EFFECTS OF PYROPHOSPHATE LEACHING IN COMBINATION WITH EGG WHITE AND BEEF PLASMA CONCENTRATE ON GEL FORMING ABILITY OF LIZARD FISH (Saurida tumbil) SURIMI

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ABSTRACT

Fresh and frozen lizard fish (Saurida tumbil) were used for making surimi by the methods of usual leaching (UL) and pyrophosphate leaching (PL) and also in combination with 0.5% egg white and 1.0% beef plasma protein concentrate. Gel strength, folding test, teeth cutting test and sensory evaluation were monitored during storage at -20°C on 0, 4, 11, 18 and 32 days.

There was no significant difference ($P<0.05$) between UL and PL of fresh lizard fish surimi throughout the storage period. The quality of these surimi were still acceptable. Addition of egg white and beef plasma protein concentrate could improve the gel forming ability in both UL and PL surimi. Good gel forming ability of frozen lizard fish surimi was not obtained in both UL and PL surimi even with addition of egg white and beef plasma protein.

INTRODUCTION

The surimi production of Thailand is primarily based upon threadfin bream (Nemipterus spp) and bigeye snapper (Priacanthus spp). There are 15 surimi plants operated on and off throughout the year. From January to August 1993, the exported quantity of surimi to Japan especially made from threadfin bream was 16,126 metric tons (MINATO SHINBUN, 21 Oct 1993). However, harvesting of threadfin bream and bigeye snapper are expected to decrease in future years.

Lizard fish have long been considered a good raw material for manufacture of fish jelly products in Japan particularly for kamaboko. The amount of lizard fish landed in the South China Sea area was between 45,000 and 65,000 metric tons per year during 1985-1991. In Thailand the amount and value of lizard fish landed in 1991 were 23,677 metric tons and 7,127,000 us$ respectively (Table 1, Fishery Statistical Bulletin for the South China Sea Area 1991, SEAFDEC 1993). In view of the relatively a large landing and low price of lizard fish and the decline in the supply of other fish species, lizard fish should be considered as a potential source of raw material for the surimi industry. The advantages of using very fresh lizard fish are that the surimi is very white in colour, has a good flavour and a very high gel-forming ability. However the gel-forming ability decreases remarkably during ice storage of the raw material even though the freshness is not so much deteriorated (Kurokawa, 1979). Generally, frozen lizard fish cannot be used for frozen surimi (Holmes et al., 1992). Nozaki et al. (1978) reported the

formation of dimethylamine and formaldehyde by trimethylamine oxide decomposition during low temperature storage of the fish, causing denaturation of muscle protein and reduction of gel forming ability. The improvement of gel-forming ability of lizard fish by washing minced meat with sodium pyrophosphate solution have been reported by many researchers (Oka et al., 1985; Oka and Ono, 1987; Oka et al., 1988 and Sophonphong and Rungjiratananan, 1993). Sophonphong and Rungjiratananan (1993) concluded that two times leaching with 0.2% of sodium pyrophosphate added in during the first leacing were the appropriate conditions for production of good quality surimi from both fresh and frozen lizard fish.

In addition, the demand of surimi-based products have been increased not only in Japan but also in the Western World particulary in USA (Wu, 1992). The textural quality is an important functional property of surimi-based products. The use of ingredients such as egg white, beef plasma, and other additives to increase the gel strength of the products are now widely practiced. The purposes of incorporation of these ingredients into the surimi-based products are to improve water binding and texture properties. Egg white and beef plasma protein display as the protease inhibitors in preventing gel softening. Moreover, egg white also imparts a white and glossier appearance to the gel (Lee et al., 1992). Many studies on the use of ingredients to inhibit the lowering of gel strength in surimi at various cooking temperature were reported (Chung and Lee, 1990; Burgarella et al., 1985; Hamann et al., 1990). They all concluded that these ingredients added in surimi-based products can improve the quality particularly gel texture. The

objectives of this study is to investigate the improvement of the functionality of surimi made from fresh and frozen lizard fish, using pyrophosphate leaching, and the use of ingredients such as egg white powder and beef plasma concentrate to improve the textural properties of products made from the surimi.

MATERIALS AND METHODS

Fresh fish : Lizard fish (Saurida tumbil) caught from the South China Sea by 3 days fishing boat were purchased. The sizes of fish were about 156.60 ± 57.48 g by weight and 27.03 ± 3.28 cm by total length. The fish were kept in the insulated boxes with ice during unloading to Marine Fisheries Research Department (MFRD).

Commercial egg white powder and AMP 600N beef plasma protein concentrate (Wee Hoe Cheng Chemicals Pte Ltd., Singapore) were used as gel-froming ingredients in this experiment.

One hundred kilogrammes of fresh lizard fish were used for making surimi. Six to ten fish were sampled for chemical analysis i.e., formaldehyde (FA), K-value, moisture content and pH. The processing of surimi was shown in Figure 1.

Treatment 1 : Surimi undergone 2 times usual leacing (UL)

Treatment 2 : Surimi undergone 2 times leaching with addition 0.2% sodium pyrophosphate during first leaching (PL)

The samples of frozen surimi (UL and PL) were taken for monitoring of gel-forming ability after 0, 4, 11, 18 and 32 days of storage (Figure2).

Frozen fish : Two- month frozen lizard fish used in this experiment were headed, gutted and frozen on board. The frozen fish were delivered to MFRD and kept in cold storage at -20°C. Prior to making surimi, they were thawed overnight in chilled room at 15°C. The experiments were done according to the procedures as shown in Figure 1 and 2.

DETERMINATION OF CHEMICAL AND PHYSICAL PROPERTIES

MOISTURE CONTENT

Five grams of meat was spreaded evenly on an aluminium foil dish. The dish was placed in the infrared moisture meter (Metler LP 16) for approximately 30-35 minutes to determine the moisture content.

pH

Five grams of meat was mixed with 45 ml of CO2-free water using a tissue disperser (Ultra-disperser LK-21, Yamato Ltd. Japan) for 30 seconds and the pH measured using a glass electrode.

K-VALUE

K-value was determined by ion exchange chromatography method presented in "MFRD Laboratory Manual on Analytical Methods and Procedures for Fish and fish Products" (Miwa and Low, 1992).

FORMALDEHYDE

Formaldehyde was determine by 4-amino-3hydrazino-5-mercapto-1,2,4,triazol (AHMT) method presented in "MFRD Laboratory Manual on Analytical Methods and Procedures for Fish and fish Products" (Miwa and Low, 1992).

GEL PREPARATION

Frozen surimi was thawed at ambient temperature and cut into smaller pieces. Previously, the moisture of surimi was measured. The surimi pieces were chopped in a Stephan vertical cutter/mixer (UM 5 Universal, Stephan Machinery Corp., Columbus, OH) with 3% NaCl, 0.5% egg white powder or 1.0% AMP 600N and water to adjust moisture to 85%. The chopping time was about 1.20 min with a maximun temperature of 10°C. The resulting paste was stuffed into 25 mm diameter sausage casing of approximately 150 mm length and heated at 40°C for 20 min followed by 90°C for 20 min. The samples were then cooled under running water. The samples of cooked gel surimi were kept overnight at 5°C in the refrigerator. Before measuring of gel strength, whiteness, folding test and teeth cutting test, samples were put under running water for about 20 min until the temperature was stabilized.

GEL STRENGTH

Fish paste mixture was filled into a 25 mm diameter sausage casing of approximately 150 mm length. After setting, cooking, cooling and immersing

in running water to obtain a steady temperature, the sausage sample was cut into 25 mm long pieces. Three pieces of the cut samples from each sausages were used. Twelve test pieces from 4 sausages were measured to represent gel strength of a treatment. The gel strength of the test pieces were measured by Rheometer (Fudoh Ltd., Japan). The sample was pressed by a plunger with ball tip (5 mm diameter) until a break occured in the surface of the sample. The weight exerted on the sample until breaking point is shown by l (g) and the depth by h (cm). The product l x h (g.cm) is used as a measure of the gel strength.

WHITENESS

Sample discs of 25 mm diameter with 5 mm thickness were measured for whiteness by using whiteness meter (Measurement Unit D-2, Nippon Denshoku Kogyo Co. Ltd., Japan). Values were expressed as % whiteness compared with standard whiteness using a 93% pure whiteness standard.

FOLDING TEST (MFRD, 1988)

Sample discs of 25 mm diameter with 5 mm thickness were folded and graded according to the following scheme:

AA No breakage when folded in quarter

A Slight tear when folded in quarter

B Slight tear when folded in half

C Breakage (but 2 pieces still connected) when folded in half

D Break completely into 2 pieces when folded in half

TEETH CUTTING TEST (MFRD, 1988)

Teeth cutting scores were obtained by trained specialists bitting the test pieces between the upper and lower incisor and rating according to the following scheme :

10 Extremely strong springiness

9 Very strong springiness

8 Strong springiness

7 Quite strong springiness

6 Acceptable springiness

5 Acceptable, slight springiness

4 Weak springiness

3 Quite weak springiness

2 Very weak springiness

1 Mushy texture, no springiness

RESULTS AND DISCUSSION

The results of chemical analysis of both fresh and frozen lizard fish are shown in Table 2. The freshness were apparently not so low from the viewpoint of K value which were 18.62 and 20.29 mg% for fresh fish and frozen fish respectively. The formaldehyde of fresh fish was 11.15 mg/g. The formaldehyde value correlated to the freshness of fresh lizard fish as indicated by the results of Sophonphong and Rungjiratananan (1993). However, the formaldehyde level in frozen lizard fish was high with a value of 66.90 mg/g. According to low temperature storage, protein denaturation by formaldehyde produced from TMAO had taken place (Nozaki et al., 1978). It showed that the higher the formaldehyde, the lower the freshness of fish. The moisture content and pH of both fresh and frozen lizard fish were about 78% and 6.11 - 6.34 respectively. Suwansakornkul et al. (1993) also found that moisture content and pH of fresh lizard fish (S. undosquamis, S. wanieso and S. elongata) were in the range of 77.03 - 81.72% and 6.53 - 6.71 respectively.

At the beginning of storage, a significantly higher ($P<0.05$) gel forming ability was found in UL than PL of fresh lizard fish surimi (Table 3,4 and Fig. 3). The gel strength of these surimi gradually decreased from 300-400 g.cm to 280-290 g.cm during 4 days of storage. After that, they became steady until 18 days and declined at the end. There was no significant difference ($P<0.05$) in the gel strength of PL surimi throughout 1 month of storage in contrast with UL surimi, But during the 4 days to 1 month of

storage, there was no significant difference ($P<0.05$) between UL and PL surimi. However, the quality of both the UL and PL surimi was still acceptable by folding and teeth cutting scores of AA 5-6. By sensory evaluation, slightly rough texture, springiness firm gel and dull appearance were observed in samples made from UL surimi but smooth texture, springiness-soft gel and glossy appearance were found in PL surimi samples (Table 6).

Theoretically, actomyosin is the main component that form kamaboko gel. During the leaching process, actomyosin was probably broken down into myosin and actin due to the homogenization process. In addition, pyrophosphate can dissociate actomyosin into myosin and actin besides enchancing the water holding capacity, protein solubility and improving textural properties. The texture of final product made from myosin was slightly softer than that of actomyosin (cited by Thammarutwasik, 1988). It could be concluded that lower gel strength of PL surimi than UL surimi was observed since the myosin gel formation gave a softer gel. In addition, pyrophosphate plays an important role as a cryoprotectant (Suzaki, 1981). Therefore the gel strength of PL surimi during storage at $-20^{\circ}C$ decreased slower than that of UL surimi. Thammarutwasik (1988) also concluded that leaching by the usual, alkaline and alkaline pyrophosphate leaching methods of sardine surimi did not give significant different results.

After 11 days of storage, egg white and AMP 600N were added in both UL and PL fresh lizard fish surimi in proportion of 0.5% and 1.0% respectively

based on weight of surimi. There was an improvement in the gel strength when compared with control as shown in Fig. 4-5 and Table 3-4. AMP 600N showed a higher effectiveness than egg white in the gel strength but the differences between them were not significant ($P<0.05$) in folding test, teeth cutting test and sensory evaluation (Table6).

The effect of both ingredients is through inhibition of the protease causing textural degradation of surimi gels (Lee et al., 1992). Moreover the effects of egg white and beef plasma on the setting ability of surimi seemed to be dependent upon the species of fish including time and temperature of cooking (Hamaan et al., 1990, Chung and Lee, 1990 and Shimizu et al., 1981). Hamaan et al. (1990) reported that addition of egg white solid and beef plasma hydrolysate in low grade Alaska pollack and menhaden surimi increased torsional shear stress and strain for all gels precooked at 60°C (90°C final cook) and a decrease in the density of the myosin heavy chain as observed by electrophoresis. Chung and Lee (1990) reporting on the thermal effects of the gel forming ingredients, concluded that the compressive force of surimi gels containing lactalbumin, egg white and wheat gluten increased markedly when initial cooked at 40°C and subsequently at 85°C.

The freshness of frozen fish used in this experiment as determined by K-value were 20.29 mg% and formaldehyde of 66.90 mg/g. In addition, fibrous texture and dehydration of fish meat were observed after thawing. Protein of this fish seemed to be denatured by frozen conditions on board. Therefore, the

quality of surimi using this frozen fish as shown in Table 7 was poor in all treatments.

At 0 day of storage, gel strength of UL and PL frozen lizard fish surimi were less than 100 g.cm. Sensory scores were also markedly low of D2. Even though egg white and AMP 600N were added in these surimi (UL and PL) after 4 days of storage to improve the gel forming ability, there was no effectiveness of both ingredients. Therefore, the experiment was not recommened to carry on because of this reason.

According to history of frozen lizard fish used in this experiment such as the method of catching, fish handling, freezing temperature and condition of storage were not cleared. Therefore, it was quite difficult to do the conclusion. However, some researchers reported that freezing sotrage temperature and formaldehyde content of fish meat have significant effect on the gel forming ability of kamaboko made from lizard fish (Nozaki et al., 1978). In addition, Oka and Ono (1987) observed that when freezing whole lizard fish at different temperatures, the gel forming ability declined at high storage temperature and lizard fish stored at $-35^{\circ}C$ for 3 months was a good material for production of kamaboko from surimi of pyrophosphate leaching method.

CONCLUSIONS

Pyrophosphate leaching did not give a differentiation of gel forming ability in fresh lizard fish surimi when compared with usual leaching within 1 month of storage. However products made from pyrophosphate leached surimi gave a smoother, springy and soft texture with glossy white appearance. Egg white powder and beef plasma protein concentrate (AMP600N) improved the gel forming ability of both usual and pyrophosphate leaching surimi which were precooked at 40°C (90°C final cook). Good gel surimi could not be produced from two-month frozen lizard fish even with addition of egg white or beef plasma protein concentrate.

RECOMMENDATIONS

Further works should be carried out as follows :

1. Analysis of protein pattern in lizard fish by electrophoresis should be carried out for identification of protein degradation causing lower gel quality.

2. Storage life of both UL and PL surimi should be carried on for at least 6 months.

3. In case of surimi made from frozen fish, history of fish, freezing temperature and condition of frozen storage should be observed. Possibly, the experiment should be started from the step of freezing.

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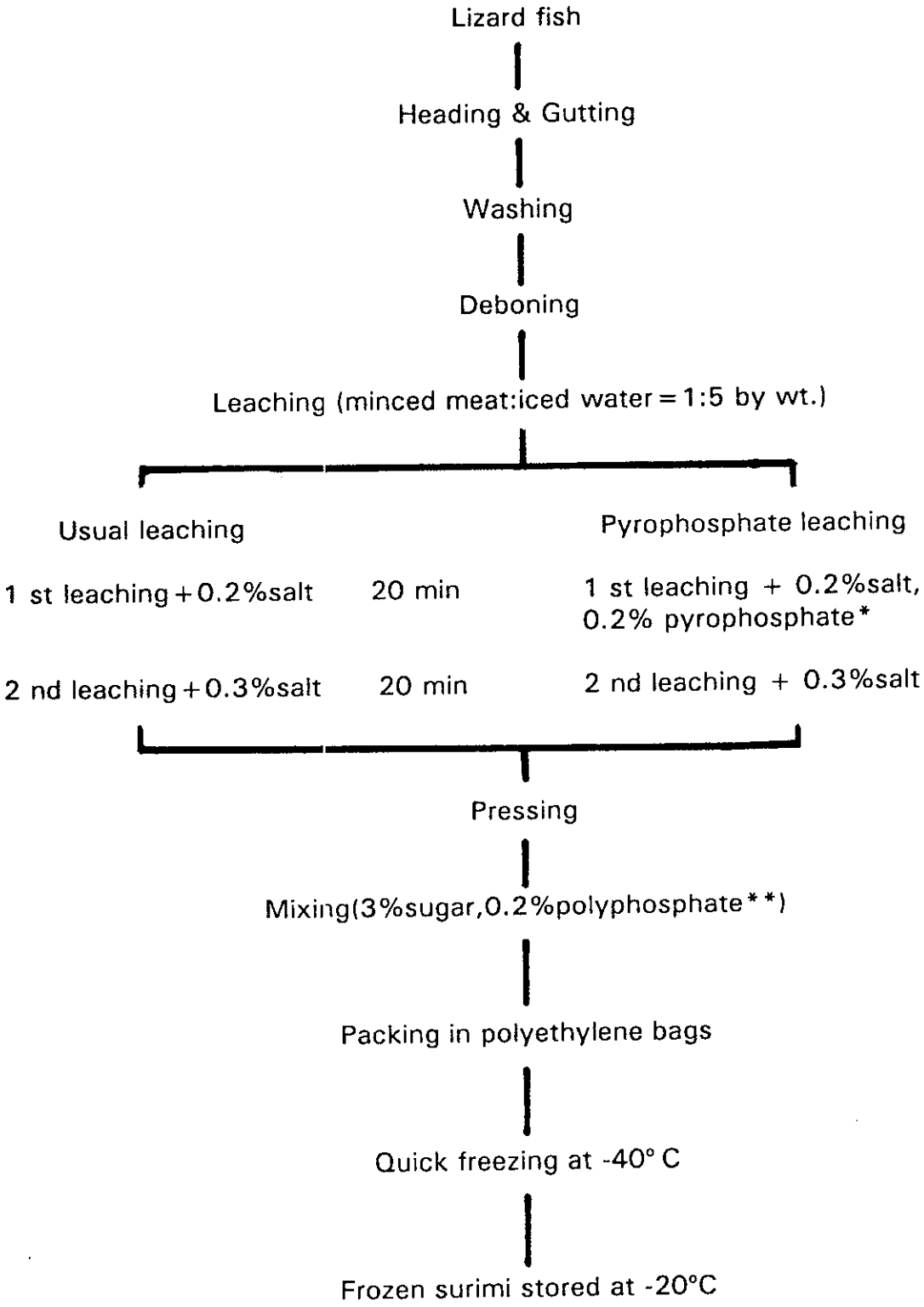

FIGURE 1 THE PRODUCTION OF FROZEN SURIMI

* tetra-Sodium-diphosphate decahydrate ($Na_4P_2O_7.10H_2O$)
** 50% pyrophosphate and 50% tripolyphosphate

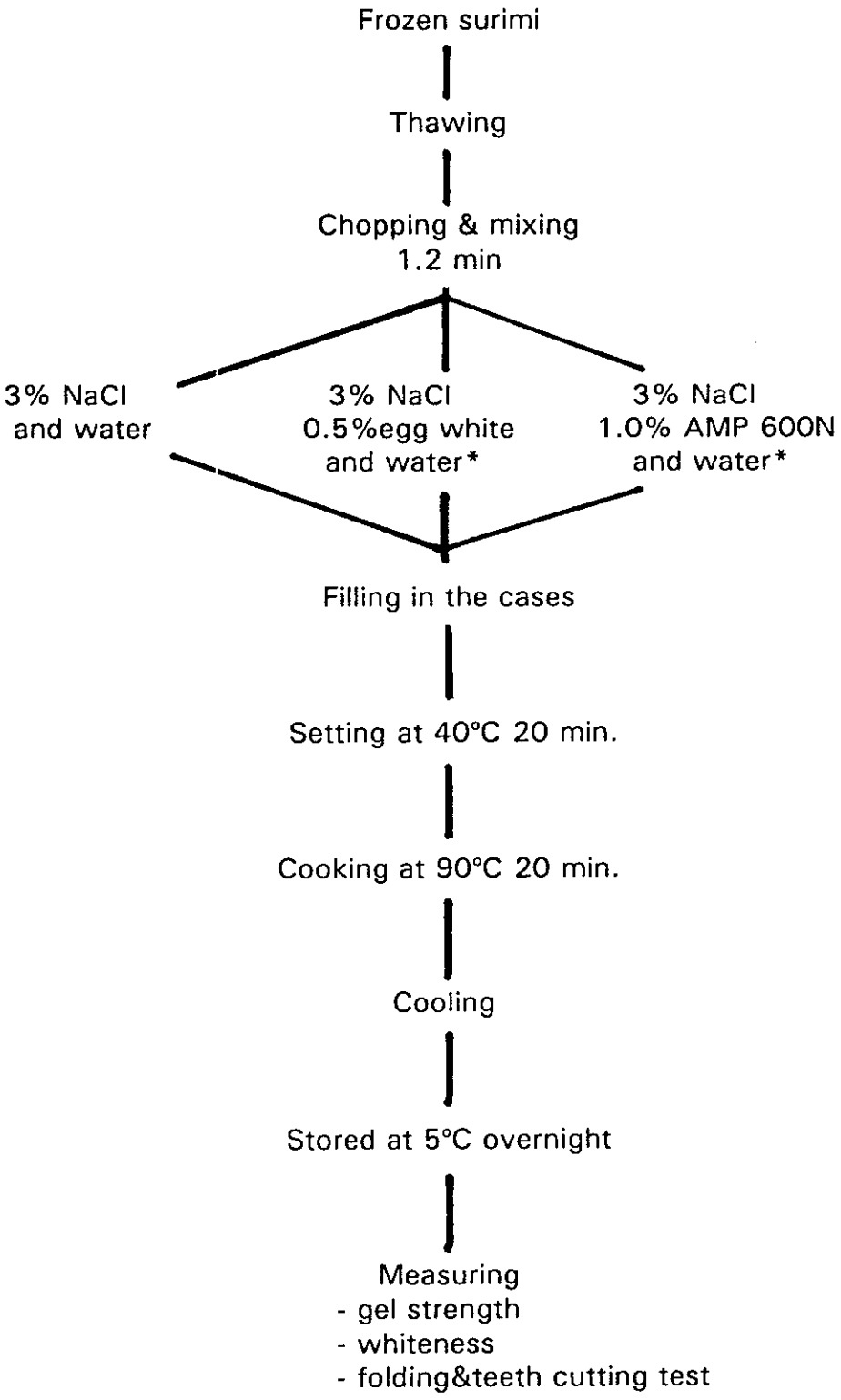

FIGURE 2 GEL PREPARATION

* To adjust moisture content to 85%

Fig. 3 Gel strengths of fresh lizard fish surimi

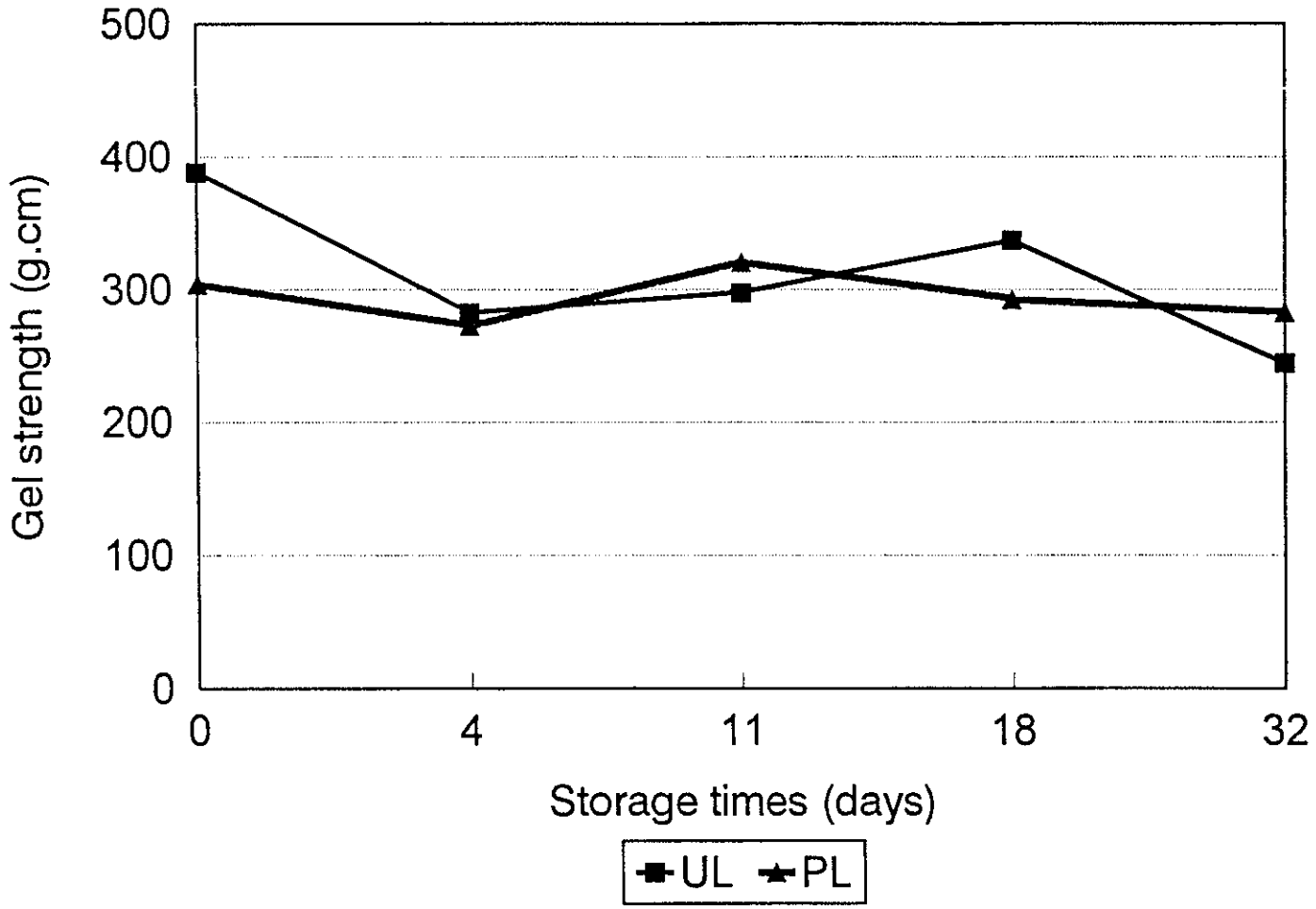

Fig. 4 Gel strengths of fresh lizard fish surimi (usual leaching) in combination with egg white and AMP 600N

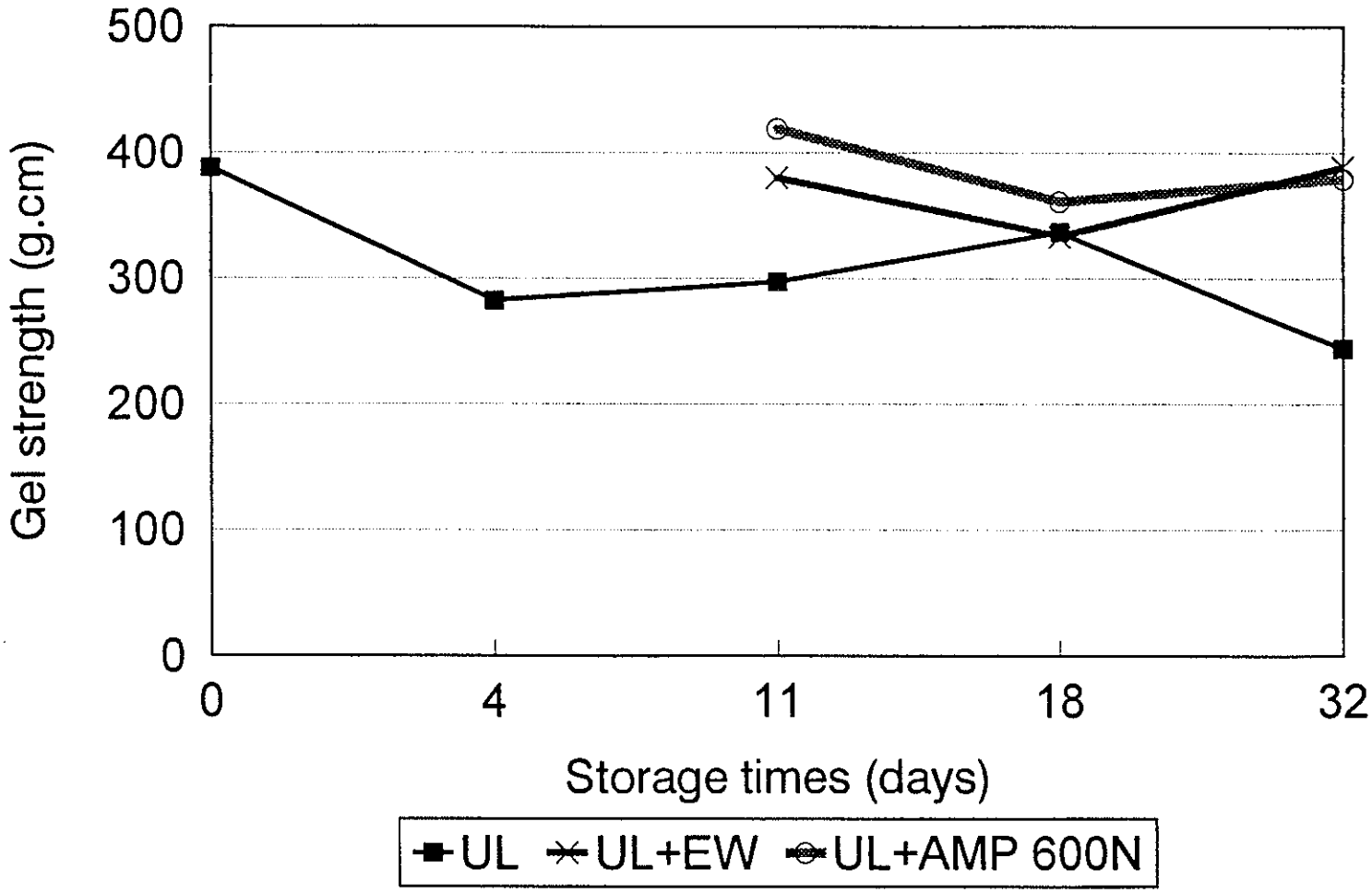

Fig. 5 Gel strengths of fresh lizard fish surimi (pyrophosphate leaching) in combination with egg white and AMP 600N

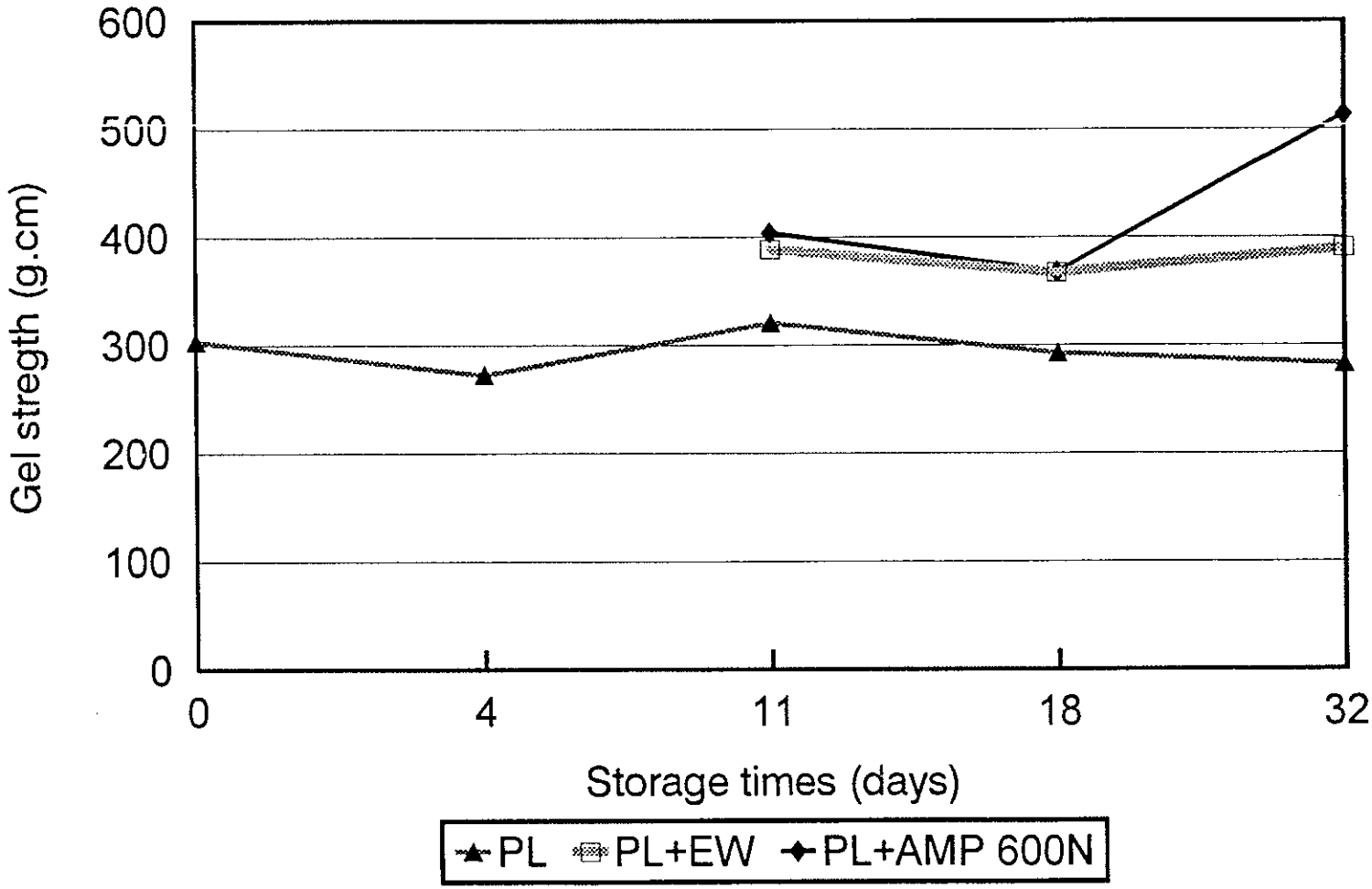

Table 1 Quantity, Value and Retail Price per Kilogram of Lizard Fish in Thailand.

Year	Quantity (Tons)	Value (US$1,000)	Retail Price	
			US$	Baht
1987	17,563	2,612	0.15	3.72
1988	17,319	2,799	0.16	4.04
1989	18,941	3,833	0.20	5.06
1990	16,454	3,575	0.22	5.43
1991	23,677	7,127	0.30	7.53

Sources : Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC),1987-1991

Table 2 Chemical Properties of Lizard Fish

Sample	K-value (mg%)	FA (ug/g)	Moisture(%)	pH
Fresh lizard fish	18.62 ± 4.30	11.15 ± 3.05	78.68	6.34
Frozen lizard fish	20.29 ± 1.80	66.90 ± 0.91	78.20	6.11

Table 3 Physical properties and gel forming abilities of fresh lizard fish surimi (usual leaching)*

Treatment	Storage time (days)	Moisture (%)	pH	Gel strength (g.cm)	Whiteness (%)	Folding&Teeth cutting score
UL(control)	0	79.51	6.91	388.16±71.99	60.23	AA 6
	4	79.24	-	282.25±21.60	59.66	AA 5-6
	11	79.02	-	297.46±47.32	59.64	AA 5-6
	18	79.29	-	336.90±43.32	58.76	AA 6
	32	78.26	-	244.12±70.14	59.54	AA 5
UL+ 0.5% Egg white	11	79.02	-	380.00±38.18	60.63	AA 6
	18	79.29	-	333.22±77.84	59.33	AA 6
	32	78.26	-	388.80±73.24	60.53	AA 5-6
UL+ 1.0% AMP 600N	11	79.02	-	424.46±44.26	58.00	AA 6
	18	79.29	-	360.89±27.00	58.52	AA 6
	32	78.26	-	379.00±45.77	58.96	AA 5-6

* results from duplicated samples

Table 4 Physical properties and gel forming abilities of fresh lizard fish surimi (pyrophosphate leaching) *

Treatment	Storage time (days)	Moisture (%)	pH	Gel strength (g.cm)	Whiteness (%)	Folding&Teeth cutting score
PL(control)	0	80.79	6.92	303.54±73.64	59.04	AA 6
	4	81.02	-	272.20±33.80	58.39	AA 5-6
	11	80.75	-	320.18±28.60	59.30	AA 5-6
	18	81.25	-	292.20±55.37	58.34	AA 5-6
	32	81.30	-	282.42±41.58	59.22	AA 5
PL+ 0.5% Egg white	11	80.75	-	388.50±84.44	59.35	AA 6
	18	81.25	-	367.14±67.30	58.40	AA 6
	32	81.30	-	390.42±65.00	58.63	AA 6
PL+ 1.0% AMP 600N	11	80.75	-	403.87±46.62	58.26	AA 6
	18	81.25	-	367.67±55.94	57.17	AA 6
	32	81.30	-	513.38±66.86	56.97	AA 6

* results from duplicated samples

Table 5 Physical properties and gel forming abilities of frozen lizard fish surimi

Treatment	Storage time (days)	Moisture (%)	pH	Gel strength (g.cm)	Whiteness (%)	Folding&Teeth cutting score
UL (control)	0	73.97	6.91	73.33±14.09	51.86	D 2
	4	74.02	-	51.42±9.56	52.36	D 2
UL+ 0.5% Egg white	4	74.02	-	70.58±9.93	50.76	D 2
UL+ 1.0% AMP 600N	4	74.02	-	131.89±20.81	47.58	C 2
PL (control)	0	76.00	7.02	56.92±13.57	51.80	D 2
	4	76.50	-	71.50±10.61	50.16	C 2
PL+ 0.5% Egg white	4	76.50	-	57.75±11.84	50.46	C 2
PL+ 1.0% AMP 600 N	4	76.50	-	77.17±14.23	48.60	C 2

Table 6 Sensory evaluation of surimi gel*

Treatment	Sensory evaluation		
	texture	gel	appearance
UL	slightly rough	springiness and firm	dull
UL+0.5% EW	slightly rough	springiness and firm	dull, white
UL+1.0% AMP	slightly rough	hard	dull, dark
PL	smooth	springiness and soft	glossy, white
PL+0.5% EW	smooth	springiness and soft	glossy, white
PL+1.0% AMP	smooth	hard	dark

* by discussion of trained panels