文章编号:1000-0615(2005)02-0246-06

Effects of changes in freshness indices and high pressure processing on the kamaboko forming ability of *Saurida wanieso* during iced and frozen storage

OU Chang-rong[1], XUE Chang-hu[1,2], YUAN Rui[2], NOZAKI Yukinori[3], LI Zhao-jie[2]

(1. *Faculty of Life Science and Bio-engineering, Ningbo University, Ningbo 315211, China*;
2. *Faculty of Fisheries, Ocean University of China, Qingdao 266003, China*;
3. *Faculty of Fisheries, Nagasaki University, 1-14 Bunkyo, Nagasaki 852-8521, Japan*)

Abstract: Changes in freshness indices such as K-value, total volatile base nitrogen (TVBN), and Mf Ca^{2+}-ATPase total activity of lizard fish (*Saurida wanieso*) during iced and frozen storage were determined. Kamaboko forming abilities of lizard fish by thermal and high pressure induced gelation were also tested in this study. The results showed that freshness of iced lizard fish decreased rapidly and the shelf life of the iced fish was about 10 days, while the freshness of frozen lizard fish decreased slowly throughout the storage. Kamaboko forming ability of lizard fish decreased with the increase of K-value and TVBN, while the definite correlation between kamaboko forming ability and Mf Ca^{2+}-ATPase activity was not observed. Kamaboko forming ability of lizard fish retained normal only for [illegible] days during iced storage and 60 days during frozen storage when kamaboko was made by heat treatment, while it could be retained normal for at least 14 days during iced storage and 90 days during frozen storage when kamaboko was made by high pressure processing. These results indicated that kamaboko forming ability of lizard fish could be improved prominently by high pressure processing.

Key words: *Saurida wanieso*; kamaboko forming ability; high pressure processing; freshness; gel strength
CLC number: S986.1 **Document code**: A

Lizard fish (*Saurida wanieso*) is caught in large quantities using huge round haul nets in the waters off western Japan, and from the East China Sea to the waters off Taiwan[1,2]. It is commercially important to the Japanese, Chinese, Korean and Taiwan trawl fisheries because of its using for high-grade surimi product-kamaboko[3]. But this fish sometimes failed in gel forming as compared with croakers[4]. It is said that the reasons are due to fast falling of freshness, action of protease and generating of formaldehyde (FA) in the fish meat[5,6]. Wang *et al*[7] studied the relation between freshness and gel-forming ability by measuring the protease activity and formaldehyde content in lizard fish meat and found that combination of formaldehyde with meat protein during cold storage exerts great influence on gel forming ability. Therefore it is cruical to find a new approach for effective utilization of those bycatches.

High-pressure process (HPP) has been known as a potential preservation technique for foods and food ingredients for over a century[8]. But the early applications of HPP were encumbered because of the unavailablity of suitable equipment[9]. Recent progress in design HPP processing system, combined with increasing consumer demand for high quality, minimally processed, additive-free and microbiologically safe food[10] have ensured the world wide acknowledgement of the potential for such a technology in food processing[11,12]. Effects of HPP on foodstuff include the inactivation of microorganisms, induction of denaturation, aggregation and gel formation of food macromolecules, and inactivation of enzyme activity[9]. Taking the advantages of HPP and the fast decrease of freshness of lizard fish into consideration, application of HPP in kamaboko production from lizard fish may be a promising solution to effective utilization of this fish.

Therefore, the present work was taken up to study the changes in freshness of lizard fish during iced

Received date: 2004-06-22

Brief introduction of the author: OU Chang-rong (1974-), male, born in Tianmen of Hubei Province, lecturer, Doctor, engaging in fisheries processing and preservation, preparation and analysis bioactivities from marine materials. Tel: 0574-87600549, E-mail: ouchangrong@nbu.edu.cn

and frozen storage. The primary objective of this study, however, was to study the effects of HPP on kamaboko forming ability by comparing the properties of kamaboko prepared by HPP and thermal-induced gelation.

1 Material and Methods

1.1 Storage of lizard fish

Lizard fish purchased from a fisheries marketplace of Nagasaki, Japan in two batches, were preserved by iced storage and frozen storage. The average body length and weight were 41.5 cm and 484 g, 40.2 cm and 460 g respectively. After washing, samples were put into wooden boxes containing smashed ice at the bottom and surface and stored at 5 ℃ for iced storage; as to frozen storage, samples (3 kg/bag) were packed in polyvinylidene chloride bag, frozen and stored at −25 ℃. Samples were taken out randomly at the set date (At intervals of 2 days, total 14 days for iced storage; at the end of 0, 1, 5, 10, 20, 30, 60, 90 days for frozen storage) for the measurement of freshness indices and kamaboko-forming ability.

1.2 Determination of K-value of lizard fish during ice and frozen storage

About 1 – 2 g white meat from backside of fish was ground in cold mortar by adding 5 mL of 10% Trichloroacetic acid (TCA). After filtering, the filtrate was adjusted to pH = 7.0 by adding 1 mol·L^{-1} KOH solution, using methyl red as indicator. The resulting solution was used for the measurement of K-value by the method of Suzuki using freshness meter (Model KV-101 NEC, Japan)[13]. Results expressed, including that of TVBN and total Mf Ca^{2+}-ATPase activity determination, are the mean of three measurements.

1.3 Determination of total volatile bases (TVBN) of lizard fish during iced and frozen storage

Determination of total volatile bases nitrogen (TVBN) was conducted using the Conway microdiffusion assay according to the method described by Beaty *et al*[14]. Samples were headed and gutted (frozen stored samples thawed in flowing water before use) and filleted to two pieces. After washing in chilled water, fish fillets were deboned using mechanical bone separator (Model M-3, Toyoseikon Kaisha Ltd, Japan) containing 5 mm perforated separation disk. Fish meat (2 g) was extracted with 8 mL of 4% trichloroacetic acid (TCA). The mixtures were filtered using Whatman no. 41 and 1 mL of the filtrate was added to the outer chamber of Conway vessel. TVBN was released after addition of saturated K_2CO_3 and diffused into the boric acid solution in the inner chamber. The titration of solution was performed and the amount of TVBN was calculated.

1.4 Determination of total Mf Ca^{2+}-ATPase activity of lizard fish during iced and frozen storage

Myofibril (Mf) was prepared by the method developed by Uchiyama *et al*[15]. Resulting Mf suspending liquid was adjusted to 2mg·mL^{-1} by adding 0.1 mol·L^{-1} KCl, 20 mol·L^{-1} Tris-maleate buffer (pH 7.0), and Mf Ca^{2+}-ATPase activity was determined by the method as described by Katoh *et al*[16]. An aliquot (1 mL) of myofibril suspending liquid was mixed with 3.5 mL of 0.1 mol·L^{-1} $CaCl_2$. After heating to 25℃, 0.5 mL of 10 mmol·L^{-1} ATP was added to initiate the reaction. The reaction mixture was incubated for 5 min at 25 ℃ and terminated by adding 5 mL of chilled 30% (w/v) TCA. The reaction mixture was then filtrated; 1 mL of the filtration was mixed with 2 mL ammonium molybdate reagent and 0.5 mL Elon reagent, incubated at 25 ℃ for 45 min. After testing the absorbance of the mixture at 640 nm, the inorganic phosphate liberated in the supernatant was calculated and the specific activity was expressed as mmoles inorganic phosphate (Pi) · mg^{-1}·min^{-1}. Total Mf Ca^{2+}-ATPase activity was the product of specific activity and content of protein in Mf solution. A blank solution was prepared by adding chilled TCA prior to addition of ATP.

1.5 Determination of kamaboko forming ability of lizard fish during iced and frozen storage

Kamaboko was prepared by the method described in Nozaki's paper[17]. Fish were treated as described in 1.3, crushed fish meat washed with 5 times of cold distilled water. After removing the excess water, fish meat was minced and ground for 30 min with 3% NaCl and cold water to adjust moisture content to 80%. Ground fish paste was packed in polyvinlidene chloride tube (5 cm in diameter). After sealing the

ends, kamaboko was made by the following method: Method 1 (M1). Heating at 40 ℃ for 30 min; M2) Heating at 90 ℃ for 20 min after heating at 40 ℃ for 60 min; M3) Pressuring at 300 MPa (Frescal MFP-700, Mitsubishi, Japan) for 45 min; M4) Pressuring at 400 MPa for 20 min. The products were cooled in ice water for 30 min and left at room temperature before analysis. The jelly strength(JS) was measured as described by Morioka *et al* [8]. Gel flakes, with a thickness of 2.0 cm, were subjected to determination. Breaking force and breaking strain were measures using gellometer (SD-305, Sunscience, Tokyo, Japan) with a cylindrical plunger (diameter 5 mm; depression speed 0.6 mm·s^{-1}). Jelly strength was the product of breaking force and breaking strain, and the result of each sample was the average value of six tests at different parts of the gel.

1.6 Folding test

A folding test was carried out by folding a 5 mm thick sample disc into halves and quarters. The scale was: A = no crack when folded into quarters; B = no crack when folded in half; C = no crack when folded in half, but half crack when folded into quarters; D = all crack when folded in half; E = normal kamaboko could not be formed.

2 Results

It is showed in Fig. 1 that K-value of ice stored lizard fish increased sharply with the prolonging of storage time. The original K-value was 10.9%, during 10 days storage it exceeded 50% and thereafter increased with a slower rate. The final value was 60.4% after 14 days storage. K-value of frozen stored lizard fish increased slowly throughout 90 days storage, which went up from 6.2% to 12.3%.

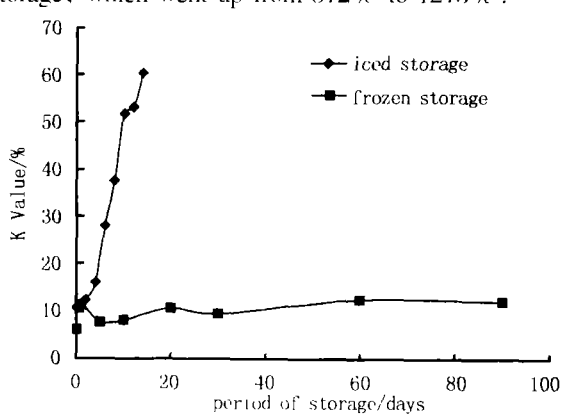

Fig. 1 Changes of K-Value of the lizad fish during iced storage at 5 ℃ and frozen storage at −25 ℃

The content of TVBN (Fig 2) in iced storage lizard fish changed a little during the early 10 days, and subsequently went up rapidly to 23.75 mg in 100 g meat. In comparison, TVBN in frozen stored lizard fish increased very slowly, and it was only 11.21 mg per 100 g at the end of 90 days storage.

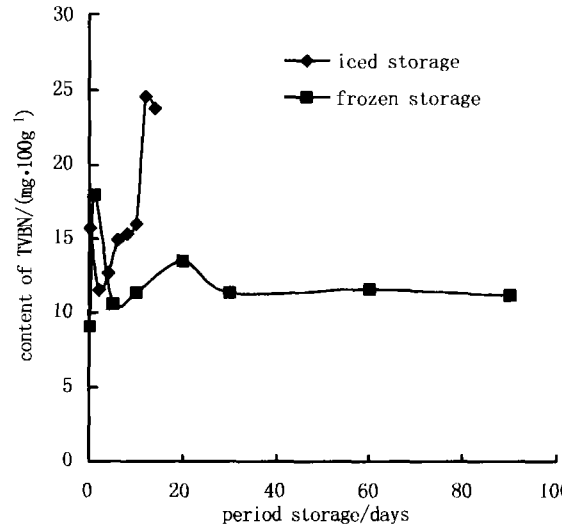

Fig. 2 Change in TVBN of lizard fish during iced storage at 5 ℃ and frozen storage at −25 ℃

JS decreased significantly when kamaboko was made from ice stored lizard fish by two types of heating treatment, as shown in Figure 4. Kamaboko could be made during 6 days storage and after that normal kamaboko could not be obtained by heating at 40 ℃ for 30 min (M1). When kamaboko was made by two step heating (M2), folding test grade was poorer, and after 4 days kamaboko could not be made any more, as shown in Table 1. Therefore the tolerant period of storage for iced storage lizard fish as material for kamaboko preparation was 4-6 day. In comparison, JS of kamaboko made from iced stored lizard fish by two types of pressure treatments was higher than that by thermal treatment, and decreased slowly throughout the storage. JS of kamaboko made by M4 was relatively higher than that by M3. According to folding test (Tab. 1), high grade kamaboko could be made from iced lizard fish throughout the storage.

JS of kamaboko made from frozen storage lizard fish by heat treatment decreased fastly during storage (Fig. 5). It was higher than that of kamabobko made by high presure processing during 60 days storage, and after that, it became lower. However JS by high pressure processing did not vary substantially through

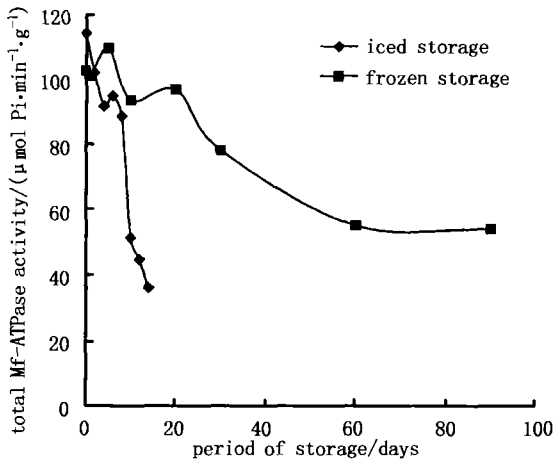

Fig.3 Changes in total Mf Ca-ATPase activity of round lizard fish during iced storage and frozen storage

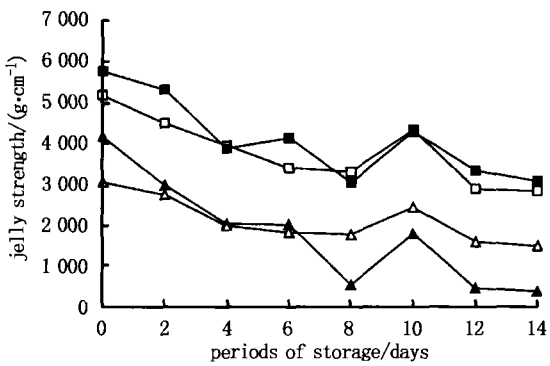

Fig.4 Changes in jelly strength of kamaboko from iced storage lizard fish prepared by different methods
▲:40 ℃ 30min (M1); △:40 ℃ 60min + 90 ℃ 20 min (M2); □:300 MPa 45 min (M3); ■400 MPa 20 min (M4)

Tab.1 Folding test scores of kamaboko made from iced storage lizard fish by different methods

iced storage period (days)	folding test grade			
	M1	M2	M3	M4
0	A	B	A	A
2	A	B	A	A
4	A	D	A	A
6	A	D	A	A
8	C	D	A	A
10	B	C	A	A
12	C	D	A	A
14	C	D	A	A

Notes: M1, M2, M3 and M4 means 4 methods for preparing kamaboko, decribed as 1.5

the storage. At the end of 90 days, a rather satisfactory kamaboko could be made from frozen lizard fish by high pressure processing. Therefore the

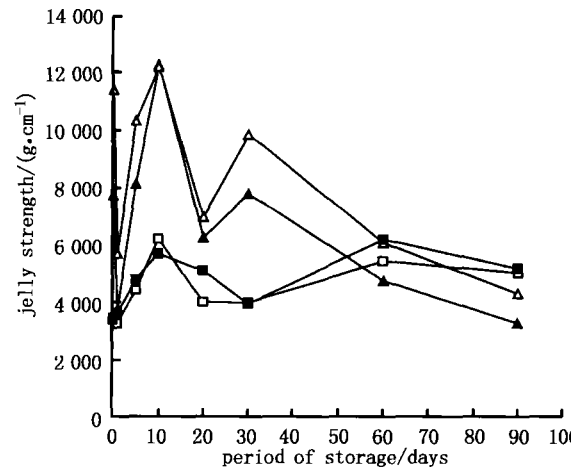

Fig.5 Changes in jelly strength of the kamaboko from the round of lizard fish during frozen storage at −25℃ prepared by the motheds described as in Fig. 4 (See legend in Fig.4)

tolerant life of frozen lizard fish as material for kamaboko was considered to be about 60 days by heat treatment, while that by HPP was at least 90 days. Jelly strength of kamaboko by two steps heating was higher than when it was made by one step heating, while there was no significant difference in JS between kamaboko made by two types of high pressure processing. All kamaboko made from frozen lizard fish by four methods were scored "A" throughout storage.

3 Discussion

Lizard fish underwent a fast falling of freshness during iced storage. Its K-value exceeded 50% at the end of 10 days storage, which was considered to be unsuitable for making surimi products anymore[19]. Kurokawa[20] studied the change of TVBN during storage using the same species of material, and observed the similar trend as in this study. On the other hand, freshness indices of frozen lizard changed slowly with the lapse of time, compared to those of ice-stored fish. It may be the result of the inactivation of protease at the low temperature of −25 ℃. A fluctuation of K-value and TVBN was observed during the storage, it might be due to the poor homogeneity when fish was stored as a whole body, and the individual difference among the samples[21].

Freshness is generally considered the most crucial factor determining the final gel quality. Kamaboko of

poor quality can be found when the gel was made from fish stored over time[3]. Results in this study showed that kamaboko forming ability of lizard fish decreased with the declining of freshness during iced storage. When traditional thermal treatment was used, normal kamaboko forming ability could be retained only for 4 to 6 days, which was comparable to Yasui's report[22]. Freshness of frozen stored fish decreased more slowly than that of ice stored fish, a relatively slow decrease in kamaboko forming ability was also observed. Normal kamaboko could be made from frozen lizard fish by two step heating after 60 days storage, it was similar to Noaki's results[4,17]. Some investigators reported that the Mf Ca^{2+}-ATPase activity of the surimi was closely related to the jelly strength of kamaboko[16]; however, the definite correlation was not observed in this study (Fig. 3 – Fig. 5). The possible reason might also be due to the poor homogeneity of the materials, which were stored as a whole body[21].

In comparison, kamaboko-forming ability of lizard fish could be improved by high pressure induced gelation. The jelly strength of lizard fish made by pressure treatment after 14 days storage was close to the original strength when it was made by thermal treatment. That is, the shelf life of iced lizard fish as the material for kamaboko was prolonged to at least 14 days. Jelly strength changed slightly during storage when the kamaboko was made by high pressure induced gelation; kamaboko forming ability still retained normal even after a long period of storage for 90 days. Therefore, heat treatment was suitable for making kamaboko from lizard fish of great freshness. As to ice stored lizard fish or that under frozen storage for a long time, high pressure processing should be applied to improving the kamaboko forming ability. The mechanism of protein gelation by high pressure is not well understood, but it may be involved in structural rearrangements taking place in proteins under pressure.

On the whole, HPP could extend the shelf live of ice stored lizard fish as material for kamaboko from 4 – 6 days to at least 14 days, and extend the shelf life of frozen fish from 60 days to at least 90 days. The kamaboko-forming ability could be notably increased if the kamaboko was made by pressure induced gelation. HPP is a novel method for processing food with no or minimal thermal treatment, it ensures the retention of better flavor, texture, nutrition and color compared to thermally processed products, and thereby improves the quality of products. It is less energy consuming, and has multiple effects of food matrix, such as inactivating the microorganisms and enzymes in food and so on. Meanwhile new designs developed recently make it possible for continuous processes by HPP. In view of the advantages and novel development of HPP, it may be a promising way to process new type of fabricated food from fish meat or other food materials.

References:

[1] Yamada U. Synodontidae[A] In Fishes of Japan with pictorial keys to the species[M]. Nakabo T ed Tokyo: Tokai University Press, 1993. 309 – 313.

[2] Yoneda M, Sakaia T, Tokimurab M, *et al* Age and growth of the lizardfish *Saurida* sp in the East China Sea using otolith ring marks[J]. Fisheries Research, 2002, 55: 231 – 238

[3] Benjakula S, Visessanguanb W, Tueksubana J Changes in physico-chemical properties and gel-forming ability of lizard fish (*Saurida tumbil*) during post-mortem storage in ice[J] Food Chemistry, 2003, 80: 535 – 544

[4] Nozaki Y, Araeda H, Taniguti T, *et al* Kamaboko forming ability of ice stored white croaker[J] Refrigeration, 1984, 59: 527 – 532.

[5] Noaki Y, Yamamoto T, Tabata Y On board treatment of lizard fish as raw material for fish jelly products[J]. Bull Jap Soc Sci Fish, 1986, 52: 1565 – 1572

[6] Lim P Y, Yasui A Changes in chemical and physical properties of lizard fish meat during ice and frozen storage[J] Bull Jap Soc Sci Fish, 1987, 34: 54 – 60.

[7] Wang X C, Narita K, Oka H On the freshness and gelngformmg ability in lizard fish[J] Refrigeration, 2000, 76: 85 – 92

[8] Hite B H. The effect of pressure in the preservation of milk[J]: Bull West Virginia Univ Agric Exp Station, 1899, 58: 15 – 35

[9] O'Reilly E C, Kelly L A, Murphy M P, *et al* High pressure treatment: applications in cheese manufacture and ripening[J] Trends in Food Science & Technology, 2001, 12: 51 – 59

[10] Gould G W. The microbe as a high pressure target. In High pressure processing of foods[A]. Ledward D A, Johnston D E, Earnshaw R G, *et al*. ed[M]. Loughborough: Nottingham University Press, UK, 1995. 27 – 35.

[11] Galazka V B, Ledward D A. Developments in high pressure food processing[J]. Food Technol Int Eur, 1995, 12: 123 – 125.

[12] Balci A T, Wilbey R A High pressure processing of milk – the first 100 years in the development of a new technology[M] Int J Dairy Technol, 1999, 52: 14 – 155

[13] Karube I, Matsuoka H, Suzuki S, *et al*. Determination of fish freshness with an enzyme sensor system[J] J Agric Food Chem, 1984, 32: 314 – 319.

[14] Beatty S A, Gibbons N E The measurement of spoilage in fish [J]. Journal of Biological Board of Canada, 1937, 3: 77 – 91

[15] Uchiyama H, Katoh N, Kudo Y, *et al*. Biochemical studies on myofibrils of fish thermo-stability of Ca^{2+}-activated myofibrillar ATPase of epipelagic and mesopelagic fish species[J]. Bull Jap Soc Sci Fish, 1978, 44: 491 – 497

[16] Katoh N, Nozaki H, Komatsu K, *et al* A new method for evaluation of the quality of frozen surimi from Alaska pollack: relationship between myofibrillar ATPase activity and kamaboko forming ability of frozen surimi[J] Bull Jap Soc Sci Fish, 1979, 45: 1027 – 1032

[17] Nozaki Y, Kanazu R, Tabata Y. Freezing storage of lizard fish for kamaboko preparation[J]. Refrigeration, 1978, 53: 473 – 480.

[18] Morioka K, Shimizu Y. Texture and breaking property of kamaboko[J]. Bull Jap Soc Sci Fish, 1990, 56: 531 – 536.

[19] Tomoka K, Endo K. K value-increasing rates and IMP-degrading activities in various fish muscles[J]. Bull Jap Soc Sci Fish, 1984, 50: 889 – 892

[20] Kurokawa T. Kamaboko-forming ability of frozen and ice stored lizard fish[J]. Bull Jap Soc Sci Fish, 1979, 45: 1551 – 1555.

[21] Hashimoto A, Kobayashi A, Arai K I. Thermostability of fish myofibrillar Ca-ATPase and adaptation to environmental temperature[J]. Bull Jap Soc Sci Fish, 1982, 48: 671 – 684.

[22] Yasui A, Fujiwara T, Lim P Y, *et al*. Changes in properties of lizard fish meat as material for fish jelly products during storage [J] Bull Jap Soc Sci Fish, 1987, 34: 109 – 114.

蛇鳏冰藏和冻藏过程中鲜度指标的变化以及高压处理对其凝胶形成能的影响

欧昌荣[1], 薛长湖[1,2], 袁 蕊[2], NOZAKI Yukinori[3], 李兆杰[2]

(1.宁波大学生命学院,浙江 宁波 315211; 2. 中国海洋大学水产学院, 山东 青岛 266003;
3. 长崎大学水产学院,日本 长崎 852 – 8521)

摘要:研究了蛇鳏(*Saurida wanieso*)冰藏和冻藏过程中 K 值、挥发性盐基氮(TVBN)、Mf Ca^{2+}-ATPase 全活性等鲜度指标的变化,并研究了高压加工法制备对蛇鳏鱼糕凝胶形成能的影响。结果表明:冰藏过程中鳏鱼的鲜度急剧降低,其货架期仅为 10d 左右,冻藏过程中蛇鳏保藏 90d,鲜度缓慢降低。随着 K 值和 TVBN 的增加,鳏鱼的凝胶形成能降低,Mf Ca^{2+}-ATPase 全活性与凝胶形成能关系不明确。通过加热处理,冰藏和冻藏的蛇鳏能保持正常凝胶形成能的时间分别为 6d 和 60d,而高压处理蛇鳏能保持正常凝胶形成能的时间分别为至少 14d 和 90d,高压处理能够显著提高蛇鳏的凝胶形成能从而延长其可利用期限。

关键词:蛇鳏;凝胶形成能;高压加工;鲜度;凝胶强度

中图分类号:S986.1 **文献标识码**:A

收稿日期:2004-06-22

作者简介:欧昌荣 (1974 –), 男, 湖北天门人, 博士,讲师,主要从事水产品加工与保鲜以及海洋生物活性物质的制备、分析方面研究。Tel: 0574 – 87600549, E-mail: ouchangrong@nbu.edu.cn