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Instrumental quality attributes of single washed surimi gels of tilapia: Effect of different washing media

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ABSTRACT

The effects of single washing cycle with different washing media on the quality of tilapia mince in comparison with the quality of conventionally washed surimi from tilapia were investigated. From the results, it was observed that compared to conventional washed surimi, alkaline saline washed surimi with single washing cycle exhibited significantly ($p < 0.05$) highest gel strength of 60.72 N.mm. Thermal transition of alkaline saline washed surimi exhibited no endothermic transition, while all other treatments showed a shift in the transition peak from surimi to paste. The single washing cycle with different washing media promoted the heat induced conformational transition from α-helix to β -sheet, β -turn and random coil structures which are positively correlated with gel strength except for surimi washed with cold water. Therefore, it can be concluded from the present investigation that single washing with alkaline saline treatment yielded good quality tilapia surimi.

1. Introduction

Surimi is stabilized myofibrillar protein obtained by mechanical deboning, mincing and repeatedly washing with cold water (5–10 °C) to remove lipids and water soluble proteins. In general white lean fish such as Alaska pollock, Pacific whiting and threadfin bream which are low in lipid content are widely utilized in the preparation of surimi. Because of the over-exploitation of lean fish and decline in the surimi resources, there have been attempts to exploit new fish resources for surimi industry such as dark flesh and low cost fishes. However, it is difficult to acquire high quality surimi from dark flesh fish species because of the high content of lipids and myoglobin present in dark muscle (Arfat & Benjakul, 2013). As an alternative to regular raw material, low cost and underutilized freshwater fish can be utilized effectively for sustainable manufacturing of surimi. Tilapia is considered as the food fish of the 21st century and one of the second most farmed fish in the world (FAO, 2014, pp. 10–11) and India is also an emerging producer of tilapia. Tilapia is a prolific breeder, omnivorous, very hardy species and grows faster which makes this species as one of the candidate species for aquaculture. The limiting factor of tilapia for surimi production is the red colour of the mince and being freshwater fish possess poor textural properties.

Gel-forming ability of myofibrillar proteins is the prerequisite to provide the excellent quality of surimi-based products. In order to augment the gel forming ability of myofibrillar proteins, elimination of endogenous proteolytic enzymes is essential. Washing is the basic stride in the creation of surimi, which enhances the quality by removing fat and undesirable substances. The number of required wash cycles depends on species, condition, type of wash, and the desired quality of the surimi end product (Carvajal, Lanier, & Mac Donald, 2005). In generation and production of 1 kg of surimi nearly around 15 kg of water is utilized (Granata, Flick Jr., & Martin, 2012). The extensive utilization of freshwater in surimi production

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threatens the availability of this resource for other users and the negative impact on the environment as a result of discharging untreated processing water. So there is a need for eco efficient production of surimi with reduced number of washing cycles not only to prevent environment pollution but also to maximize the yield and decrease the wash water volume. The various research contemplated and found that all the distinctive washing media with increasing number of washing cycles is effective against increasing the quality parameters of surimi. Conventional washing in common carp, grass carp, silver carp, tilapia was studied (Luo, Kuwahara, Kaneniwa, Murata, & Yokoyama, 2001; Rawdkuen, Sai-Ut, Khamsorn, Chaijan, & Benjakul, 2009). Alkaline saline washing in sutchi catfish (Priyadarshini et al., 2016) and silver carp (Zhou, Chong, Ding, Gu, & Liu, 2016) were studied with three washing cycles. Generally it is found that freshwater fish have substandard gel quality contrasted with that of marine fish. But these results differ accordingly by fish species, age, size, season, habitat, etc. There are no reports on the impact of single washing cycle on the quality of freshwater fish surimi. Therefore, the objective of the present study is to investigate how different washing media with single washing cycle affects the quality of the surimi and their corresponding gels.

2. Materials and methods

2.1. Fish samples

Tilapia (*Oreochromis mossambicus*), with a standard length and weight of 25.66 ± 3.27 cm and 718.78 ± 225.44 g, were obtained from a fish farm (Talegaon, Pune, Maharashtra, India). The fish were packed in an insulated container filled with ice (fish/ice ratio of 1:2 (w/w)) and transported to the Department of Post Harvest Technology, Central Institute of Fisheries Education, Mumbai within 4 h, where they were stored and covered with ice until processed.

2.2. Preparation of mince and surimi

2.2.1. Preparation of fish mince

Upon the arrival, fish were immediately washed, gutted, cleaned and subjected to deboning using a mechanical deboning machine (Baader 694, Lubeck, Germany) with a counter rotating belt and drum mechanism having a hole diameter of 5 mm. The deboned mince obtained was placed in low density polyethylene (LDPE) pouches and imbedded in ice until further use.

2.2.2. Preparation of conventional washed surimi

The conventional washed surimi (CW) was prepared according to the method of Rawdkuen et al. (2009). Fish mince was washed with cold water (4 °C) using a water/mince ratio of 3:1 (v/w) and the mixture was stirred gently for 3 min in a Hobart mixer (Hobart AE 200, London, England) and allowed to settle for 2 min. The slurry was strained with a double-layer muslin cloth, and the excess water was manually squeezed out. The washing and straining processes were repeated three times, with the last washing containing 0.5% NaCl in the deionised water to facilitate the dewatering step. Finally, the washed mince was centrifuged at 2200 rpm for 15 min in a basket centrifuge (Model 60-5, AIM Industries, Mumbai, India). The mince obtained was referred to as 'CW surimi.' The surimi was packed in LDPE pouches and stored in ice.

2.2.3. Preparation of single washed surimi with different treatments

Fish mince was washed with 3 different washing media with different pH measured i.e with cold water only (pH 7.47), alkaline saline (0.15% NaCl and 0.2% $NaHCO_3$; pH 8.69) solution was prepared according to the method described by Balange and Benjakul (2009) and with calcium chloride and salt (0.1% NaCl and 0.2% $CaCl_2$; pH 5.86) maintained at 4 °C using a water/mince ratio of 3:1 (v/w). The mixture was stirred gently for 3 min in a Hobart mixer and allowed to settle for 2 min. The slurry was strained with double-layer muslin cloth, and the excess water was manually squeezed out. The washing and straining process was done for one time. Finally, the washed mince was centrifuged in a basket centrifuge. The resulted surimi was referred to as 'single washed surimi (T-1), washed with cold water', 'alkaline saline washed surimi (T-2)' and 'calcium saline washed surimi (T-3)'. The obtained surimi was packed in LDPE and stored in ice until further use.

2.3. Gel preparation

The surimi was chopped in a Philips Food Processor (India) at low speed for 2 min. A homogenous surimi paste was obtained by extracting surimi myofibrillar protein with 2.5 g/100 g of NaCl and chopping at low speed for 1 min at 4 °C. The paste was stuffed into polyvinylidene casings (diameter: 2.5 cm, length: 17.5 cm) by using stainless steel sausage stuffer (Kitchener, 5 lb, China) and casings were tightened from both sides. Surimi pastes were cooked in a temperature controlled water bath (Steroglass strike 300, Perugia, Italy) at 40 °C for 30 min and followed by heating at 90 °C for 20 min. The gels were then cooled in iced water and stored for overnight at 4 °C prior to analysis.

2.4. Textural parameters

2.4.1. Determination of gel strength

Gels held at 4 °C were equilibrated at room temperature (25 °C) prior to test and cut into cylinders (2.5 cm in height). The breaking force (maximum penetration force, g) and deformation (penetration depth, cm) were measured using a Rheo Tex (Type SD-700, Sun Scientific Co Ltd., 4-Chome, Kamiyoga, Setagaya-KU, Tokyo, Japan) equipped with a spherical probe (5 mm diameter, 60 mm/min) with load cell of 2 kg. All determinations were carried out in triplicates.

2.4.2. Determination of textural properties

Textural profile analysis (TPA) of surimi gel was performed using a TVT 6700 texture analyser (Perten Instruments, Sweden with software TexCalc version 4.0.2.50) equipped with a stainless steel cylindrical probe of 20 mm diameter. The gels were cut into a cylinders (diameter of 20 mm, height of 25 mm), then compressed at compression degree of 40% with the pre-test, test and post-test speed of 2 mm/s, 1 mm/s and 5 mm/s. Trigger type was set at auto with 50 mN trigger force. The data acquisition rate was 200 pps.

2.5. Determination of whiteness

All gels were subjected to whiteness measurement using a Hunterlab (ColorFlex, Hunter Associates Laboratory, Reston, VA). Illuminant C was used as the light source of measurement. L^* (lightness), a^* (redness/greenness) and b^* (yellowness/blueness) were measured and whiteness was calculated as described by Park (1994) as follows:

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

2.6. SDS–polyacrylamide gel electrophoresis (SDS–PAGE)

Protein patterns of gels were analyzed by SDS–PAGE according