲品質很高而常被用來作ＰＥＲ實驗之對照蛋白質的酪蛋白，但由於加工方法之不同，以致使其品質在營養價值上受到不等量之影響。Arai（７）及孫氏（９）使用日晒乾燥法所製之南極磷蝦與酪蛋白比較其ＰＥＲ值，發現兩者並無顯著之差異。本實驗採用熱風乾燥法，其ＰＥＲ值僅微低於酪蛋白（Ｐ＜0.10）。孫氏（９）之ＰＥＲ實驗顯示，冷凍乾燥法所製之南極磷蝦的ＰＥＲ絕對值小於酪蛋白，與本實驗之結果有所不同，這可能是由於飼養法之設計不同所致。

依據本實驗結果，知冷凍乾燥法較易保存南極磷蝦蛋白質原有的高品質。致於採用熱風乾燥法之南極磷蝦，其蛋白質之品質顯著地下降（Ｐ＜0.10）。此現象可能是由於冷凍乾燥法未經煮熟，而以生鮮之狀態進行冷凍所致。但熱風乾燥法是先以沸水煮熟，因此部分蛋白質容易流失於沸水中，導致南極磷蝦之蛋白質含量下降（表一），且經過高溫處理，亦易使某些必需胺基酸產生變性或衍生物而失去其必需胺基酸之功用[16, 17, 18]。在 Yanase（４）之化學成分實驗中亦顯示，以生冷凍乾燥法製成之南極蝦，其粗蛋白之含量爲原新鮮重量之13.42%，若以煮熟冷凍乾燥法製成者，則僅含12.06%，因此可知即使脫水過程完全相同，單因前處理之不同，亦會導致粗蛋白之含量顯著地下降。

結　　論

本實驗結果證實，南極磷蝦具有豐富且營養價值極高之蛋白質，但會因加工方法之差異而對其品質有不等量之影響。一般言，加熱過程對其品質之影響較鉅，不過就加工方法而言，熱風乾燥法設備較爲簡單，其成本也遠低於冷凍乾燥法。雖然蛋白質之營養價值較遜，但仍能保留相當高之營養價值，較之被認爲蛋白質營養價值極高而價錢昂貴的酪蛋白，並沒太顯著的差異。因此綜合經濟及營養價值而言，熱風乾燥法仍不失爲當前製造南極磷蝦乾之最適當的方法。不過在加工技術上，若能繼續再多加以研究和改良，或許還能發展出一方面再降低成本，一方面提高其營養及功能品質的更佳加工技術。

綜合各種事實，南極磷蝦極具大量開發之價值，若能大量捕獲與加工推廣，必將能用來取代或補充其他動物性蛋白質之不足，對於國民健康之增進，有莫大之助益，且間接地可以促進整個社會，國家經濟之穩定與繁榮。

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摘　　要

本研究目的在於測定南極蝦（*Euphausia superba*）之蛋白質，其有效的被利用率，並且比較冷凍乾燥法與熱風乾燥法對它的影響。

實驗結果顯示，飼以冷凍乾燥南極磷蝦之白老鼠，其生長速率及ＰＥＲ都非常顯著地（$P<0.01$）超過飼以酪蛋白質者；而飼以熱風乾燥南極磷蝦者，則略遜（$P<0.10$）於飼以酪蛋白者。

雖然酪蛋白，通常被視爲極高品質之蛋白質，而常被用爲ＰＥＲ實驗之對照蛋白質，本實驗結果顯示南極磷蝦之蛋白質的品質與其可被利用性比酪蛋白這要高。不過其蛋白質的品質可因加工方法之不同而受到影響。雖然熱風乾燥法之成本低，且尙能保留其大部分蛋白質的營養價值，但若能繼續再加以研究改進，或能發展出既經濟又能保存更高蛋白質品質的加工方法。

* 本文已提出，將刋登於食品科學，第五卷第一期。

南極蝦粉蛋白質營養價值之測定

Effects of Various Dehydration Treatments on the Protein Quality of Antarctic Krill Powder

孫　朝　棟

Chao-Tung SUN*

ABSTRACT

Antarctic krill (*Euphausia superba*) powder were prepared with the various dehydration methods of freeze-drying, preboiled sun-drying, and microwave oven-drying, respectively. Nutritive values of these powder were determined by feeding each 6 weanling rats of Sprague-Dewley strain for 28 days under the condition ad libitum. The PER and NPU of *E. superba* powder were 2.32, 2.50, 1.56 and 62.7, 64.5, 58.2, respectively. The nutritive value, colour, and flavour had negative correlation with the contents of free amino acids and peptides in *E. superba* powder preparations. The rates of autolysis of fresh *E. superba* in some higher-concentration NaCl solutions were also determined. The results revealed that the best NaCl concentration for preparation of high quality *E. superba* sauce with fine protein dissolution is between 16-18% by weight.

緒　　言

南極蝦爲一重要水產蛋白質資源，對解決當前糧食問題上蛋白質缺乏現象，不失爲良好之途徑。且其產量豐富，品質優良，爲各國所注目，1977年，我國海功號前往研究漁場生態及漁法，並携回百餘噸南極蝦，供加工研究之用。查南極蝦所異於普通熱帶海蝦者，爲其自分解酵素活性特强，易於常溫下迅速水解液化，故爲加工實用上首先需克服之重點。美、日、俄、南非等國，亦曾前往開發，關於加工及營養之報告亦發表多篇[1-8]。日人桑野氏[9, 10]已確定南極蝦在沸騰海水中加熱殺菁十五分鐘，足可抑制其自分解及變色之發生。但是國人自己之研究工作，則於此次海功號凱歸後，方啓序幕。又自孫經邁等先生所

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著[11]，曾謂海糠蝦（*Neomysis intermedia*）（類似南極蝦）鹼性特强，食時能致脫髮，故不能多食等語。故爲更確實瞭解南極蝦之特性及製粉條件，對其營養價值之關係，特利用國人自己漁獲之南極蝦進行一些基本測定工作，供作參考。

試驗材料及方法

一、試驗材料

1. 南極蝦（Antarctic krill，學名，*Euphausia superba*）；於1977年二月中旬，由海功號在南極洋漁獲後，在甲板上卽盛入約每20公斤一箱之包裝中，並隨卽進行低溫凍結，五月初轉運抵達高雄，並將其曾解凍及變色之部份剝除後，繼續在－20° C下凍藏供用。

2. 蝦粉製備方法

(1) 冷凍乾燥蝦粉(Freeze dried *E. superba* powder)；將凍結狀態下之南極蝦在高眞空下，進行冰晶昇華脫水，脫水完成後，再以鋼磨磨成粉，使完全通過 80 mesh 之篩網備用。並經分析其蛋白質含量爲53.0%。

(2) 預煮日曬乾燥粉（Pre-boiled sun-dried *E. superba* powder）；將凍結狀態下之南極蝦小塊，投入廿倍之一直保持沸騰之熱水中，行解凍及殺菁，約十五分鐘，以行完全破壞其酵素活性[9]，取出後以日光曬乾六小時，日曬時蝦體之最高品溫曾達 50° C ，充分乾燥後卽行磨粉，且使完全通過 80 mesh 之篩網，並經分析其蛋白質含量爲46.1%。

(3) 微波乾燥蝦粉（Microwave oven dried *E. superba* powder）；取凍結狀態南極蝦 600 公克，置玻璃盤中全面舖開，蝦體層厚度約三公分，以東芝公司所製之小型微波爐加熱，每隔 7.5分鐘攪拌一次，共歷一小時後取出磨粉供用。並經分析其蛋白質含量爲50.0%。

3. 其他試藥：除食鹽、沙拉油、蔗糖、澱粉爲市售食品級外，餘均爲日本和光公司所出品之試藥級製品。

二、試驗方法

1. 南極蝦在食鹽溶液中水解狀態之測定；取凍結之南極蝦 1.5 公斤，分別放入四個定容三公升之容器中，然後再分別放入 22, 20, 18, 16% （三公升容積計算）之食鹽，再加自來水至三公升刻度處，拌勻，每隔八小時透過 80mesh 之篩網吸取汁液 10 毫升，置入50毫升容積之離心試管中，加蒸餾水10毫升，行 3,000 r.p.m 之遠心分離10分鐘，得上部爲油脂層，下部爲非溶解物層及中層澄清汁，以微吸管小心吸取中層清汁10毫升，並個別重複三次，置入分解瓶中分解，以 Kjeldahl method 測其總氮，再乘以 6.25，作爲蝦蛋白質液化狀態之指標。

2. 蛋白質效率比（Protein Efficiency Ratio, PER）之測定：

(1) 酪蛋白之調製；取脫脂奶粉加水十倍，充分溶解，以 HCl 調整pH爲 3.5～3.6，以紗布濾取沉澱，並行壓搾，於常溫下行眞空脫水，取出以打碎機磨成細砂狀供用，並分析總氮乘以 6.25，求得粗蛋白質爲50.2%。

(2) 飼料調製；以三種南極蝦粉及酪蛋白，按表一所示之配方，調製成飼料，並置於2～5°C之冷藏庫中貯存備用。

表一 供試飼料成分組成

Table 1. Compositions of rats diet (contg. 10% protein)

ingredients	control (casein) prot.=50.2%	freeze-dried *E. superba* prot.=53.0%	pre-boiled sun-dried *E. superba* prot.=46.1%	microwave oven dried *E. superba* prot.=50.0%
protein source	20.0	18.9	21.7	20.0
starch	53.0	54.1	51.3	53.0
sucrose	13.0	13.0	13.0	13.0
oil	10.0	10.0	10.0	10.0
cellulose	2.0	2.0	2.0	2.0
vit. mixture	1.0	1.0	1.0	1.0
salts mixture	1.0	1.0	1.0	1.0

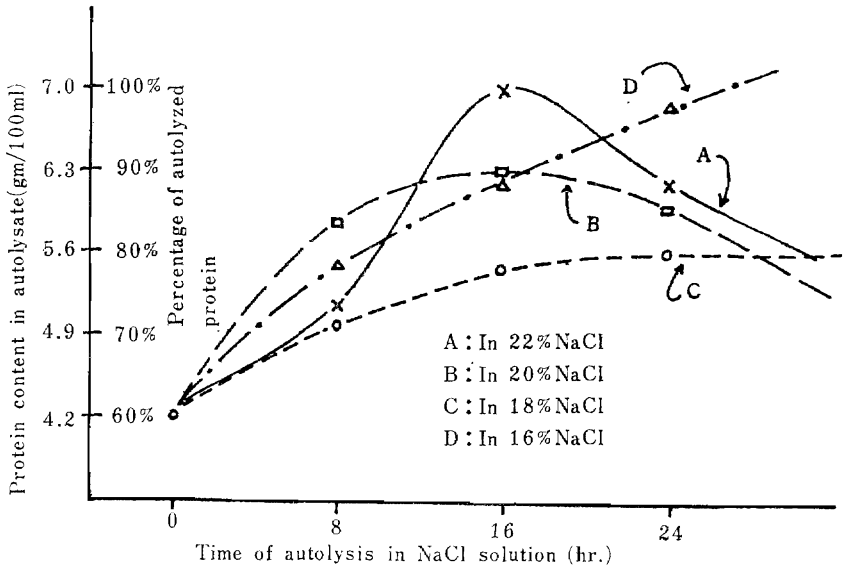
(3) 每組以體重約50公克，剛離乳之 Sprague-Dewley 種大白鼠公母各三隻，分別飼養28天，任其自由取食（ad libitum），每週秤取體重一次，記取飼料攝取情形，供計算PER值，並觀察其生長狀態，其他維他命及礦物鹽之配合成分悉參照常法行之[12]。

3. 淨蛋白質利用率 (Net Protein Utilization, NPU) 之測定

取體重約50公克剛離乳之 Sprague-Dewley 種大白鼠，公母各三隻爲一組，共五組，分別飼以表一之四種飼料，另一組則飼以無蛋白質之飼料（蛋白質部分以澱粉代之）。其管理與測定PER之方法相同。歷時十天後，以乙醚麻醉，以PE包妥，在－20°C下凍死後，置燒杯中，加濃硫酸分解，以 Kjeldahl method 測其總氮，供計算NPU之用，其餘細節均參照常法行之[12]。

結果與討論

一、南極蝦在濃食鹽溶液中之自分解速度如圖一所示，各組在24小時後，其中85%之蛋白質均已液化溶解，在72小時後，各組蝦體均已崩潰，汁液呈浮懸液狀，其24小時內之溶解情形，甚爲特殊，即高濃度者在初期汁液中之可溶解蛋白質較高，但隨後即漸降，而低濃度者則有漸增不減之趨勢。可見蛋白質均能保持溶解狀態，很顯然地，高濃度（20%以上）食鹽會引起蛋白質之脫水現象，將原已自分解之多胜肽由組織中放出，而其酵素活性亦頗受抑制，最終在近飽和之食鹽濃度下，部份沉澱，失去其可溶性，且此等多胜肽多呈苦味，將引起蝦醬油之不良風味[13]，如欲產製蝦醬油，似應控制其食鹽濃度在16～18%之間，方能提高其蛋白質之抽出率，且不影響成品之風味。



圖一　食鹽濃度對南極蝦自分解之影響

Fig. 1　Effects of salt concentration on autolysis of *E. superba*

二、南極蝦粉製備時，因其自分解很快，原樣品經解凍後，其蛋白質即有60%已經水解，如以緩慢熱風乾燥，最後僅剩蝦殼而已，其蛋白質均呈溶化液而損失。在本試驗中，以熱水殺青後之南極蝦，其自分解即行停止，乾燥時之品質亦甚安定，因熱水殺青時，已將大部份游離胺基酸及液態胜肽溶除，故所製蝦粉中游離胺基酸含量不多，製品色淺，呈橘紅色，營養價值最佳，與酪蛋白近似。以微波解凍及乾燥者，雖因快速解凍及加熱殺青（約需時20分鐘），然其中游離胺基酸未經除去，故於後段乾燥時，仍發生梅氏反應（Maillard reaction），以致製品色澤呈淺咖啡色，導致胺基酸之有效性降底，因而其營養價值劣化甚巨。凍結乾燥者之風味色澤均甚良好，大白鼠之發育及攝食量亦較多，但在經濟實用上，尚難採用之。其PER及NPU之測定結果如表二所示。

三、由本次動物試驗之觀察結果，白鼠之發育情形均甚良好，鼠毛之光澤並無異狀，所謂多食南極蝦可能導致脫髮一說，在本試驗狀況（共觀察七個月）下，未呈顯著症狀。南極蝦以海水行殺青處理者，其含 NaCl 量會增高，已被證實[10]，一般動物攝食 NaCl 太多亦常有脫毛現象，故因取食南極蝦亦將導致脫髮一說，不足憂慮。此外，由於供飼南極蝦各組之攝食量較酪蛋白爲少，可能由於其風味欠佳所致，尤其蝦粉中所含油脂高達 6.13～10.98%[6]，油脂之氧化劣變質爲降底食慾之主因。

四、結論；爲確實把握南極蝦粉之經濟及營養效益，務必於漁獲後即迅速進行殺青處理，以抑制其自分解酵素，降低蝦粉中游離胺基酸含量，並能增進色澤及風味，所得之蝦粉再以有機溶劑溶除其油脂，則對其耐貯藏性亦大有助益。色澤及風味良好之南極蝦粉，可作爲其他食品之摻加成分，以供提高其蛋白質之含量及品質之用，對改善食品營養價值方面助益甚大，其進一步之研究，有待繼續努力。

表二　各種南極蝦粉之ＰＥＲ及ＮＰＵ值

Table 2. The PER, NPU, and weight gain of rats fed with various *E. superba* powder.

treatments	body weight*			protein intake (gm)	measured PER	corrected PER	NPU
	initial (gm)	final (gm)	gain/4 wks(gm)				
control (casein)	49.2±0.25	181.7±16.5	132.5	36.29	3.66	2.50	68.3±4.5
freeze-dried *E. superba*	49.1±1.74	119.9±7.5	70.9	20.89	3.39	2.32	62.7±4.9
pre-boiled, sun-dried *E. superba*	50.9±2.5	112.0±10.5	61.9	16.86	3.67	2.50	64.5±8.1
microwave oven-dried *E. superba*	56.0±2.23	89.4±9.1	33.4	14.66	2.28	1.56	58.2±5.4

* Each value is the average of 6 determinations±S.D.

誌謝：本試驗承省水產試驗所贈送供試南極蝦及本校鄭校長森雄博士之關心及鼓勵，特此敬致由衷感激。

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摘　　要

將凍結狀態之南極蝦爲原料，以冷凍乾燥法，預煮日曬法及微波加熱法，試製南極蝦粉，經由大白鼠動物試驗，檢討其營養價值，結果其 PER及NPU 分別爲 2.32, 2.50, 1.56 及 62.7, 64.5, 58.2。並發現游離胺基酸之含量與其營養價值、色澤及風味成反比關係。在高濃度食鹽溶液中，南極蝦之自分解速率亦經測定，結果發現食鹽濃度在 16～18% 時，其蛋白質之液化狀況最佳，可供製取蝦醬油時之參考。

南極蝦新產品之研究發展——甜、鹹餅乾

The Study on the New Food Product Development on Antarctic Krill——Biscuits and Crackers

蔣　見　美

Jean-May TSIANG*

實驗材料

1. 主要原料爲蝦粉：分冷凍乾燥及熱風乾燥兩種。

   冷凍乾燥——凍結南極蝦爲原料（由水產試驗所供應），經低壓脫水（委託龍門食品公司製造），再經碾磨機碾成粉末而成。

   熱風乾燥——係以熱風乾燥法將南極蝦製成蝦乾，再行碾磨成粉（由水產試驗所供應）。

2. 鹹餅乾（冷凍小西餅）之材料：（見圖）

組別 / 材料	一	二	三	四	五
低筋麵粉	180g	180g	160g	180g	180g
冷凍乾燥蝦粉	20g(10%)	20g	40g(20%)	20g	—
熱風乾燥蝦粉	—	—	—	—	20g
白糖	1T	1T	1T	1T	1T
奶粉	0.8g	0.8g	0.8g	0.8g	0.8g
鹽	1½t	1½t	3t	1½t	1½t
白油	50g	50g	50g	50g	50g
牛油	70g	70g	70g	70g	70g
蛋	40g	40g	40g	40g	40g
葱粒	—	½C	—	—	—
混合法	手混	手混	手混	攪拌機	攪拌機

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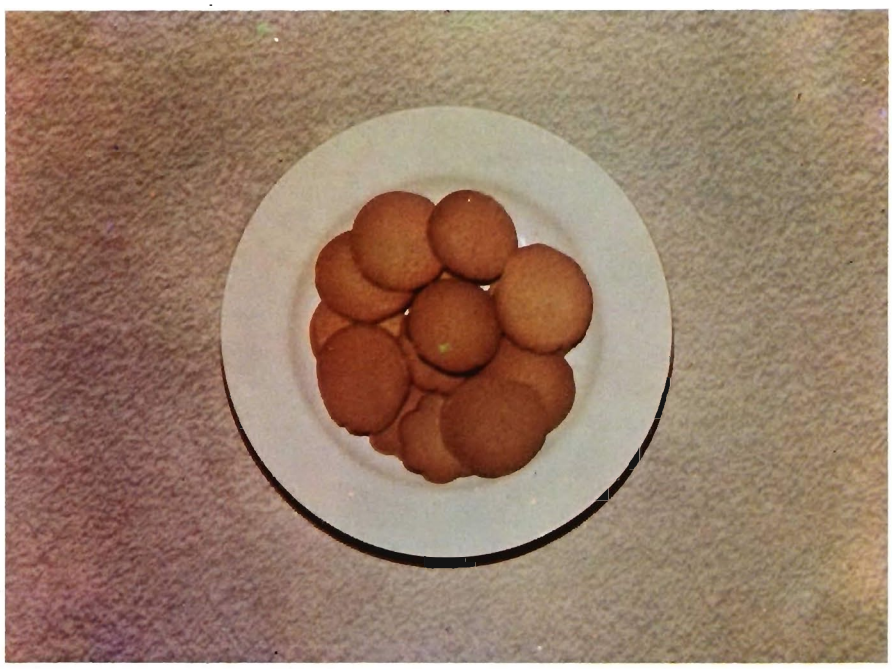
冷凍小西餅



牛油餅乾

3. 甜餅乾（牛油餅乾）之材料：（見圖）

組別 / 材料	一	二	三	四	五
低筋麵粉	180 g	160 g	185 g	190 g	190 g
冷凍乾燥蝦粉	20 g (10%)	40 g (20%)	15g(7.5%)	10 g (5%)	—
熱風乾燥蝦粉	—	—	—	—	10 g
白糖	90 g	90 g	90 g	90 g	90 g
牛油	75 g	75 g	75 g	75 g	75 g
蛋	80 g	80 g	80 g	80 g	80 g
鹽	少許	少許	少許	少許	少許
香草精	2 片	2 片	2 片	2 片	2 片
發粉	—	—	1½t	1½t	1½t
混合法	手混	手混	手混	攪拌機	攪拌機

製造方法

1. 鹹餅乾一冷凍小西餅之製作：

將麵粉、蝦粉、奶粉、糖和鹽混均勻，過篩三次，將白油、牛油和蛋液混勻，加入過篩之混合物及葱，拌勻，分成 4～5 等分，每一等分爲直徑 3 公分圓柱，用紙包裹，放凍箱中冷凍，待硬取出，切成0.4公分厚圓餅，排於烤盤，於 400°F 烤箱中烤10分鐘（見圖）。

2. 甜餅乾一牛油餅乾之製作：

將牛油和糖攪拌均勻，加入鹽和香草精拌勻，繼續加入蛋液，邊加邊攪拌，最後將麵粉及蝦粉混合過篩後分二次加入，揉成麵糰，趕成0.5公分厚，用模型印取，排烤盤內，於 400°F 烤箱中烤10分鐘（見圖）。

3. 問卷採用依個人之喜好 (Hedonic Scale Scoring) 給予分數，採用 1～9 分制。再以 Analysis of Variance Method 及 Rank Sum 兩方法統計品評結果。

4. 新產品之研究過程是將每次以不同配方製得之產品，經專家品評，選出較好的配方，並供給建議。根據大家的意見，繼續尋求新的更理想的配方。

5. 最後將大家認爲最理想的甜鹹餅乾共兩種樣品，公開請人品評。

結果及論討

1. 原料方面的試用，發現固然用冷凍乾燥之蝦粉，所得之成品顏色鮮，腥味少，但由於成本高，故目前不宜於應用。熱風乾燥蝦粉顏色較淡，腥味較濃，但成本低，而且只要調配適當，風味仍佳。

2. 南極蝦粉百分比含量，對製品之風味有極大的影響，實驗結果發現，鹹餅乾（冷凍小西餅）最多可添加10%熱風乾燥南極蝦粉，而甜餅乾（牛油餅乾）最多以添加 5 %熱風乾燥南極蝦粉爲宜。

3. 甜鹹餅乾品評之統計結果如下：

① 樣品	鹹餅乾	甜餅乾
Mean	4.3	7.45
S.D.	1.66	0.82
Rauk Sum (20人)	40	20

由 F Test 及 Rank Sum 均顯示兩產品之間有顯著差異 ($P<0.05$) 甜餅乾顯著的受到歡迎，由平均分數 (Mean) 亦可觀察相當合一般人的口味。

② 一般人觀念中認爲南極蝦產品必須是鹹的，但經我們大膽的試驗結果，意外的發現甜可以掩蓋腥味而加强南極蝦獨特的香味，因此甜的南極蝦餅乾是值得推廣的一種新產品

南極蝦市場消費反應調查研究

A Survey of Antarctic Krill Consumption in Taiwan

林　婉　慧

Woan-Huey LIN*

SUMMARY

An experimental ship, named Hai-Kong, was dispatched to the Antarctic Ocean by the government in December, 1976. The goal of this navigation was exploring new food resources of the sea and new fishing grounds. Four months later, 136 tons of krill had been caught and brought back to Taiwan. About 30 tons were consumed, and the others were used for research. The main purpose of this survey focuses on understanding the consumers' response of krill consumption. Two kinds of sample, krill purchasers and the recipients of gift krill, were investigated. The survey data of 977 consumer families were collected by mail in questionaire form. The survey results are as follows:

1. Most of the families under survey were in ignorance of krill in the past. After it was introduced into Taiwan, the information sources of krill of these families were largely from newspaper, i.e, 83%; from television, 29%.
2. Among all the buying motivations of krill, 85% of the purchases indicated curiosity, and less than 17% purchased for nutrition consideration.
3. After tasting krill, 39% of the families declared delicious, 55% thought the taste was ordinary, and 6% regarded it to be not good. Compare with shrimp, 34.39% of the consumers preferred to krill; 35.93% thought they were indifferent and 29.68% preferred to shrimp.
4. Refer to cooking of krill, 50% of the families had made krill into krill ball;

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28% cooked it by frying, and "easy to cook" was reported by more than 75% consumers as the others had some troubles to cook. False cooking would spoil the flavor of krill and alter eater's taste.

5. 65% of the consumers expect constant purchase if krill are on the market, but 35% declined to buy.
6. The reasons for the consumers to eat krill are "not polluted", "delicious", and "nutritious", while the reasons to decline it are "no flavor", and "bad flavor".
7. The proportion of the consumers who prefer to fresh krill are almost identical to those prefer to processed krill, and they suggest some favorite processed types, such as, krill sauce, krill oil, krill powder, krill cake and dried krill.

As described above, the potential consumption of the Antarctic krill has a promising future in domestic market. If commercialized production is adopted in near future, the catching & transportation cost of krill must be considered, and a sound selling system should be established as soon as possible.

一、調查動機與目的

漁產品向爲國人普遍愛好的高級副食品，亦爲我重要外銷產品之一，政府爲了增加國內的糧食資源及拓展外銷，以繁榮國家經濟，除了對近海和遠洋的漁業繼續加强發展外，特邀集國內科學技術人員及漁業專家，乘著「海功號」實驗船冒險前往南極，以試驗探測性質，捕取南極蝦，同時亦冀在前往南極沿途中發現新漁場。「海功號」於65年12月 2 日由基隆港出發，民國66年 1 月13日抵達南極水域，開始作業，果然，初次試捕成功，捕取了 136 噸南極磷蝦，於66年 3 月26日返抵國門，歷時 114 天。此一壯舉，對我開發經濟資源之貢獻，至爲重大。

南極磷蝦含有豐富的蛋白質，營養價值頗高，惟經贈送及市場售賣給消費者消費後，消費者對其評價如何？是否受歡迎？又它的市場潛力如何？關係著今後開發此一新資源發展計劃甚鉅。在現代商品的銷售已進入「消費者導向」的階段，消費者對磷蝦消費後，對這幾個問題的反應如何？實有加以調查之必要。中國農村復興聯合委員會漁業組及國立中興大學農產運銷學系有鑑於此，乃特合作舉辦南極磷蝦消費者消費反應意見調查，以提供政府當局對南極磷蝦資源開發之規劃及漁業者從事經營之參考。故本調查研究之目的有下列諸點：

1. 瞭解磷蝦是否受市場歡迎。
2. 如果受消費者歡迎，其歡迎程度如何？其銷售及價格等方面，有那些應予改進之處？
3. 如果消費者不歡迎，其原因何在？應如何促進銷售，提高消費者消費之興趣。
4. 從以上三點分析之結果，提供政府當局今後開發及銷售磷蝦之策略參考。

二、調查方法與步驟

海功號所撈捕回來之南極磷蝦，一部份作爲加工實驗之用，一小部份由水產試驗所分贈給有關人士品嚐，另外一部份則委託遠東百貨公司所附設之超級市場公開銷售約有20餘噸。本調查對象乃就「受贈南極磷蝦消費者」及「購買南極磷蝦消費者」兩部份進行之。前者卽指接受水產試驗所贈送南極磷蝦品嚐之消費者，後者卽指向遠東百貨公司超級市場自行購買南極磷蝦烹食之消費者。「受贈磷蝦消費者」及「購買磷蝦消費者」由於兩者消費動機稍有不同，因此我們的調查亦分爲兩部份，並分別擬就問卷，一由水產試驗所將調查問卷隨同贈品送請受贈者烹食後填答，逕寄本系；另一則商請接受寄售南極磷蝦之臺北、臺中、臺南及高雄等地遠東百貨公司附設之超級市場協助，於每一購買者購買南極蝦時，代爲附發調查問卷一份，請其於烹食後填答，亦逕寄本系。另外筆者及本系多位先生也多次前往遠東百貨公司分設各地之超級市場，實地觀察南極磷蝦推出銷售時消費者之購買情形和一般購買的心理，以供研究分析之參考。受贈者調查表計發出 730 封，寄回301封，回收率爲41.23%；購買者調查表計發出 2,200 封，寄回 676 封，回收率爲 30.72%。比率還算頗高（詳如表一），亦足見國人對此一新資源之開發，頗爲支持。本文卽依據所寄回之調查表分「受贈者」及「購買者」加以統計分析，然後再綜合兩者之意見，作爲臺灣居民對南極磷蝦之消費反應。

Table 1. Sample distribution of krill consumption survey
(Answered letters)

	recipient	purchaser	total
mailed letter	730	2,200	2,930
answered letter	301	676	977
answered ratio	41.23%	30.72%	33.34%

三、調查結果分析

㈠ 消費者對水產品之消費嗜好

在瞭解消費者對南極蝦之消費反應之前，首先我們調查其對一般水產品之嗜好情形。根據調查資料顯示（如表二），在接受調查的 977 戶當中，有77.28%的消費者表示喜歡食用水產品，21.70%的消費者表示不一定，只有1.02%的消費者表示不喜歡食用水產品，如果從受贈者與購買者分別加以觀察，則受贈磷蝦消費者回函的 301 戶中，有77.08%戶喜歡食用水產品，22.92%戶表示不一定，不喜歡者沒有；在購買磷蝦消費者回函的 676 戶中，有77.37%戶喜歡食用水產品，21.15%表示不一定，僅1.48%表示不太喜歡食用水產品。由此可知，絕大多數人均喜歡食用水產品，那麼我們也可以說，將有77%以上的家庭可能成爲磷蝦之消費對象。

惟商品之銷售不能僅靠可能之銷售對象，即可達銷售目的，尙須要多方面的條件予以配合，始能達成，例如消費者對商品之認識程度，商品本身的條件（如品質、滋味、價格及營養等），銷售活動，以及流通過程等，均爲不可或缺之條件。這些觀念將於下列數節中分別獲得解答。

Table 2. Comsumer's preference for seafood

region \ preference		like		dislike		No Opinion		total	
		f *	%	f	%	f	%	f	%
recipient	northern	130	82.82	—	—	28	17.72	158	100
	central	102	71.33	—	—	41	28.67	143	100
	sub-total	232	77.08	—	—	69	22.92	301	100
purchaser	northern	398	80.41	1	0.20	96	19.39	495	100
	central	88	69.29	6	4.72	33	25.99	127	100
	southern	37	68.52	3	5.56	14	25.92	54	100
	sub-total	523	77.37	10	1.48	143	21.15	676	100
total	northern	528	80.86	1	0.15	124	18.99	653	100
	central	190	70.37	6	2.22	74	27.41	270	100
	southern	37	68.52	3	5.56	14	25.92	54	100
	sub-total	755	77.28	10	1.02	212	21.70	977	100

* f: frequency

㈡ 消費者對磷蝦之認識

⑴消息來源——根據表三資料顯示，無論是受贈者或購買者獲知海功號捕取磷蝦之消息來源，主要均是看報紙和看電視。在977戶調查戶中83.21%的戶次數是看報紙，29.27%的戶次數是看電視，其他來源比率不大。受贈戶中73%以上的戶次數是看報紙，54%以上的戶次數是看電視；而購買者大都閱報而得，計幾佔88%的戶次數，看電視知曉的比率却不大，僅佔18%的戶次數。這或許是因爲受贈者大多數爲知識較高的份子，對時事比較關心，因此，經常有收聽電視新聞的興趣，而購買者多爲各階層人士，有些階層的人，對新聞報導比較不感興趣，因此亦常常不予收聽，而「報紙」是現今不可或缺的日常生活精神食糧，幾乎每家都會訂閱的，每人不論如何的忙碌，一天之中，總會抽空流覽一番，因此我們得知利用大衆傳播工具報導新產品——南極蝦的消息，報紙發揮的功能最大。今後如有其他新產品出現，我們要介紹給潛在的消費者，自亦要特別在報紙報導。

⑵購買動機——動機是存在於個人的內心，消費者的購買動機不是商品的特性，也不是廣告的一部份，它不是任何廠商所能創造的，瞭解消費者的購買動機，僅是爲進一步喚起並加强消費者內心的慾望，而引導購買某一特定產品。受贈樣本戶消費的南極蝦，並非購買的，所以也就沒有購買動機可言，而購買樣

Table 3. Information sources of krill consumption

region	source	newspaper		television		socical communicatior		neighbor		others		total
		f	%	f	%	f	%	f	%	f	%	
recipient	northern	115	72.78	76	48.10	15	9.49	1	0.63	12	7.59	158
	central	105	73.42	88	61.53	5	3.50	1	0.70	1	0.70	143
	sub-total	220	73.09	164	54.49	20	6.64	2	0.66	13	4.32	301
purchaser	northern	446	90.10	83	16.77	—	—	15	3.03	22	4.44	495
	central	105	82.68	24	18.90	—	—	2	1.57	10	7.87	127
	southern	42	77.78	15	27.78	—	—	3	5.56	5	9.26	54
	sub-total	593	87.72	122	18.05	—	—	20	2.96	37	5.47	676
total	northern	561	85.91	159	24.35	15	2.30	16	2.45	34	5.21	653
	central	210	77.78	112	41.48	5	1.85	3	1.11	11	4.07	270
	southern	42	77.78	15	27.78	—	—	3	5.56	5	9.26	54
	sub-total	813	83.21	286	29.27	20	2.05	22	2.25	50	5.12	977

本戶之購買動機絕大多數是在「好奇」的心理下購食南極蝦，計佔85%以上，而居於自我動機即重視磷蝦營養豐富的佔17%弱，認爲價錢便宜的7.4%，其他佔近2%（閱表四）。從表二中顯示購買樣本戶中尚有小部份消費者本不喜歡消費水產品，而今會成爲購買消費者，主要亦即對磷蝦好奇而嚐食。磷蝦在國內是一種創新產品，其吸引力極大，在好奇心理下購食乃必然現象，惟商品的銷售，不能單靠「好奇」消費動機來促進銷售，必需積極於其他消費動機之培養。故爲提醒潛在的消費者消費磷蝦，以拓展及穩定消費市場，我們尚須以南極蝦之「營養豐富」、「價格便宜」、「沒有汚染」、「滋味清香」、「調理方便」等之特點，並配以精緻美觀的南極蝦食譜圖樣，利用大衆傳播工具，引導潛在的消費者消費磷蝦之興趣。

Table 4. Purchasing motivations of krill consumers

region	motivation	curiosity		nutrition consideration		cheaper price		others		total
		f	%	f	%	f	%	f	%	
purchaser	northern	423	85.45	75	15.15	39	7.88	6	1.21	495
	central	111	87.40	29	22.83	8	6.30	4	3.15	127
	southern	42	77.78	10	18.52	3	5.56	3	5.56	54
	total	576	85.21	114	16.86	50	7.40	13	1.92	676

Table 5. Consumer's opinions about the flavor of krill

region \ opinion		delicious		ordinary		not good		total	
		f	%	f	%	f	%	f	%
recipient	northern	51	32.28	105	66.46	2	1.26	158	100
	central	51	35.66	74	51.75	18	12.59	143	100
	sub-total	102	33.89	179	59.47	20	6.64	301	100
purchaser	northern	198	40.00	269	54.34	28	5.66	495	100
	central	54	42.52	64	50.39	9	7.09	127	100
	southern	25	46.30	21	38.89	8	14.81	54	100
	sub-total	277	40.98	354	52.37	45	6.65	676	100
total	northern	249	38.13	374	57.27	30	4.60	653	100
	central	105	38.89	138	51.11	27	10.00	270	100
	southern	25	46.30	21	38.89	8	14.81	54	100
	sub-total	379	38.79	533	54.56	65	6.65	977	100

Table 6. Comparasion of the flavor of krill to shrimp

region \ comparasion		better		worse		indifferent		total	
		f	%	f	%	f	%	f	%
recipient	northern	43	27.21	54	34.18	61	38.61	158	100
	central	40	27.97	42	29.37	61	42.66	143	100
	sub-total	83	27.58	96	31.89	122	40.53	301	100
purchaser	northern	177	35.76	135	27.27	183	36.97	495	100
	central	54	42.52	39	30.71	34	26.77	127	100
	southern	22	40.74	20	37.04	12	22.22	54	100
	sub-total	253	37.43	194	28.70	229	33.87	676	100
total	northern	220	33.69	189	28.94	244	37.37	653	100
	central	94	34.81	81	30.00	95	35.19	270	100
	southern	22	40.74	20	37.04	12	22.22	54	100
	sub-total	336	34.39	290	29.68	351	35.93	977	100

⑶滋味品評——南極蝦首次在國內消費，大衆對其滋味的反應如何？足以影響該產品將來在市場上銷售。從表五顯示，977戶樣本戶中，93.35%的消費者認爲南極蝦滋味不錯，只有少數的6.65%覺得其滋味不佳，反應滋味不佳的比率，受贈戶與購買戶相同，而認爲滋味鮮美者，購買戶較受贈戶比率爲大。若以南極蝦和一般蝦滋味作比較，則有34.39%的消費者認爲南極蝦滋味較好，有35.93%認爲兩者滋味一樣，有29.68%認爲南極蝦滋味不及一般蝦。而購買戶認爲南極蝦較一般蝦滋味較好之反應，亦多於受贈戶（表六）。一般而言，在消費者普遍喜歡食用水產品的情況下，大衆對南極蝦之反應是相當良好，只要多加推薦，並多介紹南極蝦烹調方式，作出滋味可口食品，磷蝦的消費潛力當可發揮至超過70%。

⑷烹調方式——從資料顯示，消費者所採取之烹調方式，大多模擬一般蝦之烹調方法如「炸蝦球」、「炒蝦仁」，因此採油炸蝦球、蝦餅及清炒的方式最多，其次才當配料，配以其他菜餚，或炒或煮湯（閱表七之一及七之二）。但由於消費者首次食用磷蝦，或許在模仿與摸索的情況下，又沒能眞正針對磷蝦之特質，加以烹食，而作成不可口菜餚，所以有多數消費者對磷蝦滋味有不及一般蝦之反應。烹調的不得法

Table 7-1. Different methods for krill cooking of krill gift recipients

cooking method / region	making soup		sauteing		frying		using as condiment		others		total
	f	%	f	%	f	%	f	%	f	%	
northern	12	7.59	57	36.08	64	40.51	59	37.34	14	8.86	158
central	18	12.59	31	21.68	86	60.14	29	20.28	11	7.69	143
total	30	9.97	88	29.24	150	49.83	88	29.24	25	8.31	301

Table 7-2. Different methods for krill cooking of purchasers

cooking method / region	making soup		sauteing with egg		making krill ball		sauteing		making krill cake	
	f	%	f	%	f	%	f	%	f	%
northern	41	8.28	13	2.63	321	64.85	157	31.72	12	2.42
central	12	9.45	71	55.91	29	22.83	30	23.62	31	24.41
southern	4	7.41	13	24.07	13	24.07	8	14.81	11	20.37
total	57	8.43	97	14.35	363	53.70	195	28.85	54	7.99

cooking method / region	sauteing with leek		cooking with bean curd		using as condiment		others		total
	f	%	f	%	f	%	f	%	
northern	—	—	—	—	95	19.19	13	2.63	495
central	7	5.51	14	11.02	9	7.09	6	4.72	127
southern	6	11.11	13	24.07	9	16.67	—	—	54
total	13	1.92	27	3.99	113	16.72	19	2.81	676

Table 8. Consumer's preference for krill

region	preference	like		dislike		total	
		f	%	f	%	f	%
recipient	northern	452	56.22	352	43.78	804	100
	central	368	57.50	272	42.50	640	100
	sub-total	820	56.79	624	43.21	1,444	100
purchaser	northern	1,566	70.80	646	29.20	2,212	100
	central	404	62.15	246	37.85	650	100
	southern	192	70.59	80	29.41	272	100
	sub-total	2,162	68.99	972	31.01	3,134	100
tota	northern	2,018	66.91	998	33.09	3,016	100
	central	772	59.84	518	40.16	1,290	100
	southern	192	70.59	80	29.41	272	100
	sub-total	2,982	65.14	1,596	34.86	4,578	100

Table 9. Consumer's preference for krill and shrimp

region	prefer to	shrimp		krill		both		total	
		f	%	f	%	f	%	f	%
recipient	northern	65	41.14	11	6.96	82	51.90	158	100
	central	66	46.15	23	16.09	54	37.76	143	100
	sub-total	131	43.52	34	11.30	136	45.18	301	100
purchaser	northern	147	29.70	104	21.01	244	49.29	495	100
	central	45	35.43	19	14.96	63	49.61	127	100
	southern	18	33.33	9	16.67	27	50.00	54	100
	sub-total	210	31.06	132	19.53	334	49.41	676	100
total	northern	212	32.47	115	17.61	326	49.92	653	100
	central	111	41.11	42	15.56	117	43.33	270	100
	southern	18	33.33	9	16.67	27	50.00	54	100
	sub-total	341	34.90	166	16.99	470	48.11	977	100

，使南極蝦的鮮美滋味無法顯示出來，足以影響其銷路，所以將南極蝦烹調可口的方法，廣爲推介，至爲急要。66年7月上旬，私立實踐家政專科學校曾舉辦了南極磷蝦品嚐會，所展示之南極蝦食譜琳琅滿目，盤盤美味可口，亟宜推廣，將可誘導潛在的消費者消費，並使消費者嚐食美味的磷蝦。

(5)嗜好反應——在接受調查的消費樣本戶4,578家庭人口數中，大多數表示喜歡食用南極蝦，計佔65.14%，不喜歡者佔34.86%。其中購買戶嗜好消費南極蝦者較受贈戶爲多（如表八）。如果以南極蝦與一般蝦之消費嗜好程度比較（如表九），977戶調查戶中，有16.99%嗜好消費南極蝦，兩樣都喜歡者佔48.11%，而較喜歡消費一般蝦者佔34.90%。換言之，有消費南極蝦意願之消費者，高至65.10%，亦即有將近2/3的消費潛力，如再加以推廣，對開發磷蝦此一新資源的計劃必可預期實現。至於反應較喜歡消費南極蝦的消費者，亦是購買戶較受贈戶的比率爲高，這或許是購買戶在消費南極蝦前，已受到大衆傳播工具宣傳的影響，而發生興趣，有了潛在的消費動機，對南極蝦的排斥心理自亦較少，加之，嚐試多種的烹飪款式，有的款式做出來的菜餚，確實美味可口，所以購買戶的消費嗜好程度較高。相反的，受贈戶因較早獲得消費的嚐試，磷蝦許多的優良特質和烹調方法，都還不知道，以致對磷蝦不發生興趣，對其較少的好感（如表八及表九）。

(6)消費者喜歡購食南極蝦的理由——一般消費者喜歡購食南極蝦的理由（如表十），首爲磷蝦沒有添加硼砂污染，目前市面上有些不法商人爲了吸引顧客消費一般蝦，常在一般蝦摻添硼砂，以保其色澤鮮度，殊不知摻入硼砂對人體健康是有很大害處，爲大衆所惡者。今磷蝦沒有添加硼砂，遂爲消費者所喜愛之首要理由。次爲味道的好壞也是影響消費的重大因素，惟前面已說過烹調的款式及技術足以影響味道可口

Table 10. Reasons of consumer's preference for krill

region	reason	delicious		not polluted		nutritious		price fair		easy to prpare		others		total
		f	%	f	%	f	%	f	%	f	%	f	%	
recipient	northern	11	100.00	8	72.83	8	72.73	—	—	2	18.18	8	72.73	11
	central	11	47.83	5	21.74	12	52.17	—	—	5	21.74	2	8.70	23
	sub-total	22	64.71	13	38.24	20	58.82	—	—	7	20.59	10	29.41	34
purchaser	northern	40	38.46	48	46.15	36	34.62	30	28.85	39	37.50	17	16.35	104
	central	12	63.16	11	57.89	5	26.32	6	31.58	8	42.11	1	5.26	19
	southern	2	22.22	5	55.55	3	33.33	3	33.33	—	—	—	—	9
	sub-total	54	40.91	64	48.48	44	33.33	39	29.55	47	35.61	18	13.64	132
total	northern	51	44.35	56	48.70	44	38.26	30	26.09	41	35.65	25	21.74	115
	central	23	54.76	16	38.10	17	40.48	6	14.29	13	30.95	3	7.14	42
	southern	2	22.22	5	55.55	3	33.33	3	33.33	—	—	—	—	9
	sub-total	76	45.78	77	46.39	64	38.55	39	23.49	54	32.53	28	16.87	166

與否，這是消費者分別喜好南極蝦或喜好一般蝦的重大原因。再次從健康的觀點看，南極蝦的營養豐富，也頗能吸引消費者消費。購買戶重視南極蝦的沒有污染及受贈戶則重視南極蝦的營養價值較高，均是站在健康的觀點上，而喜歡消費南極蝦。最後磷蝦烹食前的處理方便與否，也爲消費者喜歡購食與否的要素之一，大體上消費者認爲南極蝦烹食前處理並不麻煩，計佔 76.12%，（如表十三），只有部份之消費者認爲磷蝦烹食前處理麻煩，這是因爲他們處理不得要領所至。冷凍的南極蝦解凍容易，約半小時卽可，解凍後應卽烹飪，不可久置，不必脫殼，不可用水洗，以免液汁及蝦肉流失，成爲淡而無味，甚至變黑不雅觀。

吾人從另一個角度來觀察某些消費者喜歡購食一般蝦或不喜歡購食磷蝦的原因（如表十一及十二），最主要是認爲一般蝦味道較好，而磷蝦淡而無味，事實上由於一般蝦的消費年代已久，消費者對其烹調款式及技術已有相當研究，自亦能烹調出美味之菜餚。反之，因不熟悉磷蝦的特質，烹調不得法，失其鮮美味道，而覺得磷蝦淡而無味了。再則，消費者認爲一般蝦比較新鮮，由於磷蝦遠從南極撈捕回來，再經過一些時日，才送達消費者手中，在排斥心理下，認爲磷蝦鮮度不夠，因而喜歡食用一般蝦。其實海功號實驗船如何保持磷蝦之鮮度，亦是其作業研究範圍之一。因此，要消除消費者對磷蝦之「認識的不和階」，亦是推廣磷蝦消費當務之擧。

Table 11. Reasons of consumer's preference for shrimp

region	reason	delicious		nutritious		easy to prepare		fair price		fleshy		fresh		others		total
		f	%	f	%	f	%	f	%	f	%	f	%	f	%	
recipient	northern	40	72.73	—	—	5	9.09	2	3.64	7	12.73	7	12.73	5	9.09	55
	central	20	44.44	2	4.44	4	8.89	—	—	1	2.22	10	22.22	1	2.22	45
	sub-total	60	60.00	2	2.00	9	9.00	2	2.00	8	8.00	17	17.00	6	6.00	100
purchaser	northern	69	57.50	5	4.17	18	15.00	2	1.67	3	2.50	20	16.67	7	5.83	120
	central	29	65.91	3	6.82	—	—	2	4.55	29	65.91	—	—	—	—	44
	southern	14	87.50	2	12.50	—	—	2	12.50	5	31.25	3	18.75	—	—	16
	sub-total	112	62.22	10	5.56	18	10.00	6	3.33	37	20.56	23	12.78	7	3.89	180
total	northern	109	62.29	5	2.86	23	13.14	4	2.29	10	5.71	27	15.43	12	6.86	175
	central	49	55.06	5	5.62	4	4.49	2	2.25	30	33.71	10	11.24	1	1.12	89
	southern	14	87.50	2	12.50	—	—	2	12.50	5	31.25	3	18.75	—	—	16
	sub-total	172	61.43	12	4.29	27	9.64	8	2.86	45	16.07	40	14.29	13	4.63	280

(7)價格評議——在表十中顯示消費者認爲「價錢合算」亦爲喜歡消費南極蝦的理由，計佔 23.49%，可見價格確爲影響消費之主要因素。951戶消費者反應南極蝦的零售價格應較一般蝦便宜些，計佔66.03%（如表十四），認爲兩者價格可相同，計佔 24.82%，只有 9.15%認爲南極蝦價格可較一般蝦貴些。而受

Table 12. Reasons of consumer's disinterest in krill

region	reason	inconvenient to prepare		unsavory		flavorless		cooking unknown		others		total
		f	%	f	%	f	%	f	%	f	%	
recipient	northern	8	14.55	6	10.91	28	50.91	—	—	20	36.36	55
	central	17	28.33	9	15.00	24	40.00	—	—	15	25.00	60
	sub-total	25	21.74	15	13.04	52	45.22	—	—	35	30.43	115
purchaser	northern	29	17.47	24	14.46	66	39.76	43	25.90	58	34.94	166
	central	4	7.69	8	15.38	17	32.69	18	34.62	11	21.15	52
	southern	5	18.52	4	14.81	8	29.63	7	25.93	6	22.22	27
	sub-total	38	15.51	36	14.69	91	37.14	68	27.76	75	30.61	245
total	northern	37	16.74	30	13.57	94	42.53	43	19.47	78	35.29	221
	central	21	18.75	17	15.18	41	36.61	18	16.07	26	23.21	112
	southern	5	18.52	4	14.81	8	29.63	7	25.93	1	22.22	27
	sub-total	63	17.50	51	14.17	143	39.72	68	18.89	110	30.56	360

Table 13. Consumer's opinions about the cookings of krill

region	opinion	inconvenient		convenient		total	
		f	%	f	%	f	%
recipient	northern	20	13.07	133	86.93	153	100
	central	47	36.15	83	63.85	130	100
	sub-total	67	23.68	216	76.32	283	100
purchaser	northern	107	21.62	388	78.38	495	100
	central	33	25.98	94	74.02	127	100
	southern	22	40.74	32	59.26	54	100
	sub-total	162	23.96	514	76.04	676	100
total	northern	127	19.60	521	80.40	648	100
	central	80	31.13	177	68.87	257	100
	southern	22	40.74	32	59.26	54	100
	sub-total	229	23.88	730	76.12	959	100

Table 14. Price comparasion of krill to shrimp

region	comparasion	cheaper		more expensive		same		total	
		f	%	f	%	f	%	f	%
recipient	northern	184	70.27	15	10.14	29	19.59	148	100
	central	86	67.72	18	14.17	23	18.11	127	100
	sub-total	190	69.09	33	12.00	52	18.91	275	100
purchaser	northern	314	63.43	39	7.88	142	28.69	495	100
	central	97	76.38	5	3.94	25	19.68	127	100
	southern	27	50.00	10	18.52	17	31.48	54	100
	sub-total	438	64.79	54	7.99	184	27.22	676	100
total	northern	418	65.01	54	8.40	171	26.59	643	100
	central	183	72.05	23	9.05	48	18.90	254	100
	southern	27	50.00	10	18.52	17	31.48	54	100
	sub-total	628	66.03	87	9.15	236	24.82	951	100

Table 15. Expected resonable price of consumers unit: NT$/kg

region	price	under NT$ 50								above NT$ 50		total	
		under 30		30-40		40-50		sub-total					
		f	%	f	%	f	%	f	%	f	%	f	%
recipient	northern	—	—	—	—	—	—	117	85.40	20	14.60	137	100
	central	—	—	—	—	—	—	106	86.18	17	13.82	123	100
	sub-total	—	—	—	—	—	—	223	85.77	37	14.23	260	100
purchaser	northern	138	31.65	200	45.87	37	8.49	375	86.01	61	13.99	436	100
	central	57	44.88	60	47.25	10	7.87	127	100.00	—	—	127	100
	southern	12	22.22	33	61.11	8	14.82	53	98.15	1	1.85	54	100
	sub-total	207	33.55	293	47.49	55	8.91	555	89.95	62	10.05	617	100
total	northern	—	—	—	—	—	—	492	85.86	81	14.14	573	100
	central	—	—	—	—	—	—	233	93.20	17	6.80	250	100
	southern	—	—	—	—	—	—	53	98.15	1	1.85	54	100
	sub-total	—	—	—	—	—	—	778	88.71	99	11.29	877	100

贈戶與購買戶之看法相差不大。如以具體的價格水準表示，在接受調查的877戶樣本戶中，有88.71%認爲磷蝦價格每臺斤應在50元以下（折算每公斤在80元以下），只有 11.29% 認爲每臺斤可在50元以上。在購買戶且以磷蝦價格每臺斤在30～40元之反應最多（表十五）。以目前一般蝦每臺斤市價75～90元左右，而南極蝦在遠東超級市場的零售價每半公斤30元（每公斤60元，折算每臺斤36元），兩者比較，南極蝦價格較一般蝦便宜一半，實在很低了，所以許多消費者，認爲磷蝦價格，當稱合適，更具體的說，一般消費者認爲磷蝦價格每公斤60元最爲合宜，至多也不宜超過每公斤80元以上。

⑻消費意願——拓展南極蝦資源計劃，須靠穩定的消費市場，從前面幾點反應顯示南極蝦的潛在消費者有70%以上，而這些消費者絕大多數均有經常消費的意願，計佔936戶樣本戶之63.66%，即使表示喜歡消費一般蝦的消費者也偶有消費南極蝦的興趣。從資料中觀察購買戶消費南極蝦的興趣較受贈戶濃厚，如果磷蝦經常有出售，今後亦將經常購食（表十六）。南極蝦不但可鮮消，也可製成各式的加工品。吾人調查消費者意願消費新鮮南極蝦或其加工品，所得結果，約各佔半數，而其中受贈戶意願消費加工品者較鮮銷者多，購買戶對鮮銷的興趣又較加工品濃厚。平均起來，一般消費者，近1/2意願消費新鮮的，有1/2强意願消費加工品（表十七）。在加工品種類中又意願消費蝦醬的最多，在回函件數574戶中，計佔45.64%，次爲消費乾蝦仁，計佔29.02%，再次爲蝦餅26.13%，蝦油18.12%，蝦粉9.76%，蝦丸 6.62% 及其他等等（表十八）。目前水產試驗所也正研究製造各式加工品，食品加工業者也可參考消費者之意願製造各式加工品，或應創製更新的加工品，以適應消費者的嗜好。

Table 16. Consumer's attitude towards frequent consumption

region	attitude	consume frequently		not consume frequently		total	
		f	%	f	%	f	%
recipient	northern	72	53.73	62	46.27	134	100
	central	63	50.00	63	50.00	126	100
	sub-total	135	51.92	125	48.08	260	100
purchaser	northern	347	70.10	148	29.90	495	100
	central	79	62.20	48	37.80	127	100
	southern	39	72.22	15	27.78	54	100
	sub-total	465	68.79	211	31.21	676	100
total	northere	419	66.16	210	33.84	629	100
	central	142	55.93	111	44.07	253	100
	southern	39	72.22	15	27.78	54	100
	sub-total	600	63.66	336	36.34	936	100

Table 17. Consumption tendency of fresh krill and processed krill products

region	kind	fresh krill		processed product		total	
		f	%	f	%	f	%
recipient	northern	65	41.14	93	58.86	158	100
	central	37	25.87	106	74.13	143	100
	sub-total	102	33.89	199	66.11	301	100
purchaser	northern	257	51.92	238	48.08	495	100
	central	78	61.42	49	38.58	127	100
	southern	40	74.07	14	25.93	54	100
	sub-total	375	55.47	301	44.53	676	100
total	northern	322	49.31	331	50.69	653	100
	central	115	42.59	155	57.41	270	100
	southern	40	74.07	14	25.93	54	100
	sub-total	477	48.82	500	51.18	977	100

Table 18. Consumption tendency of various processed krill product

region	kind	krill sauce		krill powder		krill oil		krill cake		dried krill		krill ball		others		total
		f	%	f	%	f	%	f	%	f	%	f	%	f	%	
recipient	northern	50	49.50	6	5.94	18	17.82	30	29.70	41	40.59	—	—	2	1.98	101
	central	56	53.85	20	19.23	20	19.23	26	25.00	41	39.42	2	1.92	1	0.96	104
	sub-total	106	51.71	26	12.68	38	18.54	56	27.32	82	40.00	2	0.98	3	1.46	205
purchaser	northern	119	46.30	27	10.51	54	21.01	71	27.63	104	40.47	—	—	3	1.17	257
	central	33	43.42	3	3.95	9	11.84	15	19.74	30	39.47	26	34.21	2	2.63	76
	southern	3	8.33	—	—	3	8.33	8	22.22	9	25.00	10	27.78	1	2.78	36
	sub-total	154	41.73	30	8.13	66	17.89	93	25.20	141	38.21	36	9.76	6	1.63	369
total	northern	169	47.21	33	9.22	72	20.11	101	28.21	145	40.50	—	—	5	1.40	358
	central	90	50.00	23	12.78	29	16.11	41	22.78	71	39.44	28	15.56	3	1.67	180
	southern	3	8.33	—	—	3	8.33	8	22.22	9	25.00	10	27.78	1	2.78	36
	sub-total	262	45.64	56	9.76	104	18.12	150	26.13	224	39.02	38	6.62	9	1.57	574

四、結論與建議

「海功號」以試驗探測性質，邀集漁業專家，共同開發遠洋漁業資源之壯舉，前往南極捕撈磷蝦，結果收穫豐碩，滿載而歸。際此世界糧食問題日益嚴重，而臺灣四面環海，耕地有限，開發海洋資源，尤其是漁業資源，更見迫切需要，所以「海功號」之開發南極磷蝦資源之成功意義至爲重大。

捕撈南極磷蝦，在政府大力支持下，雖然是成功了，惟我們爲欲繼續發展此一新產品，對下列三個問題，務須加以注意：第一、磷蝦是否受市場歡迎？第二、磷蝦的生產成本如何？第三、如何建立磷蝦的銷售系統？

關於第一點，依據本研究計劃前面的調查資料，消費者消費後反應情形，一般而言，甚爲良好，換言之，即頗受市場歡迎，惟磷蝦肉少汁多，國人對此一新產品尚少知道以何種烹飪方式，最爲可口，如能經過烹飪專家試做幾種最佳的烹飪方式，或加工業者試製成最佳的加工品，加以推廣，則必能促進消費者經常購買的意願，磷蝦的市場問題，就不足爲慮了。

關於第二點，此次捕撈南極磷蝦，是屬試驗性質，不計較成本的大小，惟如進行商業經營時，就須要斤斤計較成本了，究竟從如此遙遠，且航運艱澀之下去捕撈，所費之本錢，從事商業經營是否合算？是否仍能以原來的價格出售？就須要加以計算，這一問題，非屬本研究之範圍，而有賴主持作業機構去評估了。

前面所說第一點，根據調查消費者的反應是無問題了，如第二點亦無問題，而可從事商業經營時，則我們就要進行研究一個完善的銷售系統，因爲磷蝦的生產及本身性質具有其特性，便易銷售系統的建立，亦有其特別的需要。例如「海功號」所撈獲之磷蝦，即發生出售束手之策略，起先是計劃以整批標售方式售予商人，由商人推出市場銷售，但是，由於此一新產品，尚未經過廣大的消費者試消過，商人不瞭解在市場是否受到歡迎，況且數量龐大，主管機關又乏輔導措施，所以不敢輕率標購，以致屢經流標，無法脫售。最後雖以委託寄銷方式，透過遠東百貨公司各地超級市場出售，而時間延誤已近三個月，予人有磷蝦存倉過久，對其新鮮度存著懷疑的態度。抑有進者，既以寄售方式出售，又未能按時充份供應，致使在各寄售處發生缺貨情形，使許多殷切期待購買來嚐試的消費者，大失所望，而終至減低消費者購買的興趣，最後，甚而終止寄售。此種情況，其滯銷事小，而戕害新資源開發之影響事大，今後爲了使南極蝦人人能夠便易購着，獲得暢銷，對於銷售系統，亟應早作籌劃之建立，尤其是在運銷過程中的零售系統，應普及於各地區之市場。

總之，捕撈南極磷蝦，如計算生產成本適於商業性經營時，只要試行烹調出鮮美可口的烹飪方式，以及製成優美的加工品，並建立便利消費者購買的銷售系統，磷蝦此一新興產業，是有其遠大的前途。