Functional properties of surimi powder from three Malaysian marine fish

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Summary Lizardfish (*Saurida tumbil*), threadfin bream (*Nemipterus japonicus*) and purple-spotted bigeye (*Priacanthus tayenus*) surimi were freeze-dried to produce surimi powder. The resulting surimi powder contained 72.8–73.4% protein and 16.8–17.5% carbohydrate. Functional properties such as solubility, gelation capacity, water-holding capacity (WHC), emulsification, foaming properties and colour varied from species to species. The surimi powder formed gels and produced about 90% emulsification at a concentration of 1.0%. Threadfin bream was found to be the best source for surimi powder production, followed by purple-spotted bigeye and lizardfish, respectively.

Keywords Drying, fish protein concentrate, physicochemical.

Introduction

Freezing equipment and frozen storage facilities are essential to maintain the quality of surimi. Generally, developing countries lack such facilities and this hinders the use of frozen surimi as raw material for food systems in these countries. Recent research indicates that surimi could be converted to a dried form, surimi powder. Researchers in Mexico (Montejano *et al*., 1994), Japan (Niki *et al*., 1992) and Norway (Opstvedt, 1985) converted surimi materials into powder or dried proteins. In its powdered form, surimi can be kept without frozen storage. The powdered surimi offers many advantages in commerce, such as ease of handling, lower distribution costs, more convenient storage and usefulness in dry mixes application (Green & Lanier, 1985).

It is possible to produce surimi powder using sugar or polyols to protect the protein from denaturation during drying as well as during freezing. This means that the cryoprotectant also serves as a dryoprotectant (Suzuki, 1981). The protective action is important to maintain the functional properties of fish protein. Functional properties such as solubility, gelation, water-holding capacity, emulsion, foaming and colour are important factors if fish proteins are to be incorporated into a food or dish as additives during preparation (Barzana & Garibay, 1994).

The objective of this study was to test the hypothesis that the functional properties of freeze-dried surimi powder from three marine fish species of Malaysian water, namely lizardfish (*Saurida tumbil*), threadfin bream (*Nemipterus japonicus*) and purple-spotted bigeye (*Priacanthus tayenus*), were acceptable as a commercial preparation.

Materials and methods

Preparation of surimi powder

Three marine fish species from Malaysian water, namely lizardfish, threadfin bream and purple-spotted bigeye, were processed at a local processing plant into surimi, using 3.5% sucrose and 0.15% phosphate as cryoprotectants. The frozen blocks were transported to the laboratory and stored at −18 °C until drying. A 500-g block of

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each surimi was dried using a Labconco Freeze Dry System (USA) at a temperature of −40 °C until the moisture content reached 5%. The samples were milled and sieved using a 40-mm screen mesh. The resulting powder was vacuum-packed and stored at 4 °C until further analysis.

Proximate composition

The proximate composition was determined according to AOAC (1990) methods. Crude protein content was determined using the Kjeldahl method (Kjeltex System-Texator, Sweden). Crude lipid content was determined by the Soxhlet method (Soxtec System-Texator, Sweden). Ash content was determined by ashing samples overnight at 550 °C. Moisture content was determined by drying samples overnight at 105 °C until constant weight was achieved. Carbohydrate content was calculated by difference.

Protein solubility

One gram of surimi powder was added to 40 mL of distilled water and 3% NaCl. A Vortex mixer (Thermolyne Maxi Mix II, USA) was used for 2 min to homogenize the samples. Aliquots were centrifuged (Hettich Universal 30 RF) at 6280 ***g*** for 5 min and the supernatants collected for protein estimation. The protein solubility was calculated on the basis of 100% solubility of the protein (Venugopal *et al*., 1996).

Water holding capacity

One gram of surimi powder was added to 40 mL distilled water in a 50-mL centrifuge tube and homogenized using a Vortex mixer (Thermolyne Maxi Mix II, USA) for 5 min. Tubes were centrifuged at 7500 ***g*** for 5 min (Hettich Universal 30 RF, USA). The supernatant was poured through a funnel into a 50-mL calibrated beaker. The volume of supernatant was subtracted from the original 40 mL. The result was reported in terms of mL of water held by 1 g of protein (Miller & Groninger, 1976).

Gelation

Surimi powder was added to 10 mL of distilled water in a test tube at concentration of 1–10%, and mixed in a vortex mixer (Thermolyne Maxi Mix II, USA) for 5 min. The tubes were heated at 90 °C for 30 min in a water bath (Memmert, Germany) then placed in a cold room for 30 min. The gelation concentration was determined as the lowest concentration at which samples did not fall down or slip from an inverted test tube (Miller & Groninger, 1976).

Emulsification properties

An amount of surimi powder was added to 25 mL of distilled water and 25 mL of corn oil (Mazola, USA) to give a final concentration about 0–2%. The mixture was then blended (Waring Blendor, USA) for 1 min and transferred to a 50-mL calibrated centrifuge tube. The tube was centrifuged at 7500 ***g*** for 5 min (Hettich Universal 30 RF, USA). The emulsification was calculated by dividing the emulsion volume after centrifugation by the original emulsion volume and then multiplying by 100. Emulsifying stability was determined by the same procedure except that, before centrifugation, the emulsion was heated at 90 °C for 30 min followed by cooling in tap water for 10 min (Yasumatsu *et al*., 1972).

Foaming properties

The method of Miller & Groninger (1976) was used to determine foaming properties. Surimi powder (1%) was added to 100 mL of distilled water in commercial blender (Waring, USA) and blended for 1 min at high speed. The mixture was transferred carefully into a 250-mL calibrated beaker for volume measurement. The foam was calculated as the volume of mixture after blending compared to the original volume. The foaming stability was the ratio of the foam capacity after time observation divided by the original foam capacity.

Colour

Colour measurement was made using a colorimeter (Minolta CR 300, Japan). The colour reading includes lightness (L), redness (a) and yellowness (b). The equipment was standardized with a white colour standard.

Density

Density was determined by placing samples in a pre-weighed 10-mL graduated cylinder to the 10-mL mark, with gentle tapping. The weight of the powder was noted and the density expressed as mL volume per 10 g powder (Venugopal *et al.*, 1996).

Statistical analysis

The data collected were analysed using Statistical Analysis Systems (SAS) version 6.11. Data were analysed using the general linear model procedure (GLM). Means of treatments showing significant differences ($P < 0.05$) were subjected to Duncan's multiple range test.

Results and discussion

Proximate composition

Proximate compositions of each surimi powder are shown in Table 1. The main component of surimi powder was protein (72.8–73.4%), followed by carbohydrate (16.8–17.5%). There were no significant differences ($P > 0.05$) in the protein and carbohydrate contents of surimi powders obtained from the three fish species. The ash content of threadfin bream surimi powder was significantly higher ($P < 0.05$) than that from lizardfish or purple-spotted bigeye.

As the protein content of all samples of surimi powder was higher than 65%, it can be classified as a fish protein concentrate (FPC) as proposed by the Food and Agriculture Organization (Barzana & Garibay, 1994). The high content of carbohydrate in the surimi powder was due to the addition of 3.5% cryoprotectant during surimi preparation. The amount of carbohydrate in the surimi powder depends on the amount of cryoprotectant added during surimi preparation. Montejano *et al.* (1994) used 8% cryoprotectant during the preparation of surimi, resulting in carbohydrate contents of 30.7% and 33.5% for surimi powder from trout and tilapia, respectively. However, the higher amount of cryprotectant added will result proportionately in lowered contents of other components, including the percentage of protein content. The protein contents of surimi powder obtained from trout and tilapia were 64.8 and 57.8%, respectively.

Table 1 Proximate composition of surimi powder

Surimi powder	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)
Lizardfish	5.2[b]	73.4[a]	1.9[a]	1.9[b]	17.5[a]
Threadfin bream	5.6[b]	72.9[a]	1.9[a]	2.2[a]	17.4[a]
Purple-spotted bigeye	6.4[a]	72.8[a]	1.8[a]	1.8[b]	16.8[a]

Values are means of triplicated determination on two drying trials. Means with the same letter within the same column are not significantly different ($P > 0.05$).

Solubility, gelation and water-holding capacity

The following properties of surimi powder, namely solubility in water and in 3% NaCl, gelation and water-holding capacity (WHC), are shown in Table 2. There was no significant difference ($P > 0.05$) in solubility between threadfin bream or purple-spotted bigeye, either in water or 3% NaCl. Solubility of protein from lizardfish was lower than threadfin bream or purple-spotted bigeye. There was a slight increase in the solubility of surimi powder in 3% NaCl solution. Similar results were observed by Huda *et al.* (1999) on the solubility of surimi powder, dried using the oven method, and by Venugopal *et al.* (1996) with air-dried fish protein powder samples.

Table 2 Protein solubility, gelation and water holding capacity of surimi powder in water and 3% NaCl*

Dried products	Solubility in water (%)	Solubility in 3% NaCl (%)	Gelation (%)	Water-holding capacity (mL/g)
Lizardfish	8.0[c]	8.1[b]	4.2[a]	13.5[b]
Threadfin bream	10.9[a]	12.4[a]	1.2[b]	19.5[a]
Purple-spotted bigeye	10.7[b]	12.3[a]	1.8[b]	19.7[a]

* Values are means of triplicated determination on two drying trials. Means with the same letter within the same column are not significantly different ($P > 0.05$).

The freeze-dried surimi powder gelled at a concentration between 1% and 4%. The gelation capacity of surimi powder varied significantly ($P < 0.05$) depending on its origin. Surimi powder from threadfin bream showed significantly higher ($P < 0.05$) gelation than that from purple-spotted bigeye or lizardfish. Gel formation of freeze-dried surimi powder from trout and tilapia has been reported previously by Montejano *et al.* (1994), and for spray-dried surimi powder from Alaska pollock by Niki *et al.* (1992). However, surimi powder dried using the oven method at 50–70 °C failed to produce a gel (Huda *et al.*, 1999). Thus, only fish protein dried at lower temperatures, particularly using the freeze-dried technique with cryoprotectants, could reduce denaturation of myosin and actomyosin. These proteins are responsible for gelation.

There was no significant difference ($P > 0.05$) in WHC between surimi powder obtained from threadfin bream and purple-spotted bigeye. The WHC of lizardfish surimi powder was significantly lower ($P < 0.05$) than the other two samples. However, the WHC of threadfin bream and purple-spotted bigeye surimi powder was lower than WHC of surimi powder from spray-dried Alaska pollock, as reported by Niki *et al.* (1992). The WHC of surimi powder from Alaska pollock was 40 mL water g^{-1} powder. The higher WHC of Alaska pollock may be related to the higher amount of cryoprotectant, different drying methods or simply that different fish species exhibit different WHC.

The higher solubility, gelation capacity and WHC of dried surimi from threadfin bream and purple-spotted bigeye compared with that from lizardfish may be related to the strong gel-forming ability and their highly stable protein, as reported by Holmes *et al.* (1992). Although lizardfish surimi had a high gel-forming ability, the freshness and stability decreased quickly during frozen storage. As the mechanism of protein denaturation caused by drying can be considered to be similar to the mechanism of freeze denaturation, the stability of protein during frozen storage can be used as an indicator of the stability of protein during the drying process (Suzuki, 1981). Lizardfish protein has been reported as having lower stability during frozen storage, with higher denaturation occurring during drying. This may result in the lowering of functional properties such as solubility, gelation capacity and WHC.

Emulsification and foaming properties

Emulsification properties of surimi powder at concentrations of 0.0–2.0% are shown in Fig. 1. It was observed that the percentage of emulsion increased as a function of surimi powder concentration. The emulsification rate of surimi powder from threadfin bream and purple-spotted bigeye were similar at the same concentration and were higher than for lizardfish. At 0.8% surimi concentration, emulsification was >80% for threadfin bream or purple-spotted bigeye, whereas it was <15% using lizardfish. At higher concentrations, the emulsification rate of threadfin bream and purple-spotted bigeye increased slowly. The emulsification properties of lizardfish increased rapidly at a 1.2% concentration and gradually decreased at the higher concentration.

Surimi powder obtained from lizardfish showed lower emulsion stability than from the other species. At 2% concentration, the emulsion stability of lizardfish surimi powder was about 77.5%. The result was significantly different ($P < 0.05$) when compared to the emulsion stability of threadfin bream and purple-spotted bigeye, which were 82.8 and 80.4%, respectively.

The highest emulsification properties of surimi powder from threadfin bream and purple-spotted bigeye may be related to the high stability of their protein, which can be protected from denaturation during the drying process. Holmes *et al.* (1992) reported that the myofibrillar protein of threadfin

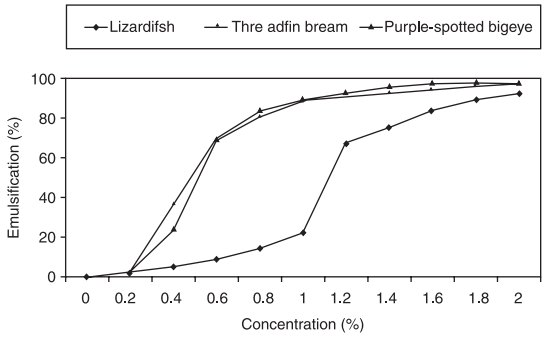

Figure 1 Emulsification properties of surimi powder from three marine fish species at different concentration.

bream and purple-spotted were more stable, and this results in high stability during frozen storage. As mentioned previously, the stability of protein during frozen storage can be used as an indicator to determine the stability of protein during the drying process.

Similar results were noted for the foaming properties. When surimi powder was blended with water, the volume of the mixture increased from 28.3 to 36.4%. There was a significant difference ($P < 0.05$) in the foaming capacity between the three fish species used in this study. Threadfin bream showed the highest foaming capacity (34.6)%, followed by purple-spotted bigeye (29.9%) and lizardfish (28.8%), respectively.

There were negligible changes in foaming stability using threadfin bream and purple-spotted bigeye surimi powder during 8 h of observation. The foaming stability of lizardfish surimi powder, however, decreases slightly within the first 5 h then increases rapidly during 5 h of observation. The highly stable foam from threadfin bream and purple-spotted bigeye may be related to their highly stable protein.

Density and colour

Table 3 showed the density, lightness (L), redness (a) and yellowness (b) of surimi powder from three marine fish species. There were no significant differences ($P > 0.05$) in density between the three surimi powders used in this study. Density was lower than that found from spray-dried Alaska pollock surimi (Niki *et al*., 1992) or oven-dried lizardfish surimi powder (Huda *et al*., 1999). However, the density was higher than in spray-dried threadfin bream hydrolysate (Venugopal *et al*., 1996). It can be concluded that factors such as the drying method, amount of cryoprotectant used and fish powder preparation methods may influence the density of fish powder.

Table 3 Density and colour characteristics of surimi powder*

Surimi powder	Density	Lightness	Redness	Yellowness
Lizardfish	2.43[a]	85.59[c]	0.30[a]	16.38[a]
Threadfin bream	2.26[a]	89.57[a]	0.19[c]	12.22[b]
Purple-spotted bigeye	2.36[a]	88.33[b]	0.23[b]	13.16[b]

* Values are means of triplicate determination on two drying trials. Means with the same letter within the same column are not significantly different ($P > 0.05$).

There were significant differences ($P < 0.05$) in colour characteristics among the samples studied. Threadfin bream surimi powder showed the greatest lightness value (L), followed by purple-spotted bigeye and lizardfish, respectively. The lightness value of freeze-dried surimi powder was slightly lower than that found for spray-dried Alaska pollock surimi powder (Niki *et al*., 1992). However, the lightness value was higher than that found for oven-dried lizardfish surimi powder, as reported by Huda *et al*. (1999). Similar results were found for redness (a) and yellowness (b) readings. The high 'b' values indicate the surimi powders were yellowish to light brown in colour. It can be concluded that factors such as fish species, drying methods and amounts of added cryoprotectant can influence the colour characteristics of surimi powder.

Conclusions

Results of this study showed that there are no significant differences in proximate composition of surimi powder obtained from the three species studied. However, functional properties such as solubility, gelation, WHC, colour characteristics, emulsification and foaming properties were significantly different ($P < 0.05$) between species. The threadfin bream surimi powder showed superior functional properties compared to purple-spotted bigeye or lizardfish based surimi. Futher research is needed to explore the suitability of surimi powder in food systems.

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References

Association of Official Analytical Chemists (AOAC) (1990). *Official Methods of Analysis*. 15th edn. Washington, DC: Association of Official Analytical Chemists.

Barzana, E. & Garibay, M.G. (1994). Production of fish protein concentrates. In: *Fisheries Processing: biotechno-*

logical applications (edited by A.M. Martin). Pp. 206–222. London: Chapman & Hall.

Green, D. & Lanier, T.C. (1985). Fish as the 'soybean of the sea'. In: *Proceedings of the International Symposium on Engineered Seafood Including Surimi* (edited by R.E. Martin & R.L. Collete). Pp. 42–52. Washington: National Fisheries Institute.

Holmes, K.L., Noguchi, S. & MacDonald, G.A. (1992). The Alaska Pollock resources and other species used for surimi. In: *Surimi Technology* (edited by T.C. Lanier & C.M. Lee). Pp. 41–78. New York: Marcel Dekker.

Huda, N., Aminah, A. & Babji, A.S. (1999). Effects of cryoprotectants on functional properties of dried Lizardfish (*Saurida tumbil*) surimi. *Malaysian Applied Biology*, in press.

Miller, R. & Groninger, H.S. (1976). Functional properties of enzyme modified acylated fish protein derivates. *Journal of Food Science*, **41**, 268–272.

Montejano, J.G., Morales, O.G. & Diaz, S.R. (1994). Rheology of gels of freeze-dried surimi of trout *(Cyanuscion nothus)* and tilapia. *(Oreochromis niloticus)*. *Revista Espanola de Ciencia Y Tehnologia de Alimentos*, **34**, 165–177.

Niki, H., Matsuda, Y. & Suzuki, T. (1992). Dried forms of surimi. In: *Surimi Technology* (edited by T.C. Lanier & C.M. Lee). Pp. 209–244. New York: Marcel Dekker.

Opstvedt, J. (1985). A national program for studies on the value for surimi production of industrial fish species in Norway. In: *Proceedings of the International Symposium on Engineered Seafood Including Surimi* (edited by R.E. Martin & R.L. Collete). Pp. 212–218. Washington: National Fisheries Institute.

Suzuki, T. (1981). *Fish and Krill Protein: processing technology*. Pp. 46–52. London: Applied Science Publishers.

Venugopal, V., Chawla, S.P. & Nair, P.M. (1996). Spray dried protein powder from Threadfin bream: preparation, properties and comparison with FPC type-B. *Journal of Muscle Food*, **7**, 55–71.

Yasumatsu, K., Sawada, K., Moritaka, S., Misaki, M., Toda, J., Wada, T. & Ishi, K (1972). Whipping and emulsifying properties of soybean products. *Agricultural and Biological Chemistry*, **36**, 719–727.

