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Original article

Rigor index, fillet yield and proximate composition of cultured striped catfish (*Pangasianodon hypophthalmus*) for its suitability in processing industries in Bangladesh

Salma Noor-E Islami • Md. Shaheed Reza • Md. Abul Mansur • Md. Ismail Hossain • Fatema Hoque Shikha • Md. Kamal

Department of Fisheries Technology, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

Correspondence: Md. Shaheed Reza, Department of Fisheries Technology, Bangladesh Agricultural University; Email: rezams@gmail.com and salmanoorbau@gmail.com

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Abstract

Rigor-index in market-size striped catfish (*Pangasianodon hypophthalmus*, locally called *Thai-Pangas*) was determined to assess fillet yield for production of value-added products. In whole fish, rigor started within 1 hr after death under both iced and room temperature conditions while rigor-index reached a maximum of 72.23% within 8 hr and 85.5% within 5 hr at room temperature and iced condition, respectively, which was fully relaxed after 22 hr under both storage conditions. Post-mortem muscle pH decreased to 6.8 after 2 hr, 6.2 after 8 hr and sharp increase to 6.9 after 9 hr. There was a positive correlation between rigor progress and pH shift in fish fillets. Hand filleting was done post-rigor and fillet yield experiment showed 50.4±2.1% fillet, 8.0±0.2% viscera, 8.0±1.3% skin and 32.0±3.2% carcass could be obtained from *Thai-Pangas*. Proximate composition analysis of four regions of *Thai-Pangas viz.*, head region, middle region, tail region and viscera revealed moisture 78.36%, 81.14%, 81.45% and 57.33%; protein 15.83%, 15.97%, 16.14% and 17.20%; lipid 4.61%, 1.82%, 1.32% and 24.31% and ash 1.09%, 0.96%, 0.95% and 0.86%, respectively indicating suitability of *Thai-Pangas* for production of value-added products such as fish fillets.

Keywords: Rigor index, fillet yield, fish processing, proximate composition, *Thai-Pangas*

INTRODUCTION

Striped catfish or Sutchi catfish (*Pangasianodon hypophthalmus*, locally called *Thai-Pangas*) is one of the most widely cultured species in Bangladesh due to its faster growth, disease resistance and its adaptability to high density. Traditionally, *Thai-Pangas* are consumed as 'fresh whole' in the domestic market, which is transported live in water to different markets. But with the changing consumer attitude, consumption trends are shifting from fresh whole towards various convenience foods like fish fillets, steaks, balls, burgers etc. Also there are opportunities for secondary processors in utilizing the by-products such as dark muscle and trimmings in creating minced products in combination with rice, potato etc (Anonymous 2002; Gavine *et al.* 2001). It has been reported that the market price of *Thai-Pangas* declines due to abundance of their production in peak season. Therefore, farmer can use this low priced fish for the preparation of various value-added products and earn handsome money to improve their livelihood. It was reported that, in Vietnam, *Pangasianodon,* commonly called *Panga*, exports increased by 48% in value and 66% in quantity compared with 2007 (Josupeit 2009). Therefore, its production, aside from meeting local demand, offers bright export opportunities for Bangladesh. The consumption of this fish species has grown rapidly in Russia, Spain, France and other European countries and the United States. In Europe, the presence of *Pangasianodon* is overwhelming; there is practically no fish shop without pangas fillets. Demand for *Pangasianodon*, should be good in these times of economic crisis, where consumers are looking for inexpensive products.

Fish fillet is a kind of value-added products which can be prepared from *Thai-Pangas*. These are made by cutting the flesh from one side of the backbone the length of the fish starting just behind the head, then turning the fish over and cutting a similar strip of flesh from the other side of the backbone. Increasing fillet yield, without any negative effect on flesh quality, is a major challenge for fish farmers and even small differences in yields have a considerable economic impact for fish processing companies (Rora *et al.* 2001) as the fillet constitutes the most valuable part of the product. It is well known that rigor-mortis progress is one of the most prominent post-mortem events in muscle that influence fillet quality. The progress of rigor mortis is dependent on many factors. The time of a fish to set into and pass through rigor depends on the species, its physical condition and size, the degree of exhaustion before death, handling and the temperature at which it is kept. There is a relationship between rigor-mortis and keeping quality of fish. The keeping quality of fish depends largely on the length of the pre-rigor period. During pre-rigor phase the fish flesh remains in a state of freshness. Deterioration sets in when relaxation starts and in post-rigor period. In general, the slower the rate of progress of rigor-mortis, the longer is the shelf-life of the fish. A prolongation of pre-rigor period can be achieved by delaying the onset of rigor, decreasing the rate of progress of rigor or by both which are obviously of great commercial importance. Retardation of onset of rigor is particularly important as the fish in pre-rigor state are considered as good as live fish in market (Iwamoto *et al.* 1987). It is generally suggested that lowering of temperature delays the onset of rigor and shows down the rate of rigor-mortis progress (Yamamoto *et al.* 1966, Bito *et al.* 1983) which suggested that the state of rigor-mortis influence the fish under various storage conditions. To increase the shelf life of fish it is to be aimed to longer the rigor mortis period.

In Bangladesh, the fresh fish are marketed and transported in iced conditions. Although it is generally accepted that the onset and duration of rigor-mortis are more rapid at high temperature but in some tropical fish, the biochemical changes and thus rigor-mortis were found to be stimulated at 0 °C compared to room temperature (Poulter *et al.* 1981). The technological importance of rigor-mortis is very important to develop marketing infrastructure under various storage condition. There has been some preliminary studies performed on *Thai-Pangas* related to gel forming ability (Hossain *et al.* 2004), production of value-added products like fish ball (Akter *et al.* 2013), but basic information related to rigor-mortis development has not been reported which is directly related to quality and yield of fish fillet and subsequent development of quality products. Since farmed *Thai-Pangas* possesses a great potentiality in the production and marketing of high quality value-added products including fillet, there are studies required on the meat yield, fillet recovery and their quality at a greater extent. The present study has, therefore, been under taken to determine rigor mortis progress of *Thai-Pangas* through calculating rigor-index. Studies were also conducted to determine proximate composition of four regions of *Thai-Pangas viz.*, head region, middle region, tail region and viscera which could be useful for processing industries in planning and designing of its filleting industry in Bangladesh.

METHODOLOGY

Raw materials: Thirty live *Thai-Pangas* with average length of 43 cm and body weight of 1.25 kg were collected from 2 fish farms of Trishal and 1 fish farm of Bhaluka, Mymensingh and transported to the Laboratory of Fish Processing, Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh. Fish were killed with cranial spiking, washed with tap water, placed in plastic bags and kept in ice until subsequent experiments.

Determination of rigor index: Rigor index of the fish was measured according to the method described by (Bito *et al.* 1983) and used as a parameter of rigor tension. The fish immediately after catch and cranial spiking was placed on a horizontal table in such a way that half of its body (tail part) kept out of the table. At selected time intervals, rigor index was calculated by the following formula:

$$\text{Rigor-index (\%)} = \frac{D_o - D}{D_o} x100$$

where, D_o and D represent the distances of the base of caudal fin from horizontal line of the table at the start of the experiment and at subsequent storage periods, respectively.

Physical and chemical analysis: pH was measured using a pH meter (Model 250 pH/ISE) after homogenizing 2 g of fish muscles with 10 ml distilled water in a blender. Total volatile base nitrogen (TVB-N, mg N/100 g) values were determined as described by Antonacopoulos and Vyncke (1989).

Proximate composition analysis: Each fish was divided into four body parts: the head, middle, tail and viscera.

Moisture content was determined by air drying of a given sample in a thermostat oven (Gallenkamp, HOTBOX, Manchester, UK) at 105 °C for 24 hr until constant weight. Crude protein was determined by the Macro Kjeldahl method by determining total nitrogen and applying the protein conversion factor of 6.25 to the results to convert total nitrogen into total protein, assuming that fish protein contained 16% nitrogen, and lipid content was determined by extracting required quantity of samples with petroleum ether for 16 to 18 hr in a ground joint Soxhlet apparatus. The oil obtained by evaporation of the solvent on a steam bath was weighed in a sensitive balance and percent lipid was calculated.

Fillet yield: Collected *Thai-Pangas* were killed with cranial spiking. Fillets were removed together with the skin and scales, as is normally done with this species on a commercial scale, the skin being removed afterwards. The fillets were then individually bagged and stored at -8 °C until analysis. Estimates were generated by weighing using a sensitive electronic balance, for (a) fillet yield (b) skin, (c) viscera, (d) head + vertebral column + fins and scales. Yield percentage of these 4 components was determined as the ratio of each component weight to the total weight of the fish (Öksüz 2010).

Statistical analysis: Data from different biochemical measurements were subjected to t-test (p<0.05). Statistical software package SPSS 10.1 (SPSS Inc, Chicago, IL, USA) was used to explore the statistical significance of the results obtained.

RESULTS AND DISCUSSION

Changes in rigor index: To study the quality changes in *Thai-Pangas* during various storage conditions, the earliest changes were observed by determining the progress of rigor in fish and rigor index of experimental fishes stored at room temperature and in ice were determined (Figure 1). The progress of rigor mortis was more rapid in fish stored at room temperature than in ice. For fish sample kept at room temperature, rigor started 1 hr after spiking and it reached a maximum of 72.23% within 8 hr. The maximum rigor stage last about 4 hr and then started to post rigor. The rigor fully relaxed after 22 hr. On the other hand, in ice stored experimental fish, rigor started also within 1 hr. But the progress rate was much slower than that of the fish kept at room temperature. Rigor increased gradually with the lapse of storage time. The rigor progressed to a maximum of 85.5% in 5 hr. At this level, they continued for 22 hr, and then started to relax from rigor. The rigor relaxed up to 29 hr in the fish without emitting a foul odor. At this stage there was no apparent change in appearance and flavor.

It has been reported that lower temperature delays the onset of rigor and slows down the rate of rigor progress (Iwamoto and Yamanaka 1986, Iwamoto *et al.* 1988). Also other factors like handling of the fish before harvest, pre-slaughter stress, biological status of the fish are important factors influencing rigor mortis progress. Even the physiological condition of the muscle of the fish before harvest and slaughter will affect postmortem muscle biochemistry (Skjervold *et al.* 2001).

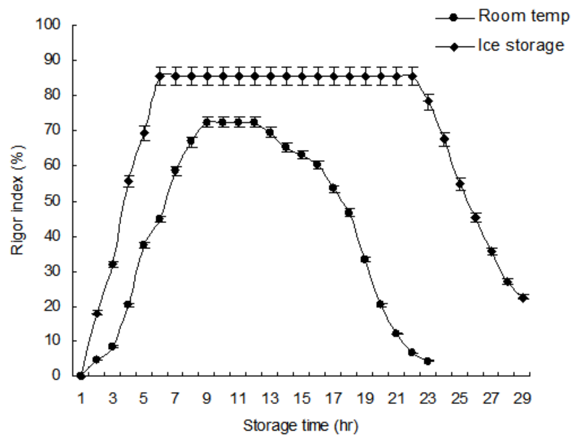

Figure 1: Rigor index (%) of *Thai-Pangas* (*Pangasianodon hypophthalmus*) at room temperature (28 °C) and in ice (0 °C) storage condition

The results obtained from the present study are more or less in agreement with reported for other fishes under different storage condition where rigor did not reach to 100%. Watabe *et al.* (1989) reported for mackerel where the fish proceeded to 80% rigor during at 10°C whereas Hossain *et al.* (1998) reported for that rigor started 1 hr after spiking and it reached a maximum of 78% within 6 hr after death at room temperature. In iced condition it reached a maximum of about 85% at 10 hr for mrigal (*Cirrhina mrigala*). However, in these studies *Thai-Pangas* showed an early onset of rigor with lower temperature in ice and a prolonged period of in-rigor in ice than that at ambient temperature. It is suggested that handling and fillet processing of *Thai-Pangas* should be done post-rigor which is approximately 22 hr after death to a maximum of 29 hr to minimize loss of quality and a lower fillet yield.

Changes in physical and chemical parameters: Changes in muscle pH of ice stored fish are shown in Figure 2. The muscle pH of *Thai-Pangas* fish immediately after death was close to neutral. Due to the post- mortem anaerobic formation of lactic acid, pH decreased during the early hours of storage. During the later post-mortem changes, pH slightly increased due to formation of basic compounds. Many workers reported that low muscle pH of the post-mortem fish muscle is associated with the quality changes in fish (Konagaya and Konagaya 1979, Kramer and Peters 1981). Live sardine muscle had a pH 7.2 was reported by Pacheco-Aguilar *et al.* (2000). After death, the muscle pH decreased to 6.8 after 2 hr, to 6.2 after 8 hr and to 5.8 after 24 hr was reported by Watabe *et al.* (1991). In the present study, we also found that after 9 hr of ice storage pH gradually increased due to formation of basic compounds and finally reached up to 6.9 after 17 hr. We observed positive correlation between rigor mortis and pH changes in fish fillets. It was reported that asphyxia and electrically stunned fish were more stressed than spiked, knocked and live chilled fish (Poli *et al.* 2005). Therefore, it may be recommended that killing fish by spiking might be a more satisfactory strategy for both animal welfare and product quality. The correlation between pH and organoleptic scores in this study suggested that pH can be used as a reliable index of quality.

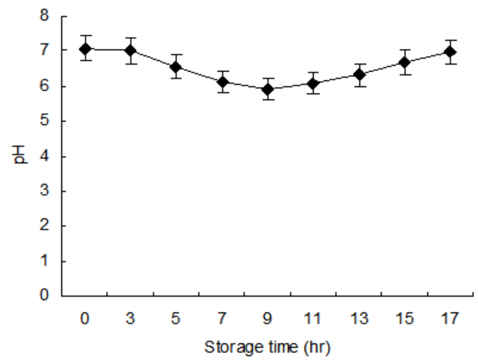

Figure 2: Changes in muscle pH of *Thai-Pangas* (*Pangasianodon hypophthalmus*) in ice storage

TVB-N (mg/100g) of experimental whole fishes and fish fillets were determined and it was found that values were 1.68 mg/100 g for both whole fishes and fish fillets. Although TVB-N better expresses signs of spoilage with progress of storage period, the values are reported here to establish correlation between TVB-N and organoleptic characteristics (e.g. color and flavor) of fillets. A lower value reported here indicates better quality of fish fillets up to 29 hr of storage at room temperature and iced condition.

Proximate composition: The result of the proximate composition of different parts of *Thai-Pangas* was summarized in Figure 3. In wet weight basis, moisture, protein, lipid and ash content in head region, middle region, tail region and viscera were 78.36%, 81.14%, 81.45% and 57.33%; 15.83%, 15.97%, 16.14% and 17.20%; 4.61%, 1.82%, 1.32% and 24.31%; 1.09%, 0.96%, 0.95% and 0.86%, respectively. The chemical composition of fish varies greatly from one individual to another depending on age, sex, environment and season (Huss 1995).Viscera contained significantly higher amount of lipid than other regions of the fish body. These values compare closely to those given by Jacquote (1961) and the nutritional composition of this species fell within reported values for fish (Huss 1995) meaning that they can be utilized for production of other valued fish products.

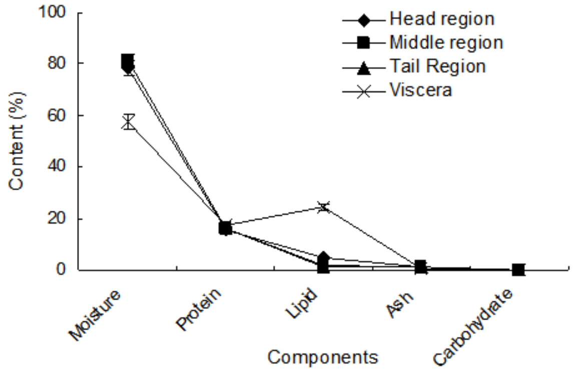

Figure 3: Proximate composition of different body parts of *Thai-Pangas* (*Pangasianodon hypophthalmus*) in wet weight basis

Fillet yield: To estimate the amount of fillet yield from *Thai-Pangas*, 30 fish were dissected to 5 (five) different constituent parts (Figure 4). It was found that 1.25 kg *Thai-Pangas* could yield 630.0±3.0 g muscle (50.4±2.1%), 100±0.2 g viscera (8.0±0.2%), 100±0.5 g skin (8.0±1.3%), and 400±0.8 g carcass (32.0±3.2%). These values are slightly higher than those reported by Sang *et al.* (2009) where they reported that fillet yield was 35.6%. There are numerous factors that may affect fillet yield such as fish size, feed ration (Einen *et al.* 1998), diet composition (Rasmussen 2001), genetic line (Smith *et al.* 1988), or sexual maturation (Paaver *et al.* 2004). Although the amount of yield from *Thai-Pangas* could vary according to fish size, sex, feeding condition, the data obtained in the present study could be useful to estimate edible parts and by-products to be obtained in a processing industry. Differences between individual fish were generally greatest in skin and viscera. Hand skinning could account for the variations in the skin. Visceral differences, on the other hand, were mainly due to gonad size and the quantity of the food ingested by the fish itself.

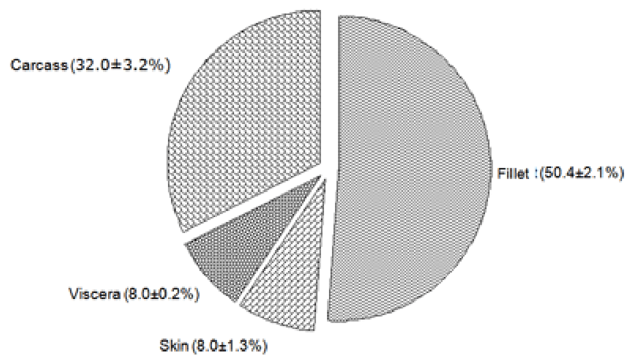

Figure 4: Fillet yield and waste of striped catfish (*Pangasianodon hypophthalmus*) (N=30)

The information obtained in the present study can be utilized to improve the quality traits of fillet and other parameters based on the processing method involved. From an academic point of view, this work provides additional knowledge in the area of the determinism of fillet quality in *Thai-Pangas*.

CONCLUSION

With the availability of good quality raw material, Bangladesh has great potential to develop *Thai-Pangas* filleting industry for its expanding domestic as well as export market. The results obtained in the present study will be helpful to processing industries in Bangladesh and help them to design effective utilization methods of the by-products coming out of the fillet industry.

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