

A Comparative Study on Physicochemical and Sensory Characteristics of Minced Fish and Surimi from Black Mouth Croaker (*Atrobuca nibe*)

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ABSTRACT

Commercial utilization of black mouth croaker (*Atrobuca nibe*) is in progress in Iran. This study was carried out to assess the physicochemical and sensory evaluation of minced fish and surimi prepared from small size of *A. nibe*, which is not common for human consumption. The surimi proximate composition contains protein ($14.77 \pm 0.506\%$), lipid ($0.94 \pm 0.081\%$), ash ($0.58 \pm 0.007\%$) contents and yield rate ($36.56 \pm 0.732\%$) were significantly lower than the mince, while the moisture content was higher in the surimi ($79.58 \pm 0.729\%$) as compared to the mince ($78.49 \pm 0.687\%$) ($P < 0.05$). Total volatile bases and thiobarbituric acid values of black mouth croaker surimi were 4.76 ± 0.594 mg N 100 g⁻¹, and 0.40 ± 0.018 mg malondialdehyde kg⁻¹, which, respectively, were significantly lower than those found for the minced fish ($P < 0.05$). Minced fish delivered significantly lower water holding capacity and pH value than the surimi ($P < 0.05$). Higher whiteness index was obtained in the surimi ($66.23 \pm 0.029\%$) compared to the mince ($51.68 \pm 0.020\%$) ($P < 0.05$). Total lipids of surimi contained more polyunsaturated fatty acids (36.32 ± 0.257 g 100 g⁻¹ total lipids) than other fatty acids of the minced fish ($P < 0.05$). Fish fingers prepared from the surimi obtained a higher mean score of all attributes (8.71 ± 0.366) than the minced fish (7.47 ± 0.326) ($P < 0.05$). It was concluded that this white-fleshed fish species was an appropriate raw material for surimi production. Further trials are needed to evaluate the surimi gel characteristics.

Keywords: Black mouth croaker, Fatty acids, Fish finger, Minced fish, Surimi,

INTRODUCTION

Fish meat is an important raw food material due to unique composition and richness of unsaturated fatty acids, essential amino acids (Usydus *et al.*, 2009; Akkus *et al.*, 2004), minerals, and vitamins (Nurnadia *et al.*, 2013). Recently, the most vital element of the fisheries marketing and exploitation is processing of raw fish.

In general, surimi is stabilized by myofibrillar protein without natural fish odour that is obtained from mechanically deboning, mincing, leaching (with water and dilute solution of NaCl), dewatering, blending with cryoprotectant, and finally freezing fish paste (Park, 2005; Tina *et al.*, 2010). Surimi is served as an intermediate raw material for a variety of products such as imitation shrimp meat, kamaboko, chikuwa, fish sausage, fish burgers and fish

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finger (Tina *et al.*, 2010) which has become markedly popular due to its nutritional benefits (Park, 2005; Jin *et al.*, 2009). Minced fish is also a significant component of seafood products in some countries (Yoon *et al.*, 1991; Lian *et al.*, 2000).

Several investigators have evaluated the quality properties of washed minced fish (surimi) and unwashed minced fish prepared from different fish species such as silver carp (Asgharzadeh *et al.*, 2010), channel catfish (Suvanich *et al.*, 2000; Hoke *et al.*, 2000), horse mackerel (Eymard *et al.*, 2005; Eymard *et al.*, 2009), escolar (*Lepidocybium flavobrunneum*) (Pattarvivat *et al.*, 2008) and yellowtail barracuda (Lertwittayanon *et al.*, 2013). For instance, thiobarbituric acid reactive substances (TBARS) index was higher in the minced fillets compared to surimi prepared from horse mackerel (Eymard *et al.*, 2005). However, there is a lack of information about physicochemical and sensory properties of minced fish and surimi products from black mouth croaker.

Black mouth croaker (*Atrobuca nibe*) (family: Scianidae) is one of the most important marine fish species that is detected in mesopelagic layers of the Oman Sea. However, human consumption of the small fish is not common in Iran. Thus, promoting to consumption of this size of the fish is necessary by producing variety products. This study aimed at finding the best way to handle and/or process black mouth croaker by producing surimi or minced fish in terms of proximate composition, physical (i.e. color, water holding capacity), chemical (i.e. pH, TVB-N, TBARS, fatty acids content) properties and sensory quality aspects.

MATERIALS AND METHODS

Raw Materials

Fresh black mouth croaker (*A. nibe*) samples were caught in the Iranian site of Oman Sea by R/V "Ferdows-1" that was equipped with a mid-water trawl net. Under

marketable size of the fish weighing 132.9 ± 24.4 g were collected and iced with a fish/ice at 1:2 (w/w) ratio in commercial foam box on board immediately after sorting and transporting to the laboratory (Islamic Azad University, Tehran, Iran) within less than 9 hours post sampling.

Preparation of Minced Fish and Surimi

Minced fish and surimi were prepared according to Lee (1984) with slight modifications. Briefly, the fish were beheaded, gutted, washed and drained by hand. The bone and skin of the fish fillets were removed from the muscles mechanically and the lean muscle was ground by a 3 mm diameter orifice using a SEPAmatic deboner (Bergisch Gladbach, Germany) in a walk-in cold room (8°C) to obtain a homogenous minced fish. The minced fish were combined with 3 times volume of chilled distilled water and mixed gently. Washing process was repeated with chilled distilled water and the supernatant containing fat and water-soluble proteins were discarded. Fish paste was then washed with chilled 0.3% NaCl solution. Each washing process was run for 4 minutes at $4 \pm 2^\circ\text{C}$. The washed minced fish was wrapped in a folded silk cloth and squeezed manually. Cryoprotectant agents (sucrose 4%, sorbitol 4%, and sodium tripolyphosphate 0.3%) were finally incorporated into the prepared dewatered minced fish with a Berjaya mixer (BM 10, Malaysia) for a further 60 seconds to obtain black mouth croaker surimi. The samples (300 g) were packed in a polyethylene sealed bag individually, frozen by air-blast freezer at $-25 \pm 2^\circ\text{C}$, and stored until analysis (not longer than 3 weeks).

Proximate Composition

The moisture and ash contents of the samples were measured by a moisture analyser (Sartorius MA30; Sartorius AG,

Germany) at 105°C and in an electric oven (Carbolite, England) at 550°C, respectively (AOAC, 1999). The total nitrogen and lipid contents were determined by Soxhlet and Kjeldahl extraction methods, respectively (AOAC, 1999). The crude protein was calculated from extracted Kjeldahl nitrogen multiplied by 6.25 correction factor. Process yields of minced fish and surimi samples were calculated from the ration of products weights to the fish body weight (Yang and Froning, 1992). Proximate composition was determined on wet weight basis.

Chemical Analytical Methods

Total volatile basic nitrogen (TVB-N) content was measured by distillation after addition of 2 g of MgO to the samples (10 g) in a distilling flask of macro-Kjeldahl. The collected distillate in 2% boric acid and methyl red indicator was titrated with 0.1N H₂SO₄ (Conway and Byrne, 1933). TVB-N content was expressed as mg of nitrogen per 100 g of sample.

Thiobarbituric acid reactive substances (TBARS) were determined according to the method described by Benjakul and Bauer (2001) with slight modifications. The samples (1 g) were homogenized with 5 ml of 0.375% 2-thiobarbituric acid, 15% trichloroacetic acid and 0.25N HCl. The mixture was incubated in a water bath (90°C) for 10 minutes. The tubes were then cooled in running tap water followed by centrifuging at 3,600×g for 20 minutes at ambient temperature. The absorbance of supernatant was determined at 532 nm using spectrophotometer (Cary 50, Varian, Mulgrave, Australia). TBARS values were expressed as mg malondialdehyde (MDA) per kg of sample. The concentration of MDA was calculated from the reaction of 0.005M TBA (2 ml) solution with serial dilutions of 1,1,3,3-tetraethoxy-propane (TEP) to generate a standard curve.

A 5 g of each sample was homogenized in 45 ml distilled water prior to measuring its pH (Metrohm digital pH meter 654,

Switzerland) at ambient temperature (Das *et al.*, 2008).

Fatty acids profile of the minced fish and surimi was conducted by Metcalfe *et al.* (1961). The lipid was first extracted using chloroform, methanol and water according to Bligh and Dyer (1959) method. The methyl esters of the fatty acids were then prepared from total extracted lipid based on Christie (1982) method and the fatty acid methyl esters solution was purified (Ghioni *et al.*, 1996). A volume of 1 µL of the solution was injected into the gas chromatograph (Younglin-ACME 6000, Japan), equipped with a capillary column (100 m length×0.250 mm internal diameter×0.2 µm film thickness). Hydrogen was used as the carrier gas at a 30 mL min⁻¹ flow rate (inlet pressure of 23.3 psi). The oven and detector temperatures were adjusted to 180 and 250°C, respectively (10°C/min ratio). Fatty acid composition of the samples was detected by comparing the methyl esters peaks of the retention times with the authentic standards (Sigma-Aldrich, Supelco SLB, UK). Fatty acid values were expressed as g of fatty acid methyl ester per 100 g of total lipid content (g 100 g⁻¹ total lipid content).

Colour Determination

Sample colour was performed using a HunterLab (HunterLab colourflex, USA). The determined parameters were lightness (L*) within the range 0-100, redness/greenness (a*) and yellowness/blueness (b*). Whiteness was measured using the following equation (Park, 1994):

$$\text{Whiteness} = \left[(100 - L^*)^2 + a^{*2} + b^{*2} \right]^{-\frac{1}{2}}$$

Water Holding Capacity

The water holding capacity (WHC) in both minced fish and in surimi was measured based on Himonides *et al.* (1999) with slight modification. A 5 g sample was wrapped in



double individual Whatman filter papers (No. 1) and subjected to centrifugation at $1,900\times g$ for 30 minutes at 8°C . The excluded water was calculated from the weight difference of the filter paper before and after centrifugation. The *WHC* of the samples was calculated using the following equation:

$$\text{WHC (\%)} = \left[\left(1 - \frac{M_{\text{w}}}{M_{\text{s}}} \right) 100 \right]$$

Sensory Evaluation

Fish finger samples were produced according to Tokur *et al.* (2006) method with slight modification. The sample contained 93.5% fish meat, 1.52% salt, 3% wheat flour, 1% onion powder, 0.02% thyme and 0.96% fried powder. Sensory evaluation of the samples was carried out by 7 trained judges. The panelists were scored for colour, odor, texture, taste, and general acceptability on a 9-point hedonic scale sensory evaluation (1: Dislike extremely to 9: Like extremely) (Paulus *et al.*, 1979). Fish fingers weighing 50.13 ± 2.3 g were prepared from minced fish and surimi from black mouth croaker and then deep-fried at $170\pm 5^{\circ}\text{C}$ for 3-4 minutes. The samples with uniform size were prepared for sensory evaluation.

Statistical Analysis

All physicals and chemicals experiments were replicated five and three times, respectively. SPSS 15 (SPSS Inc, Chicago, USA) was used to conduct statistical analyses. Significant difference among means values were evaluated by one-way analysis of variance (ANOVA) with Tukey's pair-wise comparison test to determine the differences between treatment means values at $P < 0.05$. The Kruskal-Wallis test was used to find out significant differences for the sensory attributes as a non-parametric analysis of variance at a 5% level of significance.

RESULTS AND DISCUSSION

Proximate Analysis

The proximate composition of minced fish and surimi are shown in Figure 1. The surimi proximate composition contains protein ($14.77\pm 0.506\%$), lipid ($0.94\pm 0.081\%$), and ash ($0.58\pm 0.007\%$) contents were significantly lower than the mince ($P < 0.05$). The reduction in these values were reported in surimi against minced fish from silver carp, channel

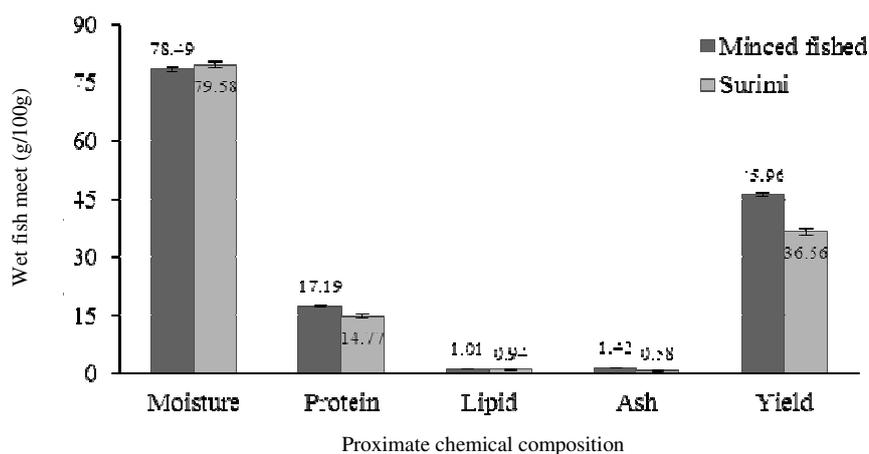


Figure 1. Comparisons of proximate characteristics mean value of minced fish and surimi productions from black mouth croaker. Bars indicate the standard deviations and different letters indicate significant differences ($n = 3$, $P < 0.05$).

catfish, and gangetic croaker (*Johnius gangeticus*) (Asgharzadeh *et al.*, 2010; Suvanich *et al.*, 2000; Kim *et al.*, 1996; Dey and Dora, 2011). Moisture content indicates quality of surimi (Hur, 2007) and industrial surimi (with addition cryoprotectants) should have less than 80% moisture content for high grade surimi (Lee, 1984; Sych *et al.*, 1990). The produced surimi had a moisture content of $79.58 \pm 0.829\%$, which is ideal for surimi production. In surimi production, washing process may lead to an increasing hydration availability of the minced meat (Lin and Park, 1997), resulting in higher content of moisture in the surimi than minced fish ($P < 0.05$; Figure 1). Fat content in the minced sample was similar to silver pomfret (1%) and markedly less than large yellow croaker (4.58%), respectively, as reported by Chakraborty *et al.* (2005) and Nazeer and Kumar (2012). It is because this fish species is classified as a lean fish (high amounts of white muscle), making it a good candidate for surimi manufacturing (Park, 2005). The lower lipid content were observed in the surimi due to washing process (Babbit, 1986; Suvanich *et al.*, 2000) and presumably lipid oxidation during stages of processing (Eymard *et al.*, 2005). Protein value in minced fish was in the normal marine fish range (8-21% wet weight) (Wu and Shiau, 2002) and significantly higher than protein content of tiger tooth croaker (*Otolithes ruber*) (Nazeer and Kumar, 2012) and more similar to African catfish (Osibona *et al.*, 2006) and large yellow croaker (Tang *et al.*, 2009). Higher content of protein was recorded in the minced fish compared to surimi ($P < 0.05$). Similar results were reported from gangetic croaker (*Johnius gangeticus*) (Dey and Dora, 2011) and channel catfish

(Suvanich *et al.*, 2000). This low protein value in the surimi could be due to the removal of sarcoplasmic protein during washing (Lin and Park, 1997; Park, 2005). Average yield of black mouth croaker surimi production was higher than cod (20%) (Vareltis *et al.*, 1989), Anchovy (*Engraulis encrasicolus*) (22%) (Kaba, 2006), pacific whiting (21-24%) (*Merluccius productus*) (Simpson *et al.*, 1994), catfish (31.6%) (Suvanich *et al.*, 2000) and gangetic croaker surimi (32.9%) (Dey and Dora, 2011). Mean yield of the minced fish was higher than result reported for silver carp (24.6%) (Yinghong *et al.*, 2003) an inferior to catfish (53.6%) (Suvanich *et al.*, 2000).

Change in Chemical Properties

It has been proved that pH is an important indicator of the freshness of seafood and seafood products which influences WHC, colour and textural properties of the meat (Byrne *et al.*, 2001; Brewer *et al.*, 2006). Higher pH values were obtained in the surimi than minced fish ($P < 0.05$; Table 1). Higher pH value of surimi could be due to the removing of free fatty acids content, free acidic amino acids, and especially lactic acid (Suvanich *et al.*, 2000). Adding the phosphates in surimi as a cryoprotectant can also increase the pH slightly (Park, 2005). Similarly, slight enhancing of pH in surimi was recorded by Dey and Dora (2011). Also, a positive correlation between pH and WHC (Tables 1 and 3) could be due to the minimizing the space between filaments and the amount of free water in acidic pH (Alvarado and McKee, 2007). Furthermore, optimal pH value for strong

Table 1. Comparison of some chemical properties of minced fish and surimi samples from black mouth croaker.^a

Samples	pH	TVB-N (mg N 100 g ⁻¹)	TBARS (mg MAD kg ⁻¹ tissue)
Minced fish	6.83 ± 0.084^a	11.81 ± 0.495^c	0.76 ± 0.056^e
Surimi	7.13 ± 0.099^b	4.76 ± 0.594^d	0.40 ± 0.018^f

^a Values are mean \pm SD (n= 3). Different letters in the same column denote the significant difference ($P < 0.05$).



white muscle fish surimi gelation is approximately 7.0-7.5 (Chung *et al.*, 1994; Ni *et al.*, 2001) and in the present study pH value of the surimi was calculated at 7.13 ± 0.099 .

Development of lipid oxidation can significantly inhibit the shelf life of meat, which may cause rancidity, affecting the colour, flavour, and taste of meat by forming free radicals (Botsoglou *et al.*, 2002; Kanner, 1994). In this study, the lipid oxidation of the minced fish and surimi were measured as the formation of malonaldehyde (MDA) using the TBA technique (Table 1). Also, fatty acids profile analysed (Table 2), as well as, the measurement of volatile compounds such as the total volatile basic

nitrogen (TVB-N) has become a well-accepted indicator of fish meat spoilage (Ross and Smith, 2006) and indicates the extent of the breakdown of proteins into non-protein N-compounds due to bacterial and enzymatic actions, leading to amines production (Pearson, 1976; Kerr *et al.*, 2002). The TBARS value in the surimi was 1.9 fold lower than minced fish (Table 1). The results of TBARS value were similar to the previous work done by Asgharzadeh *et al.* (2010) and Eymard *et al.* (2005), which showed that the TBARS of surimi was lower than minced fish. Also, in a research conducted by Hoke *et al.* (2000) TBARS value of catfish surimi ($0.20 \text{ mg MAD kg}^{-1}$ tissue) was lower than the minced fish (0.30

Table 2. The fatty acid contents ($\text{g } 100 \text{ g}^{-1}$ total lipid content) in minced fish and surimi obtained from black mouth croaker.^a

Fatty acids	Minced fish	Surimi
C _{12:00}	0.58±0.032 ^a	0.28±0.043 ^b
C _{14:00}	3.27±0.185 ^a	3.36±0.268 ^a
C _{15:00}	0.84±0.002 ^a	0.96±0.093 ^b
C _{16:00}	24.08±0.246 ^a	24.38±0.202 ^a
C _{17:00}	1.57±0.022 ^a	1.29±0.014 ^b
C _{18:00}	8.18±0.193 ^a	8.05±0.020 ^b
C _{20:00}	1.02±0.018 ^a	1.18±0.086 ^b
Total SFAs	39.54±0.272 ^a	39.50±0.070 ^a
C _{14:1 ω-5}	0.19±0.009	-
C _{16:1 ω-9}	9.38±0.257 ^a	7.64±0.144 ^b
C _{17:1 ω-11}	0.20±0.017	-
C _{18:1 ω-9}	25.29±0.314 ^a	25.40±0.056 ^b
C _{18:1 ω-7}	2.22±0.141 ^a	2.97±0.071 ^b
C _{20:1 ω-9}	0.39±0.006 ^a	0.31±0.098 ^a
Total MUFAs	37.66±0.161 ^a	36.32±0.257 ^b
C _{18:2 ω-6}	1.21±0.023 ^a	1.83±0.152 ^a
C _{18:2 ω-3}	1.30±0.110 ^a	1.09±0.091 ^b
C _{18:3 ω-3}	0.36±0.005 ^a	1.50±0.051 ^b
C _{18:3 ω-6}	0.18±0.005 ^a	0.54±0.020 ^b
C _{18:4 ω-3}	0.72±0.022 ^a	0.68±0.003 ^a
C _{20:3 ω-3}	1.72±0.146 ^a	0.99±0.085 ^b
C _{20:4 ω-6}	1.37±0.042 ^a	0.58±0.109 ^b
C _{20:5 ω-3} (EPA)	2.28±0.191 ^a	3.38±0.186 ^b
C _{22:5 ω-3}	1.00±0.132 ^a	0.94±0.077 ^a
C _{22:6 ω-3} (DHA)	9.99±0.186 ^a	10.63±0.110 ^b
Total PUFAs	20.13±0.161 ^a	22.25±0.136 ^b
Total ω-3	17.38±0.125 ^a	19.29±0.105 ^b
Total ω-6	2.77±0.048 ^a	2.96±0.241 ^a

^a Values are mean±SD (n= 3). Different letters in the same row denote the significant difference (P< 0.05). SFAs: Saturated Fatty Acids; MUFAs: Monounsaturated Fatty Acids; PUFAs: Polyunsaturated Fatty Acids, EPA: EicosaPentaenoic Acid, DHA: DocosaHexaenoic Acid, -: Not detected.

Table 3. Comparison of some physical properties of minced fish and surimi produce from black mouth croaker.^a

Samples	L*	a*	b*	Whiteness (%)	WHC (%) ^b
Minced fish	53.21±0.042 ^a	2.81±0.014 ^c	11.74±0.085 ^c	51.68±0.020 ^g	63.32±0.780 ⁿ
Surimi	67.34±0.028 ^b	-0.42±0.035 ^d	8.59±0.028 ^f	66.23±0.029 ^h	71.94±0.906 ^m

^a Values are mean±SD (n= 5). Different letters in the same column denote the significant difference (P< 0.05).

^b water holding capacity

mg MAD kg⁻¹ tissue). The lower *TBARS* value in surimi may be mainly due to the washing process and followed by reduction of carbonyl compounds in secondary fat oxidation stage (Ota, 1985; Silva and Ammerman, 1993).

TVB-N value showed a reduction trend in the surimi (P< 0.05; Table 1). Lower *TVB-N* value in surimi may be due to partial removal of free amino acids, sarcoplasmic protein or non-protein N-compounds by washing and dewatering (Suvanich *et al.*, 2000). It is noticeable that non-protein nitrogen fractions are water soluble and include 9-18% of the total nitrogen content of fish muscle (Huss 1988). Similarly, Asgharzadeh *et al.* (2010) recorded lower *TVB-N* value in silver carp surimi (5.8 mg N 100 g⁻¹) compared to the mince (13.2 mg N 100 g⁻¹). Pearson (1976) also suggested that *TVB-N* level below 20 mg N 100 g⁻¹ of white-fleshed fish was an indicator of freshness of these samples. *TVB-N* value in this study for both the minced fish and surimi did not exceed the standard levels.

A wide variety of fatty acids were detected in total lipids from both minced fish and surimi (Table 2). Among the total determined fatty acids, saturated fatty acids (SFAs) were similar in both minced (39.54±0.272 g 100 g⁻¹) and surimi (39.50±0.070 g 100 g⁻¹) samples (P> 0.05). Palmitic acid (C16:0) was the major abundant fatty acids among SFAs in both samples. This result is similar to Hoke *et al.* (2000) who showed that palmitic acid was the major abundant fatty acids among SFAs in both minced fish (17.32%) and surimi (17.51%) of catfish. Samples proportion of monounsaturated fatty acids (MUFAs) of the minced fish was slightly higher than the

surimi (P< 0.05; Table 2). Similar results were obtained by Hoke *et al.* (2000), Eymard *et al.* (2005), and Eymard *et al.* (2009). The impact of PUFAs on phospholipids composition is influenced by factors that control phospholipids biosynthesis in several respects (Sargent *et al.*, 1995). Polyunsaturated fatty acids (PUFAs) concentration was significantly more abundant in surimi than in minced fish (P< 0.05; Table 2). This increase may be due to PUFAs interactions with proteins and phospholipids that were less easily removed during the processing than other lipids and proportions of PUFAs such as DHA and EPA that increased in surimi (Bandarra *et al.*, 2001; Passi *et al.*, 2002). Similarly, Eymard *et al.* (2005) found higher PUFAs content in horse mackerel surimi, while Hoke *et al.* (2000) recorded slightly higher content of PUFAs in catfish minced fish (18.7%) than in the surimi (18.0%). As a consequence, lower *TBARS* value in surimi (Table 2) and higher proportion of PUFAs in surimi (Table 3) may indicate lower oxidation of PUFAs associated with lower rancidity (auto or enzymatic oxidation) during surimi production (Hsieh and Kinsella, 1989). Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) were the main abundant fatty acids in PUFAs contents. Major abundance of DHA followed by EPA among PUFAs were explained previously in mince fish fillets (Sarenson, 1990; Czesny *et al.*, 1999; Tang *et al.*, 2009) and surimi (Hoke *et al.*, 2000; Eymard *et al.*, 2005; Eymard *et al.*, 2009).

Assessment of Colour and WHC



Colour attributes concerning *L*, *a*, *b* values and *whiteness* index were apparently different between minced fish and surimi ($P < 0.05$; Table 3). The highest *lightness* value and *whiteness* index were obtained in the surimi sample compared to minced fish ($P < 0.05$). This increase may be due to the leaching of several components especially blood and pigments during washing and dewatering, resulting in improving the color of surimi compared to the raw minced fish (Lertwittayanon *et al.*, 2013). Kim *et al.* (1996) noted that washing and dewatering of catfish mince to produce surimi can enhance the whiteness and gel-forming ability of the product. The value of surimi markedly decreased compared to minced fish ($P < 0.05$; Table 3). Similar results were found by Nakayama and Yamamoto (1977), Hoke *et al.* (2000), and Jahncke *et al.* (1992). Furthermore, Miyauchi and Steinberg (1970) reported that washing process improves color and flavor stability of mince from dark flesh fish due to removal of the blood and heme pigments.

The highest WHC was observed in the surimi samples ($P < 0.05$; Table 3). WHC is directly correlated to the myofibrillar protein content (Smith, 1991) and washing and dewatering processes remove several components such as fat, sarcoplasmic proteins and other water-soluble agents that may interfere with the stability of the protein network and their removal would lead to increase myofibrillar protein WHC (Baxter and Skonberg, 2008). These results revealed myofibrillar protein of black mouth croaker surimi possesses higher water binding capacity and also lower drip loss than minced fish samples. This result is strongly similar to Niwa (1992) and Benjakul *et al.*

(2005).

Sensory Analysis

Changes in scoring of the sensory attributes of minced fish and surimi are shown in Table 4. Generally, the panelists preferred fish fingers prepared from surimi samples than minced fish ($P < 0.05$). Similarly, Tokur *et al.* (2006) reported higher sensory score for fish finger made from mirror carp surimi than the minced fish due to desirable flavour. Indeed, the odour and color seem to be deeply affected by washing and dewatering processes. The general desirability of fish finger prepared from mirror carp minced fish and surimi were measured as 8.25 and 8.75 scores, respectively (Tokur *et al.*, 2006). However, fish fingers in this investigation from minced fish and surimi samples reached the scores of 7.47 ± 0.326 and 8.71 ± 0.366 , respectively. Several investigators confirmed that the processes of washing, dewatering, and cryoprotectant in surimi manufacturing can improve the sensory quality (Nakayama and Yamamoto, 1977; Lin, 1992; Hoke, 1993).

CONCLUSIONS

Black mouth croakers is potentially an important seafood raw material for manufacturing fish fingers and burgers due to white lean flesh, therefore, these results show the differences between the minced fish and surimi quality as a based products. The obtained results show a significant effect of washing and dewatering processes on the proximate composition of the final surimi product due to partial removal of fat and water-soluble compounds e.g. blood, pigments, sarcoplasmic proteins and salts from the minced fish. Most of

Table 4. Comparison of sensory evaluation characteristics of fish fingers produce from minced fish and surimi of black mouth croaker.^a

Fish fingers	Color	Odour	Texture	Taste	Overall desirability
Minced fish	7.29 ± 0.976^a	7.14 ± 0.900^b	8.00 ± 0.816^c	7.49 ± 1.134^d	7.43 ± 1.113^d
Surimi	9.00 ± 0.000^e	8.86 ± 0.378^f	9.00 ± 0.000^e	8.57 ± 0.535^h	8.14 ± 0.690^m

^a Values are mean \pm SD (n = 7). Different letters in the same column denote the significant difference ($P < 0.05$).

pro-oxidant substances were presumably removed during washing and dewatering stages of surimi sample, but to prevent development of spoilage, all procedures should be carefully monitored during surimi manufacturing. PUFAs proportions mainly omega-3 fatty acids (e.g. DHA and EPA) in total lipid were more stable than other neutral fatty acids during production of surimi samples being higher in the surimi than in minced fish samples. Adding cryoprotectants and antioxidants is recommended to enhance surimi quality during frozen storage. However, using different types of these substances during frozen storage in both surimi and minced fish warranted further studies. Also, unlike surimi, minced fish delivers natural fish flavor and less whiteness colour that received lower sensory score. However, further researches are required on gel-forming ability of surimi from black mouth croaker.

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مطالعه مقایسه ای بر خصوصیات فیزیکوشیمیایی و حسی ماهی چرخ شده و سوریمی حاصل از ماهی شوریده دهان سیاه (*Atrobuca nibe*)

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چکیده

بهره برداری تجاری از ماهی شوریده دهان سیاه (*Atrobuca nibe*) در ایران در حال اجرا است. این مطالعه به منظور ارزیابی فیزیکوشیمیایی و حسی ماهی چرخ شده و سوریمی تهیه شده از اندازه های کوچک ماهی *A. nibe* که از نظر مصرف انسانی زیاد معول نیستند، انجام شد. ترکیبات تقریبی سوریمی شامل محتویات پروتئین (۱۴/۷۷±۰/۵۰۶٪)، چربی (۰/۹۴±۰/۰۸۱٪)، خاکستر (۰/۵۸±۰/۰۰۷٪) و نرخ بازده (۳۶/۵۶±۰/۷۳۲٪) به طور معنی داری نسبت به ماهی چرخ شده کاهش یافت، در حالی که محتویات رطوبت سوریمی (۷۹/۵۸±۰/۷۲۹٪) درمقایسه با ماهی چرخ شده (۷۸/۴۹±۰/۶۸۷٪) بیشتر بود (p<۰/۰۵). سطوح مجموع بازهای نیتروژنی و مقدار اسید تیوباریتوریک سوریمی ماهی شوریده دهان سیاه به ترتیب ۴/۷۶±۰/۵۹۴ میلی گرم N در ۱۰۰ گرم و ۰/۴۰±۰/۰۱۸ میلی گرم مالون دی آلدئید در کیلو گرم بوده، که به طور قابل توجه ای از مقادیر بدست آمده از ماهی چرخ شده کمتر است (p<۰/۰۵). بر خلاف سوریمی، ظرفیت نگهداری آب و مقدار pH ماهی چرخ شده به طور قابل توجه ای پایین تر است (p<۰/۰۵). بالاترین شاخص سفیدی در سوریمی (۰/۶۶/۲۳±۰/۰۲۹) درمقایسه با ماهی چرخ شده (۰/۵۱/۶۸±۰/۰۲۰) بدست آمد (p<۰/۰۵). مجموع چربی سوریمی واجد اسیدهای چرب چند غیر اشباع (۳۶/۳۲±۰/۲۵۷) گرم/۱۰۰گرم از چربی کل) بیشتری نسبت به سایر اسیدهای چرب خنثی در ماهی چرخ شده بود (p<۰/۰۵). فیش فینگر حاصل از سوریمی میانگین نمره بالاتری (۸/۷۱±۰/۳۶۶) نسبت به ماهی چرخ شده (۷/۴۷±۰/۳۲۶) را به خود اختصاص داد (p<۰/۰۵). با توجه به گوشت سفید و چربی کم این گونه ماهی به عنوان ماده خام مناسب برای تولید سوریمی محسوب می شود. آزمایش های بیشتری جهت بررسی خصوصیات ژل شونده سوریمی مورد نیاز است.