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Surimi Production from Mud Carp (*Henicorhynchus siamensis*)

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Abstract.

Mud carp (*Henicorhynchus siamensis*) is a major source of income for many families in the delta in the flooding season. It is considered a valuable source of protein in the diets of rural citizens. Utilization of small size mud carp (*Henicorhynchus siamensis*) produces a new value added product known as surimi. Hatchers can benefit from this product during the harvesting season. In order to improving the added value of this fish, the aim of this research was to develop and evaluate a new kind of surimi from mud carp (*Henicorhynchus siamensis*). Effect of washing condition (water, water+salt, water+$NaHCO_3$), gelling additive (salt+sugar, sorbitol+tripolyphosphate, carrageenan+modified starch), and blending time (2, 4, 6 minutes) on the physico-chemical, microbiological, and sensory characteristics of surimi were investigated. Results revealed that the optimal formula was recorded at washing condition (water+salt), gelling additive (carrageenan + modified starch) and 4 minutes of blending. Today surimi serves as a convenient raw material for the manufacture of various comminuted fish products and a variety of fabricated products.

Keywords: *Henicorhynchus siamensis, surimi, washing, gelling, physico-chemical, microbiological, sensory*

I. Introduction

Surimi is made from minced fish flesh, providing opportunities to use underutilized species with little or no commercial value, fish too small to undergo a processing method or residues from the industrialization (Martin-Sanchez et al., 2009; Barreto & Beirão, 1999), so obtaining a value-added product despite of minimizing wastes and reducing environmental impacts. Surimi constitutes a wet frozen concentrate of myofibrillar proteins of fish muscle that is prepared by deboning, washing the fish mince and stabilizing by mixing with cryoprotectants. Muscle proteins, mainly myosin, important for protein functionality gets degraded during frozen storage (Dey and Dora, 2010).Cryoprotectants are food additives that prevent protein denaturation in surimi during frozen storage. The mechanism of stabilization of fish muscle protein during frozen storage by cryoprotectant is by interaction and bonding with the protein molecules via functional groups on the surfaces. Thus each protein molecule gets covered by hydrated cryoprotectant molecules resulting in increased hydration and decreased aggregation of the proteins (Dey and Dora, 2010).

The Siamese mud carp (*Henicorhynchus siamensis*) is a species of freshwater cyprinid fish, a variety of Asian carp native to the Mekongand Chao Phraya Rivers in Southeast Asia, especially in Cambodia, Laos, Thailand and Vietnam. *Henicorhynchus siamensis* is a synchronous, i.e. single spawned species that clearly shows a single peak of gonadosomatic index in June to September and the highest in August (Suvarnaraksha et al. 2010). During the wet season, this species migrates into floodplains for spawning (Fukushima et al. 2014). Eggs and larvae grow in the floodplains and the larvae migrate back to rivers when the floodwaters begin to recede at the starting of dry season (Rainboth 1996; Fukushima et al. 2014). *Henicorhynchus siamens* is also adapts to lentic environmental conditions, such as lakes and reservoirs, and contributes a significant portion in fish catches (Suvarnaraksha et al. 2010). Not only does this fish provide protein, but also vitamins and minerals to the people (Roos et al. 2007).

Siamese mud carp is a major source of income for many families in the delta in the flooding season (Piyathap Avakul, 2015). A family can catch 100 kg of the fish or above a day on average, which is retailed to local residents or wholesaled to traders. The volume of Siamese mud carp caught a year depends on rainfall in the rainy season. Viraxay Bandavong et al. (2016) performed isolation and screening of protease producing halotolerant bacteria from fermented freshwater fishes. From the tenth to eleventh months of the lunar calendar, the flooding season comes to Mekong Delta. But that marks the start of the migratory Siamese mud carp (*Henicorhynchus siamensis*) season, a vast multitude of fish species in the Mekong River. In Vietnam, catching or farming aquatic resources forms a vital part of rural people's livelihoods and contributes a major source of protein. With a huge volumn of Siamese mud carp (*Henicorhynchus siamensis*) caught a year, Vietnamese farmers ussually process them into fermented fish sauce (Minh N. P., and Nga N. H., 2018).

There were few studies mentioned to the mud carp (*Henicorhynchus siamensis)* processing. A production of fish cake from Siamese mud carp was investigated. By investigation different parameters probably affecting to gelation, we noticed that we would get the best physicochemical properties and sensory characteristics of fish cake by the addition of carrageenan 1.0%: gelatin 1.0% (Minh N. P., and Nga N. H., 2018). The use of mud carp (*Henicorhynchus siamensis)* for new products is still limited. To increase the value of mud carp (*Henicorhynchus siamensis)*, value added product should be considered. The aim of this work was to study the feasibility of utilization of mud carp (*Henicorhynchus siamensis)* to create a new surimi. This research focused on the effect of effect of washing condition (water, water+salt, water+$NaHCO_3$), gelling additive (salt+sugar, sorbitol+tripolyphosphate, carrageenan+modified starch), and blending time (2, 4, 6 minutes) to physico-chemical, microbiological, and sensory qualities of surimi.

II. Material And Method

2.1 Material

Mud carp (*Henicorhynchus siamensis)* was collected from Chau Doc city, An Giang province, Vietnam. They were selected in good quality and appearance and then be kept below 8^{o}C ready for experiments. Apart from that, we also used other ingredients such as salt, sugar, sorbitol, tripolyphosphate, carrageenan, modified starch.

Figure 1. Mud carp (***Henicorhynchus siamensis)***

2.2 Researching method

2.2.1 Effect of washing condition (water, water+salt, water+$NaHCO_3$) to physico-chemical, microbiological, and sensory qualities of surimi

The mud carps were ground, washed in three washing cycles, the water was drained through a 100% polyester bag with vigorous manual wringing until no more water appeared. Different washing conditions *(water, water+salt, water+$NaHCO_3$)* were examined. The optimal parameter was selected by measured different values such as physico-chemical (moisture content %, crude protein %, yield %, texture (chewiness, kgf), microbiological (total plate count cfu/g), and sensory characteristics of the dry fermented sausage.

2.2.2 Effect of **gelling additive** *(salt+sugar, sorbitol+tripolyphosphate, carrageenan+modified starch) to physico-chemical, microbiological, and sensory qualities of surimi*

The mud carps were ground, washed in three washing cycles by water+salt, the water was drained through a 100% polyester bag with vigorous manual wringing until no more water appeared. Different gelling additives (salt+sugar, sorbitol+tripolyphosphate, carrageenan+modified starch) were examined. The optimal parameter was selected by measured different values such as physico-chemical (moisture content %, crude protein %, yield %, texture (chewiness, kgf), microbiological (total plate count cfu/g), and sensory characteristics of the dry fermented sausage.

2.2.3 Effect of blending time (2, 4, 6 minutes) to physico-chemical, microbiological, and sensory qualities of surimi

The mud carps were ground, washed in three washing cycles by water+salt, the water was drained through a 100% polyester bag with vigorous manual wringing until no more water appeared. Then the minced fish was supplemented with carrageenan+modified starch. Different blending times (2, 4, 6 minutes) were examined. The optimal parameter was selected by measured different values such as physico-chemical (moisture content %, crude protein %, yield %, texture (chewiness, kgf), microbiological (total plate count cfu/g), and sensory characteristics of the dry fermented sausage.

2.3 Physico-chemical, microbial and sensory evaluation

Moisture content (%) was determined by comparing the weights of the sample with the electronic balance. Crude protein (%) was measured by by AOAC (2000). The yield of the treatments (%) was calculated by the ratio between the weight of the raw muscle used and the weight of the final surimi. Chewiness (kgf) was determined Texture Analyzer. The total plate count (cfu/g) was enumerated during the storage period by Petrifilm - 3M. The sensory attributes such as visual appearance, color, taste, flavor and acceptability was carried out by selected panel of judges (9 members) rated on a nine point hedonic scale.

2.4 Statistical analysis

The experiments were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Statgraphics Centurion XVI.

III. Result & Discussion

3.1 Effect of washing condition (water, water+salt, water+$NaHCO_3$) to physico-chemical, microbiological, and sensory qualities of surimi

Washings are of great importance for the final quality of the surimi, since they increase the concentration of the myofibrillar proteins, so improving the ability to gel formation (Belibagli et al., 2003; Lee, 1984). Surimi moisture can be influenced by the number of washings, since excessive washing may cause losses of myofbrillar proteins, well as by the cryoprotectants, since they have the ability to bind free water. Martin-Sanchez et al. (2009), state that the use of alkaline saline solution during the rinses increases the muscle pH providing greater solubilization and further elimination of the lipids. The use of alkaline salt solutions for the washings also solubilizes the sarcoplasmatic proteins and so facilitates their removal from the muscle. Te removal of these proteins is extremely important to avoid their precipitation during heating and the consequent adherence to the myofbrillar proteins, what hinders the gelatinization. According to Kirschnik & Macedo-Viegas (2009), the washing cycles largely remove bacterial enzymes and muscle proteases that can hydrolyze the proteins. The fnal color of the surimi is due to the loss of lipids, blood, carotenoids and other pigments during the washings of the muscle (Chawla et al., 1996) A research aimed at studying the effects of different washing conditions (distilled water x distilled water + NaHCO3 + NaCl) for the production of tilapia surimi (Dayse Licia de Dliveira et al., 2017).

From table 1, washing by water+salt was appropriated for mud carp surimi production. Another study investigated to improve adding additives and washing step on surimi processing from moontail bigeye was examined. The research shows that surimi production from moontaintail bigeye fish export Japanese standards (Gel Strength> 300g.cm, whiteness> 48%), moontail bigeye meat should be washed three times: using NaCl 0.2% for the first washing, etanol 2% for the second washing and sorbitol 3% for the third washing; Duration for each washing time and ratio of washing solution and fish meat were 9 minutes and 4:1 (vol./wt.) (Nguyen Thi Le Phuong et al., 2015).

3.2 Effect of gelling additive (salt+sugar, sorbitol+tripolyphosphate, carrageenan+modified starch) to physico-chemical, microbiological, and sensory qualities of surimi

The use of cryoprotectants for the surimi production is important to keep the gel stability during freezing and thawing (Kuhn & Soares, 2002). They avoid the proteins denaturation during freezing by binding water and proteins and support the gel structure afer thawing by diminishing the intermolecular aggregation of the proteins. Additionally, moisture can be affected by the presence of salts and metal ions in the washing solution because they interfere in the formation of hydrogen bounds between proteins and water. the water binding provided by the cryoprotectants could increase the yield. A research aimed at studying the effects of cryoprotectants (NaCl + saccharose x sorbitol + sodium tripolyphosphate) for the production of tilapia surimi (Dayse Licia de Dliveira et al., 2017).

From table 2, the optimal gelling additive was noticed at carrageenan+modified starch so this value was selected for further experiments. Study to improve adding additives and washing step on surimi processing from moontail bigeye was examined. Additives were used, including sugar 3.5%, sorbitol. 3.5%, 0.2% sodium tripolyphosphate 0.2%, caragin 0.3%. Gel strength of moontail bigeye surimi can be reached to 740g.cm, whiteness was 80.25% and black spot with 2 spots/10g (Nguyen Thi Le Phuong et al., 2015). A study was undertaken with the aim of reducing the concentration of cryoprotectants in surimi without adversely affecting frozen storage stability. Minced meat from a tropical fish, *Nemipterus japonicus*, was strained, water leached and mixed with different levels of sucrose-sorbitol (1:1) mixture (henceforth called sugar mixture), quick frozen at −35 °C and frozen stored at −20 °C. The surimi samples were subjected to storage stability studies for a period of 5 months. Water leaching resulted in slight absorption of water by meat and reduction in protein, fat and mineral contents. Surimi was found to have moderately white colour. A concentration of 2 to 4% sucrose-sorbitol mixture is well-accepted by the consumers in products—surimi sausage, patty and cake and at this range of concentration surimi could be well-preserved at −20 °C for at least 5 months (Parvathy U. and Sajan George, 2014).

Starch is an important ingredient in surimi seafood products since it would affect textural and physical characteristics of surimi fish protein gels. For instance, it can improve surimi gel strength, modify texture, reduce cost (L. Ma et al., 1996), and improve freeze-thaw stability (C. M. Lee, 1994). The starch could replace a portion of the fish protein while maintaining desired gel properties due to its water-holding ability (D. J. Mauro, 1996). A study investigated the effect of overdrying potato starches on surimi products. The chemical composition of protein and chemical interactions, gel solubility, and protein conformation of the mixture of surimi gel protein, respectively, with 8% native potato starch and with 8% overdrying potato starch were investigated (Tangfei Li et al., 2017).

Table 1. Effect of washing condition (water, water+salt, water+$NaHCO_3$) to physico-chemical, microbiological, and sensory qualities of surimi

Washing condition	Water	Water+salt	Water+$NaHCO_3$
Moisture (%)	77.32 ± 0.01^a	77.04 ± 0.01^b	77.15 ± 0.01^{ab}
Crude protein (%)	11.23 ± 0.01^b	11.67 ± 0.02^a	11.43 ± 0.01^{ab}
Yield (%)	62.04 ± 0.03^{ab}	61.98 ± 0.03^b	62.08 ± 0.03^a
Chewiness (kgf)	5.03 ± 0.00^b	5.19 ± 0.02^a	5.08 ± 0.02^{ab}
Total plate count (cfu/g)	$3.9x10^2 \pm 0.01^a$	$2.1x10^2 \pm 0.00^a$	$2.8x10^2 \pm 0.01^a$
Sensory score	7.07 ± 0.02^b	7.20 ± 0.02^a	7.11 ± 0.00^{ab}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 2. Effect of gelling additive (salt+sugar, sorbitol+tripolyphosphate, carrageenan+modified starch) to physico-chemical, microbiological, and sensory qualities of surimi

Gelling additive	Salt+sugar	SSorbitol+tripolyphosphate	Carrageenan+modified starch
Moisture (%)	77.13 ± 0.02^b	77.19 ± 0.03^{ab}	77.24 ± 0.02^a
Crude protein (%)	11.73 ± 0.01^a	11.69 ± 0.00^{ab}	11.61 ± 0.01^b
Yield (%)	62.17 ± 0.01^b	62.29 ± 0.01^{ab}	62.43 ± 0.00^a
Chewiness (kgf)	5.22 ± 0.01^b	5.27 ± 0.03^{ab}	5.31 ± 0.01^a
Total plate count (cfu/g)	$2.1x10^2 \pm 0.01^b$	$2.5x10^2 \pm 0.01^{ab}$	$2.6x10^2 \pm 0.01^a$
Sensory score	7.25 ± 0.03^b	7.34 ± 0.01^{ab}	7.45 ± 0.03^a

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 3. Effect of blending time (2, 4, 6 minutes) to physico-chemical, microbiological, and sensory qualities of surimi

Blending time (minutes)	2	4	6
Moisture (%)	77.24±0.02[a]	77.31±0.03[a]	77.38±0.01[a]
Crude protein (%)	11.61±0.01[a]	11.59±0.02[a]	11.55±0.02[b]
Yield (%)	62.43±0.00[b]	62.59±0.01[a]	62.60±0.03[a]
Chewiness (kgf)	5.31±0.01[b]	5.38±0.03[ab]	5.43±0.02[a]
Total plate count (cfu/g)	$2.6x10^2$±0.01[a]	$2.6x10^2$±0.02[a]	$2.6x10^2$±0.03[a]
Sensory score	7.45±0.03[b]	7.78±0.01[a]	7.61±0.01[ab]

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

3.3 Effect of blending time (2, 4, 6 minutes) to physico-chemical, microbiological, and sensory qualities of surimi

The oscillations in the texture parameters may be due to the breaking of myosin, which leads to an increase in the semi gel fluidity, causing the separation of some protein grids already existent. Still, according to the author, the air inside the gel interferes on the attainment of the texture since the increase of the pressure accomplished during the test causes the disruption of the structure (Visessanguan et al., 2000). From table 3, the blending time should be 4 minutes so this value was selected for application.

Surimi seafood paste was characterized in different mixing durations by measurements of particle size, protein solubility and water absorption, temperature and viscoelastic properties, in order to follow the structural modifications and the interactions generated by the mixing process. Two major periods are highlighted during the process: in the first step, the frozen surimi melts; therefore, the shredding of fibers causes a huge reduction in particle size and protein solubilization. Then, temperature increases due to viscous heating. Temperature augmentation leads to denaturation and aggregation of proteins. This then render to the formation of a gel network that will be broken by the ongoing mixing operation. During this second step, overmixing affects the functionality of proteins. This functionality is countered by the gelling due to the increase in temperature and subsequent degradation in the mixing process during the gel formation. The effect of the mixing operation in the manufacturing process of surimi seafood was noted (F.Ducept et al., 2012).

IV. CONCLUSION

Mud carp is a famous specialty as the floods approaching. The little fish is sweet and soft with edible bones. It plays a highly important role in the food and nutritonal security of rural, urban and coastal populations throughout Mekong river delta in the flooding season. We have successfully investigated the surimi production from mud carp (*Henicorhynchus siamensis*).

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