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Processing of surimi from freshwater fish – Tilapia

(Pemprosesan surimi daripada ikan air tawar – Tilapia)

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Key words: freshwater fish, tilapia, surimi processing, surimi quality, iced storage, frozen storage

Abstrak

Kesesuaian ikan tilapia sebagai bahan mentah untuk pemprosesan surimi telah dikaji. Tilapia didapati sesuai untuk pemprosesan surimi. Surimi yang dihasilkan berwarna putih dan dapat membentuk gel setanding dengan surimi ikan kerisi. Masalah bau hanyir diatasi dengan merendam ikan yang dibersihkan di dalam air garam sebelum proses pengasingan tulang. Tiada perbezaan yang bererti diperoleh dari segi keupayaan membentuk gel bagi ketiga-tiga sampel surimi daripada dua spesies tilapia yang dikaji. Ikan tilapia yang disimpan dalam ais masih sesuai dijadikan surimi dalam tempoh 7 hari penyimpanan. Keupayaan membentuk gel bagi surimi yang mengandungi 3% gula sukrosa dan 3% sorbitol (b/b) tidak berubah dalam tempoh 10 bulan penyimpanan pada suhu –20 °C.

Abstract

The suitability of tilapia as a raw material for surimi processing was investigated. Tilapia was a suitable raw material for surimi processing. The surimi has good colour and gel-forming ability, comparable with surimi from threadfin bream. The muddy taste and fishy odour of the fish was reduced by mild salt water treatment before deboning. There were no significant differences in the gel forming ability of surimi from the two species of tilapia used in this study. Iced stored tilapias were suitable for surimi processing up to 7 days of storage. The gel-forming ability of surimi containing 3% sucrose and 3% sorbitol (w/w) remained unchanged up to 10 months of frozen storage at –20 °C.

Introduction

Surimi is the deboned fish meat that has been subjected to the leaching and dewatering processes to remove the sarcoplasmic proteins and to concentrate the myofibrillar proteins (Lee 1984). Sucrose, sorbitol and polyphosphate are added into surimi to prevent freeze denaturation of myofibrillar proteins during frozen storage, hence preserving the gel-forming ability of surimi (Park and Lanier 1987). Surimi paste forms a rigid, elastic and cohesive gel upon heating. Due to this unique textural characteristic of surimi gel, surimi has become an important ingredient in many comminuted foods such as kamaboko, fishballs and fabricated seafood analogues.

The gel-forming ability of fish protein is species specific. Many studies had been conducted in search of other potential raw

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material for surimi processing apart from the traditional species Alaska pollack. Now, a range of species have been identified as potential raw material for surimi. These include hoki, whiting, white hake, cod and Atlantic croaker (Pacheco-aguilar et al. 1989; Sych et al. 1990; Ablett et a1. 1991). However, the potential of freshwater fish as a raw material for surimi processing has not been fully explored.

The recent decline in traditional surimi resources together with the recent development in aquaculture industry world-wide provide a ground for freshwater fish to be an attractive raw material for surimi processing in the future. Today, aquaculture contributes about 13% of the world fish supply. In Malaysia, aquaculture has become more important involving 16 243 farmers with pond size totalling 4 248 ha (Anon. 1990). Among the aquaculture species, tilapia seems to be more promising. It is a prolific species which can attain marketable size in 4–5 months and has become the fourth important species in terms of production in 1990 (Anon. 1990). It is hoped that alternative use of freshwater fish other than fresh consumption will help to boost the local aquaculture industry.

This study examined the potential of processing tilapias into surimi. The effects of processing methods and raw material freshness on surimi quality together with the freeze stability of tilapia surimi were studied.

Materials and methods

Materials and methods of surimi processing

Fresh ungutted nile tilapia *(Tilapia nilotica),* red tilapia (*Oreochromis* spp.) and brackishwater red tilapia (*Oreochromis* spp.) having an average bodyweight of 300 g were obtained from local fish farms. They were packed in ice and brought to MARDI research station in Kuala Terengganu. Fish were stored in ice (ratio of 1 fish: 2 ice) for 0, 3, 5, 7, 10 and 12 days in insulated fish containers at ambient temperature (26–31 ^{o}C). Ice was replenished daily. Fish of 20–30 kg/batch were processed into surimi according to the conventional method described earlier (Che Rohani and Rokiah 1989). Fish were either deboned directly after gutting and cleaning with portable water or after dipping in chilled salt solution (5%) for 30 min, once or twice. Leached meat from fresh red tilapia was treated as follows:

- control (no additives added),
- mixed with 3.0% sucrose and 0.2% sodium tripolyphosphate (STPP), and
- mixed with 3.0% sucrose, 3.0% sorbitol and 0.2% sodium tripolyphosphate (STPP).

Each sample was subdivided into 2-kg lots, formed into blocks, packed into low density polyethylene bags and blast frozen until the internal temperature reached –22 °C. Samples were stored frozen at –20 °C and evaluated monthly for 10 months. The raw surimi was evaluated by determining the changes in protein and moisture content, and the surimi gel quality was evaluated by the folding test.

Chemical and colour analyses

Moisture content of the tilapia mince and surimi was determined by drying the samples to a constant weight at 100 °C. Ash and crude fat contents were determined on the dried samples according to AOAC (1984) procedures 18.025 and 7.062 respectively. Crude protein (N x 6.25) was determined by AOAC (1984) procedure 18.026. All analyses were carried out in triplicates and results were expressed in wet-weight basis. The colour of the raw surimi samples and cooked gels was determined using a Minolta chromameter model CR-300 to measure the CIE *L*, a*, b** values using at least four replicate samples.

Evaluation of surimi gel

Surimi samples which had been tempered to a temperature of near 0 °C were used. Frozen samples were thawed at ambient

temperature for an hour and chopped into small pieces. Surimi paste was prepared by blending 1.5 kg of surimi for 10 min in a stainless steel bowl grinder with the addition of 2.5% sodium chloride (w/w). Ice was added when necessary to adjust the moisture of the surimi paste to 82%. The paste was extruded into a 30 cm diameter vinylidene chloride casing using a sausage stuffer (Dicks, Germany). The stuffed paste was placed in a water bath at 40 °C for 20 min then in another water bath at 90 °C for another 20 min to set the gel. The gels were immediately cooled in ice water mixture and used in gel evaluation.

The ability of surimi to form a strong and elastic gel was evaluated using the folding test (Anon. 1980) and grades were converted into a 5-point score (grade AA = 5 and grade D = 1). The gels were also subjected to sensory evaluation by trained panelists using a 9-point hedonic scale (9 = like extremely and 1 = dislike extremely) as described earlier (Che Rohani and Rokiah 1989). Panelists were served with warm samples of surimi gel (3 cm diameter x 5 cm length) and asked to evaluate preference for colour, odour, taste, texture after chewing and overall acceptability.

Statistical analyses

Data were collected using the completely randomized design. Analysis of variance was performed on the observations using IBM mainframe computer (Gomez and Gomez 1984). Duncan's Multiple Range Test on attribute means was also performed (Hochberg and Tamhane 1987).

Results and discussion

Surimi processing from tilapia

The method of surimi processing employed in this study involved a two-cycle leaching process, straining to remove fine bones and scales, and dewatering to concentrate the myofibrillar protein. Sarcoplasmic proteins, fat and other solubles were removed during the leaching process. Therefore, the proximate composition of surimi was lower compared with its unleached mince *(Table 1).* The process reduced the protein content by 10–20% while the fat and ash contents by 60–80%. Similar observation was reported by Pacheco-aguilar et al. (1989).

Table 1. Proximate composition of the minced meat and surimi from three types of tilapia

Composition (%) (wet basis)	Nile tilapia	Red tilapia	Brackishwater red tilapia
Minced meat			
Moisture	80.4a	78.9a	80.5a
Protein	16.6a	16.7a	16.4a
Fat	1.4a	3.0a	2.3a
Ash	1.1a	1.5a	0.9a
Surimi			
Moisture	82.5a	81.7b	81.1b
Protein	13.3a	13.8a	14.6b
Fat	0.6a	0.5a	0.4a
Ash	0.5a	0.4a	0.5a

Mean values in each row with the same letter are not significantly different at $p < 0.01$ according to DMRT

Many consumers object to freshwater fish because of its earthy or muddy taste. This off-flavour is caused by geosmin, a chemical released into the water by the dying algae (Anon. 1994). Similar off-flavour problem was detected in the surimi gel from tilapia prepared by conventional method. About 70% of the sensory panelists rejected the sample because of fishy odour and muddy taste. Therefore, the leaching was extended to 30 min instead of 15 min to allow prolonged contact between the fish muscle and chilled water. The technique did not reduce the off-flavour. Alkali leaching too failed to overcome the problem. When the gutted and cleaned fish were soaked in 5% salt solution before deboning and processing into surimi by the same method, the scores for odour, taste and overall acceptability of the surimi gel increased significantly *(Table 2).* This means that the compounds related to fishy odour and muddy taste did not leach out during the leaching process. However, results in *Table 2* clearly showed that soaking the fish in mild salt solution before deboning was

Table 2. Effect of soaking in salt solution on the sensory score of surimi gel

Soaking time	Odour	Taste	Texture	Overall acceptability
No soaking	5.7a	5.6a	6.4a	5.4a
30 min x 1 soaking	6.4b	6.7b	6.6a	6.5b
30 min x 2 soaking	6.6b	7.1c	7.5b	7.3c

Mean values with the same letter are not significantly different at $p < 0.01$

Table 3. Scores of folding test and sensory attributes of surimi gel

Type of tilapia	Colour	Texture	Acceptability	Folding score
Nile tilapia	7.2b	6.9b	6.8a	5.0a
Red tilapia	7.4a	7.1a*	6.9a	5.0a
Brackishwater red tilapia	7.5a	6.9b	6.9a	5.0a

Mean values with the same letters are not significantly different at $p < 0.01$ according to DMRT

*Even though the mean values for texture seemed approximately similar, the F-ratio of the model is significant due to smaller error mean square compared with model mean square. This is exhibited by the difference in means.

more effective in improving the taste and odour of surimi gel from tilapia. Therefore, this technique is recommended to produce acceptable surimi from tilapia.

Quality of surimi from tilapia

The surimi produced from the two species of tilapia used in this study had a good gel-forming ability which determines the quality of surimi. The gel-forming ability of surimi is related to several factors including the fish protein, added materials such as salt, polyphosphates and starches, and the processing parameters (Lee and Toledo 1976). The most important factor is the fish protein itself. This study found that the crude protein content in tilapia surimi ranged from 13.3% to 14.6% *(Table 1)* and comparable with the content in surimi (13–15%) from marine fishes (Che Rohani and Rokiah 1989). This protein is essentially the myofibrillar proteins which are salt soluble. The water-soluble proteins had been removed during the leaching process. Surimi from brackishwater red tilapia had a significantly higher protein content. However, the differences in protein content did not have any significant effect on the texture and overall acceptability of the gels prepared from them *(Table 3).*

The folding test scores for the same samples further supported the results. All samples were rated as AA grade with maximum scores of 5.0. Folding test is a simple and rapid test which indicates the strength and elasticity of surimi gels (Hastings et al. 1990). The test is suitable for separating high quality from low quality surimi (Lanier 1992). However, the protein content is not the only factor which determined the gel-forming ability of surimi. Both the protein content and the functional quality of proteins affect the textural characteristics of surimi gels. The protein content relates more to the rigidity or hardness of the gel while the functional quality of proteins affects the elasticity and cohesiveness of the gel (Lanier 1986; Pacheco-aguilar et al. 1989). Therefore, the gel-forming ability of surimi from different species of tilapia used in this study can be best explained on the basis of the similarity in the functional quality of proteins rather than the protein content alone.

The L^*, a^* and b^* colour values indicate the quality of surimi and surimi

Table 4. Colour of surimi and surimi gel from red tilapia and two marine species

Type of fish	Surimi			Surimi gel		
	L^*	a^*	b^*	L^*	a^*	b^*
Red tilapia	56.63	0.39	3.17	73.63	–1.17	5.89
(n=3)	(0.78)	(0.34)	(0.39)	(0.34)	(0.12)	(0.18)
Threadfin	56.78	1.81	6.83	74.14	–1.47	6.71
bream[1] (n=8)	(0.51)	(0.15)	(0.22)	(0.29)	(0.06)	(0.35)
Lizardfish[2]	57.04	–0.51	1.32	74.85	–1.42	4.2
(n=3)	(0.84)	(0.07)	(0.45)	(0.66)	(0.13)	(0.19)

Values in brackets indicate standard deviation
L^* denotes lightness on a 0–100 scale from black to white
a^* denotes redness (+) or greenness (–)
b^* denotes yellowness (+) or blueness (–)
[1, 2]Che Rohani 1990 (unpublished data)

gels from tilapia and two marine species studied *(Table 4)*. Surimi from tilapia is white in colour and comparable with both surimi from threadfin bream and lizardfish. Surimi from threadfin bream has been exported successfully to Japan by Thailand. The colour of surimi gel from all species was whiter than the surimi itself due to the effect of protein coagulation upon heating.

Effect of raw material freshness on the surimi quality

Freshness is one of the most important factors determining the ability of surimi to form a strong and elastic gel (Lee 1986). The effect of iced stored whole fish on the quality of surimi prepared from them is shown in *Table 5*. Iced stored tilapias were suitable for surimi processing up to 7 days of ice storage. The gel strength, as indicated by the folding test scores, started to decrease after the seventh day of fish storage. Overall acceptability scores by the panelists also began to decrease after the seventh day of ice storage of fish. Similar results were obtained for the nile, red and brackishwater red tilapias. It is possible that the decrease in gel strength observed in this study was attributed to the decrease in the functional quality of proteins due to proteolytic degradation during storage. Proteolytic enzymes are normally present in the fish gut. During storage, these enzymes may be leached out from the gut into the fish muscle, hence causing the proteolytic degradation of proteins after prolonged ice storage of fish (Lanier 1986). In a similar study, using an ice-to-fish ratio of 1:1, nile tilapia for surimi processing can be stored in ice up to 4 days only (Somboonyarithi 1990). White hake was reported to be more susceptible to quality loss during ice storage with subsequent decrease in gel strength of surimi gel after 2 days of storage (Ablett et al. 1991).

Table 5. Scores for overall acceptability and folding test of surimi gel prepared from iced stored tilapias

Days of storage	Overall acceptablity			Folding score
	NT	RT	BRT	
0	6.8bc	7.1ab	7.1ab	5.0a
3	7.0ab	7.2a	7.0ab	5.0a
5	7.2a	7.1ab	–	5.0a
7	6.9a	6.9ab	6.7ab	4.8a
10	6.4c	6.6bc	7.1a	3.5b
12	6.5b	6.2c	6.5b	3.3c

NT = nile tilapia, RT = red tilapia,
BRT = brackishwater red tilapia
Mean values with the same letter are not significantly different at $p < 0.05$ according to DMRT

Frozen storage of surimi

Fish muscle undergoes freeze-induced protein denaturation during frozen storage which affects the gel-forming ability. Thus, the use of cryoprotectants to prevent protein denaturation in Alaska pollack during frozen storage was considered a major breakthrough in Japanese kamaboko industry. Compounds reported to have a good cryoprotective effect on myofibrillar protein include sucrose, sorbitol and polyphosphates (Roussel and Cheftel 1990; Sych et al. 1990).

The effect of frozen storage of surimi from red tilapia on its gel-forming ability as indicated by the folding score is shown in *Figure 1*. The gel-forming ability of the control surimi declined rapidly during frozen storage. The folding score of the sample decreased from 5.0 (grade AA) to 2.0 (grade C) after 3 months of storage. The gel-forming ability of the surimi samples containing 3% sucrose and 0.2% STPP or 3% sucrose, 3% sorbitol and 0.2% STPP remained stable up to 10 months of storage. The decline in gel-forming ability of the control surimi was probably due to denaturation of myofibrillar proteins during storage. Sych et al. (1990) reported that without any additive, the salt-extractable protein in cod surimi stored at –20 °C for 4 months decreased by 18.4% indicating the freeze denaturation of protein. The presence of cryoprotective agents, sucrose and sorbitol, stabilized the myofibrillar protein and maintained their gel-forming ability. Better cryoprotection was obtained from sucrose and sorbitol at 6% (w/w) level. The use of higher levels of cryoprotectants as in commercial surimi overseas is not desirable to local consumers because they impart a sweet taste.

No direct relationship was observed between the protein content in raw surimi and folding scores of surimi gels. There were no significant changes (p <0.01) in the protein and moisture contents of the three surimi samples throughout the storage period (*Figure 2* and *Figure 3*) even though

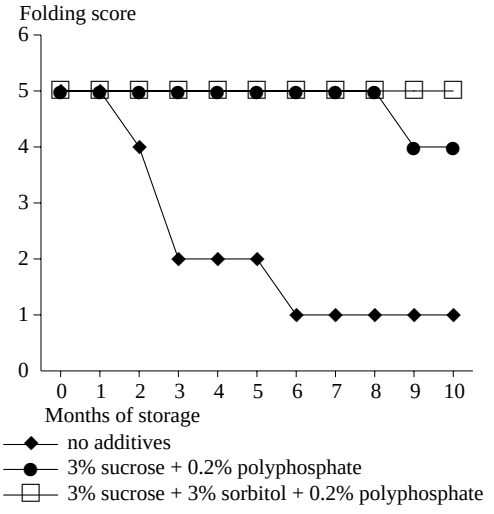

Figure 1. Changes in folding score during frozen storage of surimi from red tilapia

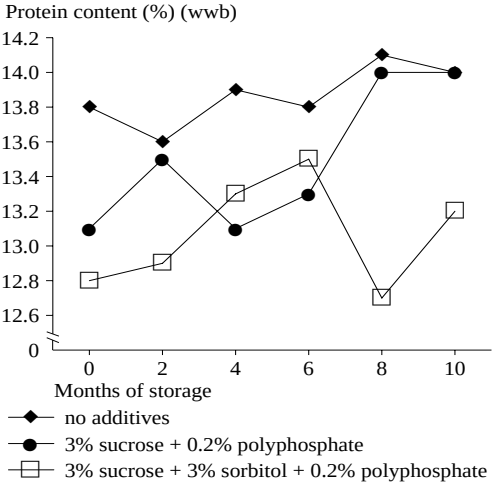

Figure 2. Changes in protein content during frozen storage of tilapia surimi

a significant decrease in folding score was observed in control surimi. The Pearson correlation coefficient between protein content and folding scores is 0.0527 with probability greater than absolute /r/ which indicates no significant association between protein content and folding score. Ablett et al. (1991) also reported a significant decrease in gel strength and cohesiveness of white hake surimi without any changes in the protein content. Based on the results of

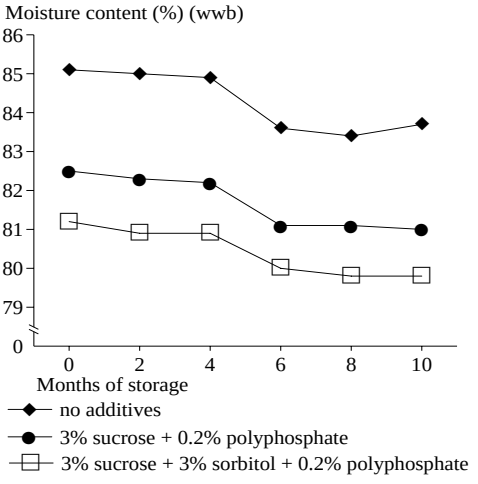

Figure 3. Changes in moisture content during frozen storage of tilapia surimi

this study, it can be concluded that the protein content was not a reliable indicator of gel-forming ability of frozen surimi from tilapia. Other tests which are related to the functional properties of proteins such as salt-extractable protein and expressible moisture, would be more reliable (Sych et al. 1991).

Conclusion

Tilapia is a suitable raw material for surimi processing. Its surimi has good colour and high gel-forming ability. No significant difference was obtained in the folding score and overall acceptability of surimi gels prepared from nile, red and brackishwater red tilapias. Dipping the gutted and cleaned fish in mild salt solution before deboning was found to be effective to overcome the problem of fishy odour and muddy taste in tilapia surimi. Freshness was a critical factor affecting the gel-forming ability of tilapia surimi. Whole ungutted tilapia can be stored in ice at a temperature near 0 °C for 7 days without significant changes in gel-forming ability. Addition of 3% sucrose, 3% sorbitol and 0.2% polyphosphate (w/w) to tilapia surimi inhibited the freeze denaturation of its myofibrillar proteins and increased its shelf-life at –20 °C to 10 months. There was no significant relationship between the protein content in frozen surimi and the folding score of surimi gel.

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