

The Gel Forming Ability of Washed and Unwashed Fish Meat (Lizardfish and Nile tilapia)

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ABSTRACT

The gel forming ability of unwashed and washed lizardfish (*Saurida undosquamis* and *Saurida elongata*) and Nile tilapia (*Oreochromis niloticus*) was investigated. Two-step heating of meat gels at 20°, 30°, 40°, 50°, 60°, 70° and 80°C for 20 minutes and 2 hours and further heating at 80°C 20 minutes were performed. Gel strength (g.cm), folding test and degradation of myosin heavy chain (MHC) by SDS-PAGE analysis were evaluated. The high gel strength and high folding test of unwashed and washed lizardfish meat were found at 30° and 40°C of heating and decreased remarkably at 60° and 70°C. However, the decrease of intensity of MHC without the appearance of MHC degraded products were obtained at a heating temperature lower than 50°C. A similar result of gel forming ability of Nile tilapia was found in this experiment. It showed that washed meat had better gel forming ability in both species. Moreover, the MHC degradation of meat gel was found to be a significant indicator for gel forming ability too.

Key words : gel forming ability, washed meat, unwashed meat, lizardfish, Nile tilapia, SDS-PAGE

INTRODUCTION

There are various species of fish used as raw material for surimi production. The important properties of fish meat for making surimi are that they should be lean and white-fleshed. However, high quality surimi must be processed from fresh fish. Gel forming ability is an index of surimi quality which varies according to species and season. In Japan, several studies have been reported on the gel forming characteristics of fish species (Shimizu *et al.*, 1981; Itoh *et al.*, 1995). Washing and unwashing of fish meat as well as heating temperature also affected the gel degradation (Nomura *et al.*, 1993; Suwansakornkul *et al.*, 1993). Itoh *et al.* (1995) reported that the effect of washing

on gel degradation or myosin heavy chain degradation at 40°C and 60°C of lizardfish meat was different. Serine and cysteine type proteinase activities were the factors affecting this gel degradation and varied with the season (Suwansakornkul *et al.*, 1993). Generally myosin heavy chain degradation analysis using sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) is conducted to describe these occurrences.

In Thailand surimi is commercially produced from several species of mostly marine fish, such as threadfin bream, big-eye, lizardfish, etc. Freshwater fish were used particularly for research works (Somboonyarathi, 1990; Kongpun, 1996). However, the fundamental factors affecting the quality of

surimi have not yet been studied.

Therefore, the objective of this experiment was to study the effect of washing and unwashing of meat and heating temperature on gel-forming ability of some species of lizardfish and Nile tilapia.

MATERIALS AND METHODS

Fish

Lizardfish and Nile tilapia (*Oreochromis niloticus*) were bought at the Bangkok fish landing place. Most of lizardfish consisted of true lizardfish (*Saurida undosquamis*) and shortfin lizardfish (*Saurida elongata*). Sizes of lizardfish were 122.9 ± 60 g of total weight and 23 ± 3 cm of total length while total weight of Nile tilapia was 253.8 ± 30 g and total length was 23.3 ± 0.7 cm. Two trials of each fish were carried out using fifty kilograms of fish in each trial.

Chemical analysis

The dorsal muscle was sampled for determination of proximate composition and pH (AOAC, 1984). Total volatile bases, TVB (MFRD, 1992) and K-value (Uchiyama and Kakuda, 1984) as index of freshness were also determined.

Gel preparation

Both fish were deheaded, eviscerated and washed. Minced meat was separated from bone by meat bone separator (BIBUN NDX 103-5). Two kinds of meat gel, washed and unwashed, were prepared from each fish (Figure 1). The moisture of meat gels was adjusted to 80%. Salt was added to a final concentration of 3% and ground with meat for 6 minutes by a Stephan vertical cutter/mixer (UM5 Universal, Stephan Machinery Corp., Columbus, OH). The meat sol was stuffed into a sausage casing of 1.5 cm diameter and 10 cm length. Each of the five stuffed sausage casings

were set in water bath at 20°, 30°, 40°, 50°, 60°, 70°, and 80°C for 20 minutes and 2 hours. These meat sol were further heated at 80°C for 20 minutes and cooled in ice water. The obtained meat gels were stored at 5°C for 18-24 hours and then the gel assessment was carried out.

Assessment of gel properties

The gel strength was determined by cutting the prepared meat gels into 2.5 cm thickness and measured with a Rheometer (Rheo tex SD-305) equipped with a spherical plunger (5 mm in diameter) at the speed of 60 mm/min. The sample was pressed by a plunger until a break occurred. The weight exerted on the sample until breaking point (force or strength) is shown by l (g) and the depth (deformation or strain) by h (cm). The $l \times h$ (g.cm) is used as a measure of the gel strength.

The folding test was conducted by folding the slices of 5 mm thickness gel. Five grades of this test are categorized as follows: AA no crack when folded twice; A no crack when folded in half; B cracks gradually when folded in half; C cracks immediately when folded in half; D breaks by finger pressure.

SDS-PAGE analysis of fish meat gels

Each gel of 0.5 g was solubilized with 20 ml of 0.05M sodium phosphate buffer (pH 6.8) containing 8M Urea, 2% SDS and 10% 2-mercaptoethanol. SDS-PAGE was carried out according to the method of Weber and Osborn (1969). Five microlitre of solubilized samples were applied on the 5% polyacrylamide gel (Mini-PROTEAN II Electrophoresis cell, BIO-RAD)

The patterns of protein as polymer, myosin heavy chain (MHC) and MHC breakdown or degraded products, which appeared between MHC and actin bands, were evaluated.

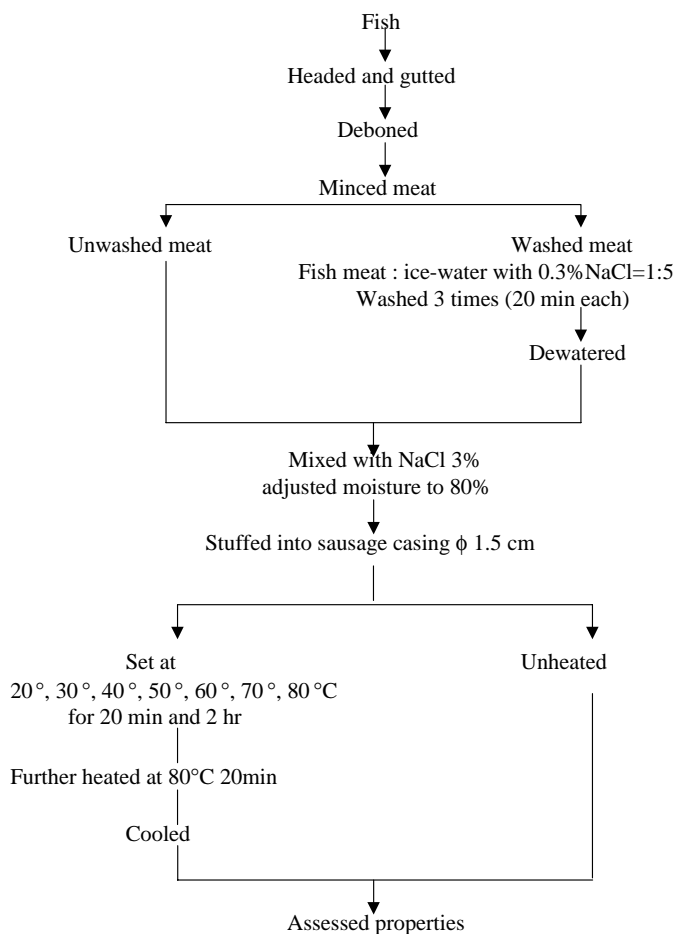


Figure 1 Gel preparation.

RESULTS AND DISCUSSION

Chemical analysis of fresh lizardfish and Nile tilapia is shown in Table 1. The two trials of lizardfish had a protein content of 17.65%, 19.55% and moisture content of 79.03%, 78.33%. The fat contents of this fish were 1.07% and 1.95%. It could be concluded that lizardfish was a lean fish because its fat content was less than 4% (Spinelli and Dassow, 1982). This result was different from experiments on lizardfish in Japan reported by Suwansakornkul *et al.* (1993) whose fat contents of

S. undosquamis, *S. wanieso* and *S. elongata* were less than 1%. TVB of lizardfish in both trials were almost the same value of 17.88 and 17.66 mg/100g. Generally, TVB of fresh fish is less than 20 mg/100 g (Connell, 1990). Moreover, the K-value of this fish in the second trial was 41.17%, higher than in the first trial that was 12.51%. Uchiyama (1978) reported that the K-value of fresh fish fitting for raw consumption was about 20%. However, the K-value of fresh lizardfish was not correlated to the freshness as indicated by Sophonphang and Rungjiratananan (1993). As compared to Nile

tilapia, the small amount of obtained TVB and K-value were 9.94 and 12.00 mg/100g and 6.92 and 2.86% respectively. These results could indicate that the Nile tilapia in this experiment was very fresh.

Gel-forming ability defined by gel strength (g.cm) and the folding test of the first trial of unwashed and washed lizardfish meat gels heated at various temperatures and times are shown in Figure 2. The gel strength of unwashed meat gels was less than 150 g.cm and folding tests were C and D at most heating temperatures and times, especially, the unwashed meat gel at 60°C showed no gel strength. The extension of heating time seemed to decrease gel strengths of both unwashed and washed lizardfish meat gels at all heating temperatures except at 30° and 80°C. The washing of meat resulted in the increase of gel strength at all heating temperatures. The obtained gel strengths of washed meat gels were 137-308 g.cm while folding tests were A-AA. The extreme decrease of gel strength was observed at 60°C of both unwashed and washed meat gels. The highest gel strength was obtained in washed meat heated at 30°C for 2 hours. However, the gel strength of unwashed and washed lizardfish meat gels at 40°C for 20 minutes

was about 200-260 g.cm and obtained folding test were AA. The same phenomenon was reported by many researchers (Makinodan and Ikeda, 1971; Shimizu *et al.*, 1981 and Suwansakornkul *et al.*, 1993). Recently the gel-degrading factor of both sarcoplasmic type and myofibrillar type was presumed to be the cause of this result (Suwansakornkul *et al.*, 1993). The drastic decrease of unwashed meat gel heated at 70°C for 2 hours was also found similar to the report of Suwansakornkul *et al.*, (1993). The lizardfish meat gels of the second trial had higher gel strength and folding test than those of the first one (Figure 3). Possibly, the differentiation of gel degradation between two trials of lizardfish meat gels was due to the seasonal variation as supported by Suwansakornkul *et al.* (1993).

Figure 4 shows the plotting between force or strength (g) and deformation or strain (cm) of unwashed and washed lizardfish meat gel. By comparing this figure with Lanier's map, the gel-forming properties was provided by XY plotting of the strength (stress) and cohesiveness (true strain) of fish meat gel in terms of brittle, tough, mushy and rubbery (Lanier, 1986). The gel of unwashed and washed lizardfish meat which had low gel

Table 1 Chemical analysis of fresh lizardfish and Nile tilapia.

Sample	Protein (%)	Fat (%)	Ash (%)	Moisture (%)	TVB (mg/100g)	K-value (%)	pH
1. Fresh lizardfish							
-1 st trial	17.65 ^a ±0.43 ^b	1.07±0.05	1.04±0.08	79.03±0.05	17.88±0.03	12.51±0.25	6.9
-2 nd trial	19.55±0.13	1.95±0.02	1.64±0.14	78.33±0.15	17.66±0.01	41.17±0.88	6.8
2. Fresh Nile tilapia							
-1 st trial	16.57±0.32	1.23±0.03	0.92±0.01	78.92±0.60	9.94±0	6.92±0.10	6.4
-2 nd trial	16.57±0.32	1.23±0.04	0.92±0	78.92±0.60	12.00±0.05	2.86±0.11	6.5

a : mean of triplicate determination

b : standard deviation

strength were expressed as slightly mushy in the map while the high gel strength samples showed slightly rubbery and tough gel.

SDS-PAGE analysis showed the changes of myosin heavy chain (MHC) intensity according to various heating temperatures and times (Figure 5). MHC degradation of unwashed lizardfish meat gels was obviously observed at 60° and 70°C. The decrease of MHC bands intensity and the amount of MHC degraded products which appeared between MHC and actin on SDS-PAGE patterns were found at these temperatures in both trials. Suwansakornkul *et al.* (1993) also reported that the degradation of unwashed meat gels occurred at 40°, 60°, 70°C in *S. elongata*, at 60° and 70°C in *S. undosquamis* and at 60°C in *S. wanieo*. These results were similar to the results of Makinodan and Ikeda (1971) and Shimizu *et al.* (1981). In addition, the results of this analysis of washed lizardfish meat gels in both trials had similar patterns (Figure 6). MHC degradation and the degraded products of MHC of the first trial were observed at 40°, 50°, 60° and 80°

C for 20 minutes and 2 hours of heating, For the second trial, they were observed at 30°, 40° and 70° C for 20 minutes and 2 hours of heating, especially at 60° and 70°C 2 hours of both trials, the degraded products of MHC were clearly found. Corresponding to Suwansakornkul *et al.* (1993) that MHC degradation of washed meat gel occurred at 40°C in *S. elongata* or at 60°C in *S. undosquamis*. Moreover, they concluded that the degradation of gel at 70°C or higher temperature of heating took place by sarcoplasmic-type proteolytic degrading factor. However, the lower intensity of MHC band was found accompanying the disappearance of MHC degraded products of gels heated at 40°C. This occurrence may be due to the polymerization of myosin by transglutaminase which was active at this temperature (Araki and Seki, 1993, Nowsad *et al.*, 1993).

Gel strengths of unwashed and washed Nile tilapia meat in both trials were almost the same (Figure 7, 8). Washed Nile tilapia meat had higher gel strength than unwashed meat at all heating

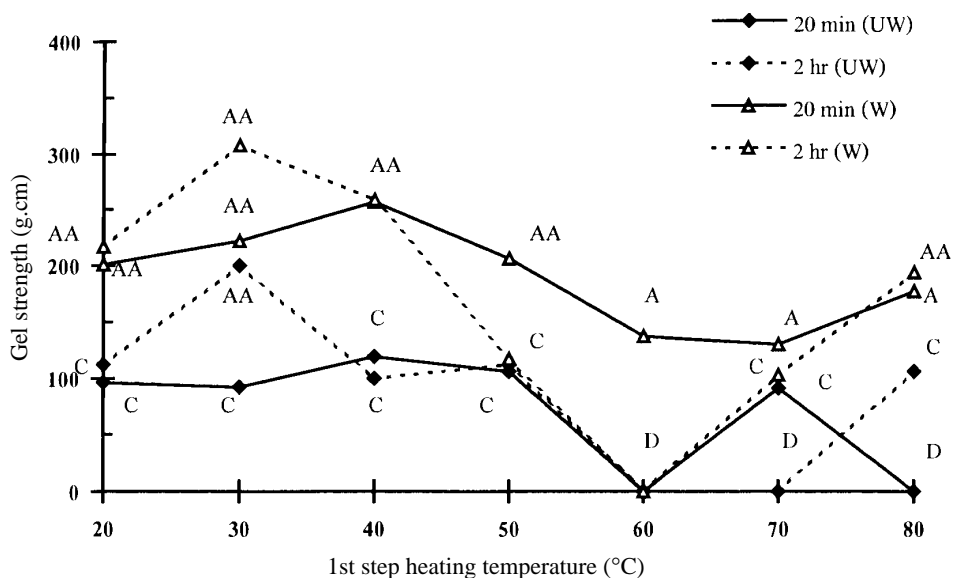


Figure 2 Gel strength and folding test of unwashed and washed lizardfish meat (1st trail).

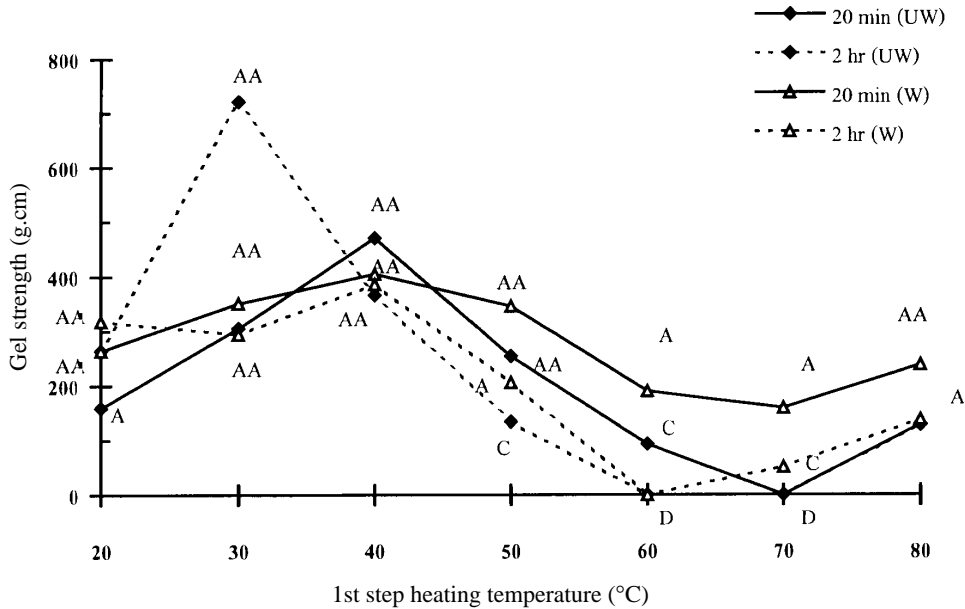


Figure 3 Gel strength and folding test of unwashed and washed lizardfish meat (2nd trail).

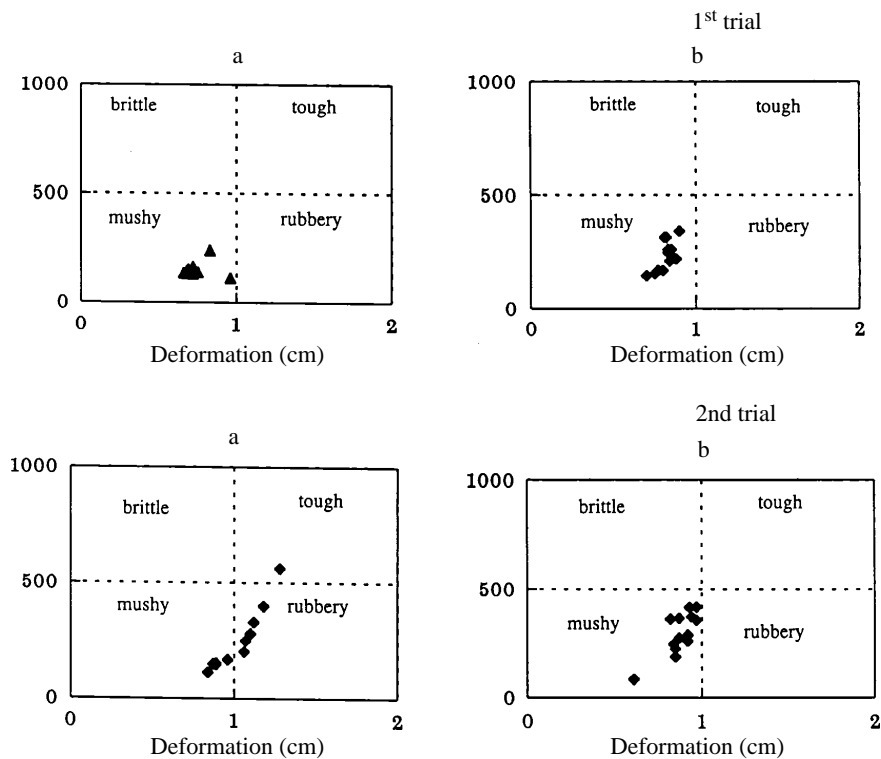


Figure 4 Force and deformation of unwashed and washed lizardfish meat.

a, unwashed meat

b, washed meat

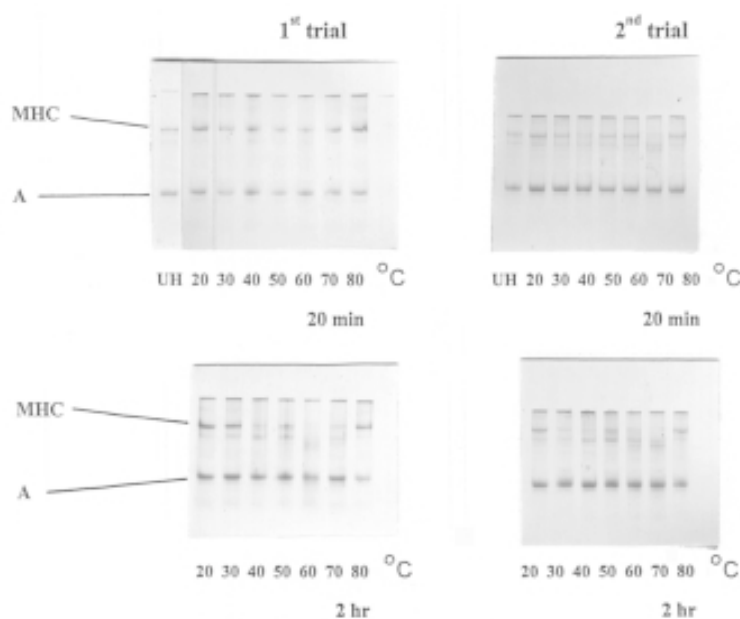


Figure 5 Myosin heavy chain degradation patterns of unwashed lizardfish meat gels at various heating temperatures and times.

MHC, myosin heavy chain; A, actin; UH, unheated meat

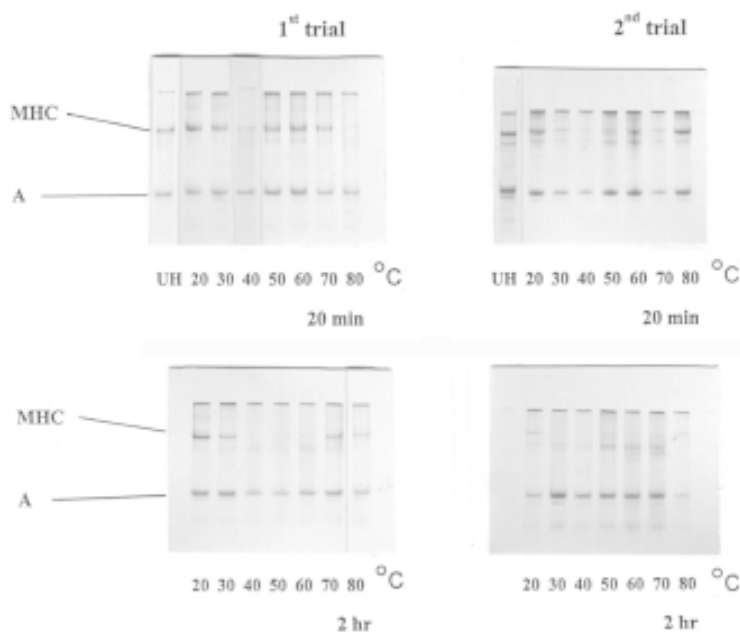


Figure 6 Myosin heavy chain degradation patterns of washed lizardfish meat gels at various heating temperatures and times.

MHC, myosin heavy chain; A, actin; UH, unheated meat

temperatures since washing could upgrade the gel forming ability (Okada, 1964). The highest gel strengths of the first and second trials of washed Nile tilapia meat, heated at 40°C 2 hours, were 1048 g.cm and 705 g.cm while those of unwashed meat were found at 30°C 2 hours of heating as 272 g.cm and 240 g.cm respectively. However, the lowest gel strength of the first trial of both unwashed and washed meat were observed at 60°C 2 hours of heating as 0 g.cm and 115 g.cm respectively. The second trial of both meat was also found the lowest gel strength at 70°C 20 minutes and 60°C 2 hours as 103 g.cm and 208 g.cm. In addition, the results of the folding test of all unwashed and washed Nile tilapia meat samples were correlated to their gel strengths, since the folding test of AA was observed when the gel strength was higher than 150 g.cm.

The relation between force (g) and deformation (cm) of Nile tilapia meat gel compared with Lanier's map showed a tough and rubbery texture for washed meat but slightly mushy for unwashed meat (Figure 9).

Figure 10, 11 show the protein patterns of

Nile tilapia meat gels as SDS-PAGE analysis. The MHC degradation patterns of the first trial of unwashed meat gel at various heating temperatures were slightly different. The decreasing intensity of MHC band and the appearance of MHC degraded products were found at 60° and 70°C for 2 hours of heating. The patterns of the first trial were observed more clearly than in the second one. Moreover, these observations were corresponding to the decline of gel strength shown in Figure 7, 8. The MHC degradation patterns of washed Nile tilapia meat gels of both trials showed similar results. At 40°C 2 hours of heating, a decrease of MHC band intensity was obtained contrary to the highest gel strength being observed. In addition, at 50°, 60°, and 70°C of heating, not only were the decrease of MHC bands intensity found but also the degraded products were correlated to the decrease of gel strength.

In conclusion, the gel-forming ability of lizardfish and Nile tilapia was induced by heating at 30° and 40°C and declined at 60° and 70°C. Washing of meat resulted in better gel-forming ability in both species. A heating time of more than

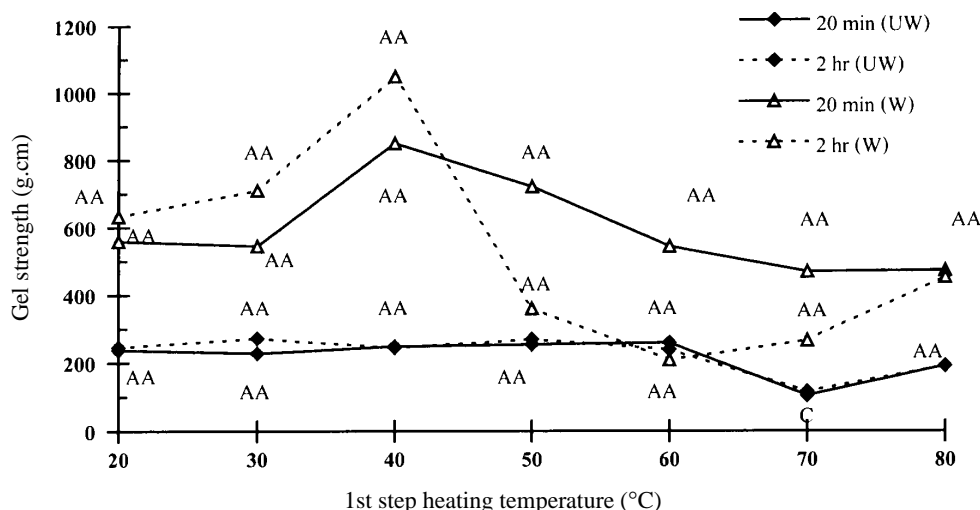


Figure 7 Gel strength and folding test of unwashed and washed Nile tilapia meat (1st trial).

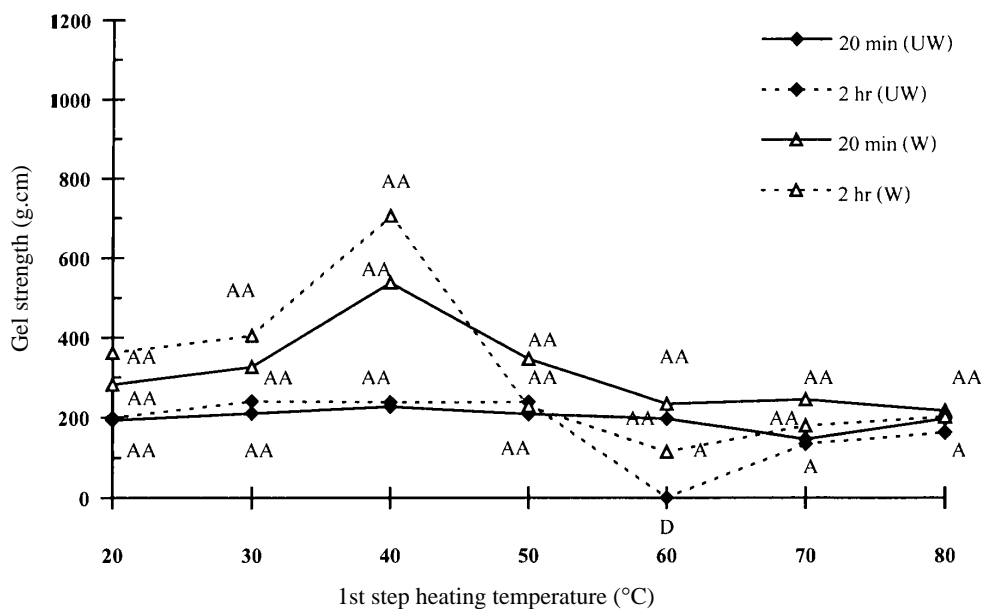


Figure 8 Gel strength and folding test of unwashed and washed Nile tilapia meat (2nd trial).

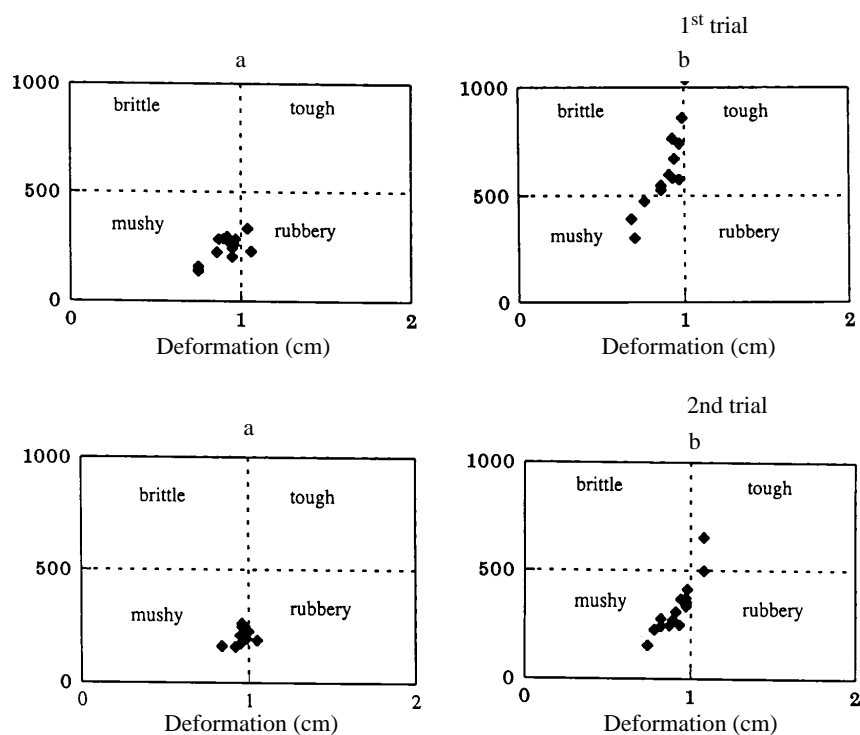


Figure 9 Force and deformation of unwashed and washed Nile tilapia meat.

a, unwashed meat

b, washed meat

20 minutes influenced the increase of gel-forming ability at 20°, 30° and 40°C but was found to decrease at 50°, 60° and 70°C. The results of SDS-PAGE indicated the decline of gel formation at 60° and 70°C were due to the degradation of MHC. The washing of meat also influenced the degradation of MHC at 60° and 70°C, suggesting that there was some salt soluble proteolytic degrading factor activated by high temperature in these species.

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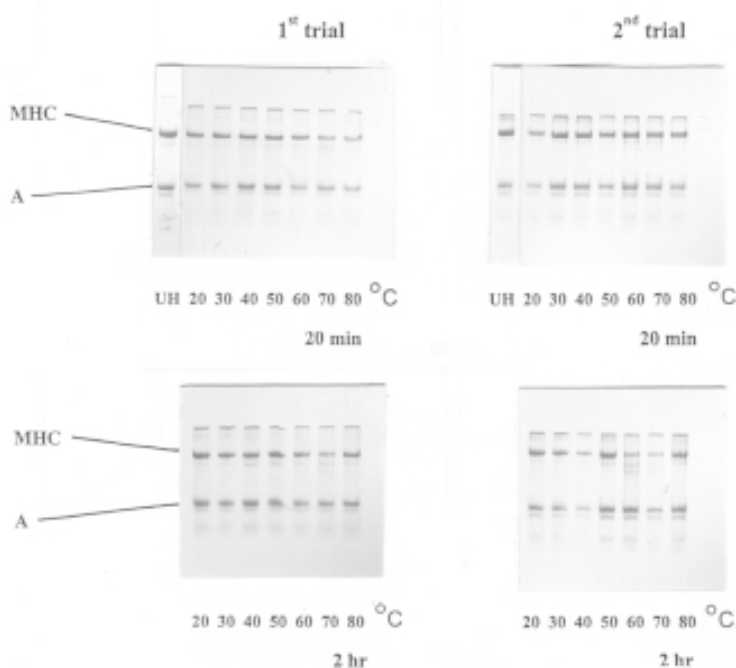


Figure 10 Myosin heavy chain degradation patterns of unwashed Nile tilapia meat gels at various heating temperatures and times.

MHC, myosin heavy chain; A, actin; UH, unheated meat

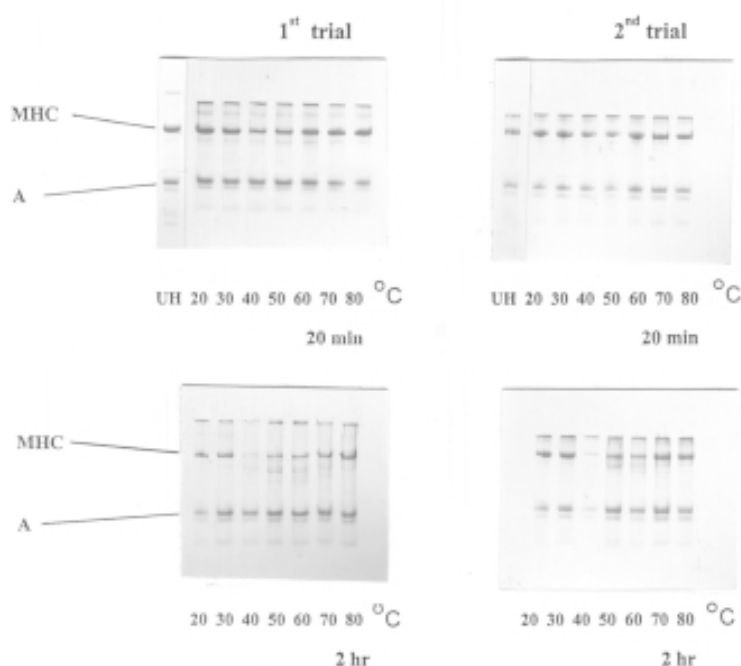


Figure 11 Myosin heavy chain degradation patterns of washed Nile tilapia meat gels at various heating temperatures and times.

MHC, myosin heavy chain; A, actin; UH, unheated meat

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