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# Physicochemical properties and sensory characteristics of red tilapia *(Oreochromis* sp.*)* Sausage

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**Abstract.**

Red tilapia *(Oreochromis* sp.*)* is an important freshwater fish in economic value of Vietnam. It is commonly sold in the form of fillet or whole in plastic bags and kept on ice during transportation and distribution. Gelation is one of important functional properties of fish sausage. There is no scientific research mentioned to the application of red tilapia **(***Oreochromis* sp**.)** in fish sausage. We evaluated some technical parameters affecting to the physicochemical properties and sensory characteristics of red tilapia sausage. Our results showed that 1.5% carrageenan, 0.5% modified starch greatly reinforced the shear stress of sausage gels made from red tilapia muscle. Modified starch and carrageenan were useful additives for improving the physicochemical properties and sensory characteristics of fish sausage. By grinding the paste in 3 minutes, sausage had a high holding water capacity. Fish sausage had the high score of consumer evaluation under sterilization in 115$^{o}$C in 5 minutes. Red tilapia sausage is an inexpensive and healthy source of protein that can be used as a convenience meat sources in food product formulation.

***Keywords:*** *Red tilapia, sausage, gelation, carrageenan, modified starch, sterilization*

## 1. Introduction

Red tilapia *(Oreochromis* sp.*)* is one the most important species for aquaculture in the world. Tilapia is marketed either as whole fish or as fresh or frozen fillets, although consumers prefer fillet. Fillet yield of tilapia varies widely (30-40%).[1] Demanding for fish products is high because they are safe, nutritious, varied and attractive in appearance and texture. There is a perspective that fish consumption will increase, considering that the supply of products derived from fish and the diversifcation of products may contribute to the increase of consumption of these foods.[2]

Emulsified fish products like sausage can be other alternatives for food manufacturers. Minced fish and functional ingredient have been used as raw materials for emulsion sausage production for many years. The best solution might be to encourage consumers to consume fish-based products.[3] Sausage is a product in which meat flesh is mixed with additives, stuffed into suitable casings, and heat processed.[4] The addition of fish meat in sausage formulation could improve nutritional quality of the product and can be a way to insert fish meat in human diet. Fish sausage is a product that sausage manufactures have started producing due to changing consumer preferences toward healthier lifestyles, safer and cheaper foods.[5, 6] Several recent studies have examined the use of various functional ingredients or adjuncts in sausage formulations. Among such ingredients are starch, egg white, salt, carrageenans, other gums and konjac flour.[7, 8, 9, 10, 11, 12]

There were several scientific results about the application of red tilapia (*Oreochromis* sp.) in fish sausage.

One study assessed the quality of sausage elaborated using minced Nile tilapia submmitted to cold storage.[13] One research evaluated physicochemical and sensory properties of sausages made with washed and unwashed mince from Nile tilapia by-products.[14] One research evaluated the physicochemical and microbiological stability of sausages produced from mechanically separated fish meat (MSM) obtained from Nile tilapia filleting residues.[15] The shelf life of minced tilapia to replace synthetic preservatives with Hijiki and Nori seaweeds extracts was evaluated.[16]

One study evaluated the functional sausage made from mechanically separated tilapia meat.[1] One study analyzed the influence of quinoa flour on the physicochemical properties, texture and oxidative stability during storage and sale of Frankfurter sausages made with red tilapia fllet waste when adding quinoa flour.[17]

The goal of our study was to determine if the addition of modified starch, carrageenan as well as the sterilizing temperature and time could improve the physicochemical properties and sensory chacarteristics of red tilapia sausage.

## 2. Material & Method

### 2.1 Material

We raised red tilapia fishes in Hau Giang province, Vietnam. They must be cultivated following Global without using antibiotic to ensure food safety. After harvesting, they must be kept in ice chest (< 4$^{o}$C) and conveyed to laboratory within 2 hours for experiments. Proteolysis and biochemical changes of muscle can be taken place to some degrees during iced storage. We used knife to fillet the muscle out of bone. The carcasses resulting from this process were washed with chlorinated water .Besides collecting muscle of red tilapia, we also used other materials such as NaCl, monosodium glutamate (MSG), pepper, sugar, garlic, carrageenan, modified starch. Lab utensils and equipments included grinder, weight balance, thermometer, autoclave, ice chest, texture analyzer.

**2.2 Research method**

***2.2.1 Investigate the effect of carrageenan concentration to the gelation***

Red tilapia fishes were filleted to collect muscle and discard bone. Fish muscle was kept under 4°C in 2 hours before being grinded thoroughly. Salt 1.5%, MSG 0.3%, sugar 0.8%, pepper 2.0% and garlic 2.0% were used as food ingredients. Red tilapia muscle was grinded into paste in 3 minutes at 0-4°C. We added different carrageenan concentrations (0, 0.5, 1.0, 1.5 and 2.0%) into fish paste. Then the fish paste was stuffed and formed sausage. Fish sausage was then sterilized in 115°C in 10 minutes. We evaluated moisture content in paste and sausage, sausage recovery, sausage elasticity (strain and stress), sausage sensory (score from 1-5).

***2.2.2 Investigate the effect of modified starch concentration to the gelation***

Red tilapia fishes were filleted to collect muscle and discard bone. Fish muscle was kept under 4°C in 2 hours before being grinded thoroughly. Salt 1.5%, MSG 0.3%, sugar 0.8%, pepper 2.0% and garlic 2.0% were used as food ingredients. Red tilapia muscle was grinded into paste in 3 minutes at 0-4°C. We added different modified starch concentrations (0, 0.5, 1.0, 1.5 and 2.0%) into fish paste. Then the fish paste was stuffed and formed sausage. Fish sausage was then sterilized in 115°C in 10 minutes. We evaluated moisture content in paste and sausage, sausage recovery, sausage elasticity (strain and stress), sausage sensory (score from 1-5).

***2.2.3 Investigate the effect of sterilization time and temperature to the gelation***

Red tilapia fishes were filleted to collect muscle and discard bone. Fish muscle was kept under 4°C in 2 hours before being grinded thoroughly. Salt 1.5%, MSG 0.3%, sugar 0.8%, pepper 2.0% and garlic 2.0% were used as food ingredients. Red tilapia muscle was grinded into paste in 3 minutes at 0-4°C. We added carrageenan 1.5% and modified starch 0.5% into fish paste. Then the fish paste was stuffed and formed sausage. Fish sausage was then sterilized in different temperatures (110, 115, 120°C) and in different times (5, 10, 15 minutes). We evaluated moisture content in sausage, sausage recovery, sausage elasticity (strain and stress), sausage sensory (score from 1-5).

***2.2.4 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). Data were statistically summarized by Statgraphics Centurion VXI.

## 3. RESULT & DISCUSSION

**3.1 Effect of carrageenan concentration to the gelation**

Gelation is the cross-linking of randomly dispersed polymer chains to form a three-dimensional network which including initial denaturation to cause protein unfolding, protein interactions and aggregation giving rise to matrices capable of holding water, fat or other components through physico-chemical forces.

We added different carrageenan concentrations (0, 0.5, 1.0, 1.5 and 2.0%) into fish paste. Our results were elaborated in table 1. We noticed the optimal carrageenan concentration at 1.5 % for red tilapia sausage. One study evaluated some physicochemical and sensory properties of cake supplemented with marjoram as partially substituted of flour at different levels (1, 2 and 3 %). The results showed that phenolic compound of marjoram extract in descending order were ellagic, salicylic, pyrogallol and catechol (157.98, 66.55, 43.24 and 23.86 respectively).[19] One study declared that the use of 5.2% (w/w) chicory root inulin and 2.6% (w/w) extra hake mince in fish sausage formulation results in an increase in gel strength and hardness values compared to the control fish sausage.[20]

One study assessed the quality of sausage elaborated using minced Nile tilapia submmitted to cold storage. The addition of minced fish to sausages increased lipid oxidation values and decreases total volatile nitrogenous bases, L*, a* and b* values. Acceptability of color attribute decreased with increasing minced fish; best flavor, texture and overall acceptability scores were registered for sausages containing 40 and 60% minced fish; best odor was registered for 100% minced fish. Pathogenic microorganisms were not detected, but decrease in pH and proliferation of aerobic psychrotrophic bacteria which, however, did not compromise sensory evaluation of sausages were registered throughout storage. Sausages prepared with minced fish from tilapia filleting waste have a shelf-life of 40 days when stored at 0±0.3ºC, and the maximum recommended minced fish inclusion to maintain good sensory quality is 60%.[13]

One research evaluated the effects of inclusion level (60 to 100%) and washing cycles (0 to 2) of minced fish from Nile tilapia fillet by-products on proximate composition, mineral contents, color, hardness, and sensory acceptance of sausages. The optimum combinations for the independent variables are sausages made with 100% non-washed minced fish, which represents a better use of by-products without generating washing residues, leading to less expensive sausage with higher nutritional value.[14] One study investigated the physicochemical, bacteriological and sensory parameters of sausages made from waste of Nile tilapia with the prebiotic inulin added and reduced sodium. Mechanically separated carcass meat and mechanically separated head meat were processed into sausages with or without inulin and salt replacer. T1 and T3 showed the greatest lipid, but lowest carbohydrate levels, a* and b*values ($P<0.05$). In general, the inulin formulations showed higher acceptability and purchase intent (P <0.05). The addition of inulin to low sodium tilapia sausages is a promising technological strategy to minimize negative effects on the taste and texture from KCl increment.[1]

**3.2 Effect of modified starch concentration to the gelation**
Texture plays an important role in acceptance of food products. We added different modified starch concentrations (0, 0.5, 1.0, 1.5 and 2.0%) into fish paste. Our results were elaborated in table 2. We noticed the optimal modified starch concentration at 0.5% for red tilapia sausage.

**Table 1. Effect of carrageenan concentration to moisture content (paste and sausage), sausage recovery, texture and sensory**

| Carrageenan content (%) | Paste moisture (%) | Sausage moisture (%) | Recovery (%) | Shear strain | Shear stress (Kpa) | Sensory score |
|---|---|---|---|---|---|---|
| 0 | 47.94±0.02$^{c}$ | 45.66±0.03$^{c}$ | 85.20±0.01$^{c}$ | 2.11±0.02$^{c}$ | 46.40±0.04$^{d}$ | 2.34±0.01$^{d}$ |
| 0.5 | 54.75±0.03$^{bc}$ | 52.77±0.01$^{bc}$ | 88.75±0.00$^{bc}$ | 2.19±0.02$^{bc}$ | 48.70±0.01$^{c}$ | 3.20±0.00$^{c}$ |
| 1.0 | 55.37±0.02$^{b}$ | 53.49±0.01$^{b}$ | 90.11±0.04$^{b}$ | 2.25±0.02$^{b}$ | 51.49±0.02$^{b}$ | 3.90±0.02$^{b}$ |
| **1.5** | 56.75±0.01$^{ab}$ | 54.74±0.03$^{ab}$ | 93.75±0.00$^{a}$ | 2.63±0.01$^{ab}$ | 61.23±0.03$^{a}$ | 4.51±0.03$^{a}$ |
| 2.0 | 56.80±0.04$^{a}$ | 55.01±0.02$^{a}$ | 93.88±0.02$^{a}$ | 2.65±0.01$^{a}$ | 61.35±0.01$^{a}$ | 4.63±0.01$^{a}$ |

*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 2. Effect of modified starch concentration to moisture content (paste and sausage), sausage recovery, texture and sensory**

| Modified starch content (%) | Paste moisture (%) | Sausage moisture (%) | Recovery (%) | Shear strain | Shear stress (Kpa) | Sensory score |
|---|---|---|---|---|---|---|
| 0 | 46.49±0.00$^{b}$ | 44.77±0.03$^{b}$ | 87.60±0.00$^{b}$ | 2.17±0.01$^{b}$ | 46.74±0.00$^{b}$ | 2.29±0.01$^{b}$ |
| **0.5** | 50.79±0.04$^{a}$ | 49.35±0.00$^{ab}$ | 90.35±0.01$^{ab}$ | 2.59±0.00$^{a}$ | 51.38±0.01$^{a}$ | 4.79±0.01$^{a}$ |
| 1.0 | 50.83±0.03$^{a}$ | 49.48±0.03$^{a}$ | 90.79±0.03$^{a}$ | 2.62±0.02$^{a}$ | 51.54±0.03$^{a}$ | 4.84±0.02$^{a}$ |
| 1.5 | 50.85±0.02$^{a}$ | 49.50±0.01$^{a}$ | 90.83±0.02$^{a}$ | 2.66±0.03$^{a}$ | 51.60±0.02$^{a}$ | 4.90±0.00$^{a}$ |
| 2.0 | 50.90±0.01$^{a}$ | 49.53±0.01$^{a}$ | 90.90±0.02$^{a}$ | 2.70±0.02$^{a}$ | 51.63±0.01$^{a}$ | 4.92±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 sterilization time and temperature to sausage moisture content (%)**

| Sterilization temperature ($^{o}$C) | Sterilization time (minutes) | | |
|---|---|---|---|
| | **5** | 10 | 15 |
| 110 | 53.35±0.02$^{b}$ | 53.11±0.01$^{b}$ | 52.74±0.00$^{b}$ |
| **115** | 54.89±0.00$^{a}$ | 54.70±0.04$^{a}$ | 53.80±0.03$^{a}$ |
| 120 | 53.94±0.01$^{ab}$ | 54.33±0.03$^{ab}$ | 53.21±0.02$^{ab}$ |

*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 4. Effect of sterilization time and temperature to sausage recovery (%)**

| Sterilization temperature ($^{o}$C) | Sterilization time (minutes) | | |
|---|---|---|---|
| | **5** | 10 | 15 |
| 110 | 93.50±0.00$^{b}$ | 92.84±0.03$^{b}$ | 91.95±0.01$^{b}$ |
| **115** | 95.21±0.02$^{a}$ | 94.19±0.01$^{a}$ | 93.36±0.02$^{a}$ |
| 120 | 94.58±0.01$^{ab}$ | 93.40±0.01$^{ab}$ | 92.67±0.03$^{ab}$ |

*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 5. Effect of sterilization time and temperature to sausage firmness**

| Sterilization temperature ($^{o}$C) | Sterilization time (minutes) | | | | | |
|---|---|---|---|---|---|---|
| | **5** | | 10 | | 15 | |
| | Shear strain | Shear stress (Kpa) | Shear strain | Shear stress (Kpa) | Shear strain | Shear stress (Kpa) |
| 110 | 2.19±0.00$^{b}$ | 59.71±0.04$^{ab}$ | 2.21±0.03$^{ab}$ | 56.41±0.02$^{ab}$ | 2.19±0.01$^{b}$ | 55.39±0.01$^{b}$ |
| **115** | 2.38±0.01$^{a}$ | 60.40±0.01$^{a}$ | 2.35±0.01$^{a}$ | 57.60±0.03$^{a}$ | 2.31±0.02$^{a}$ | 57.88±0.03$^{a}$ |
| 120 | 2.29±0.02$^{ab}$ | 59.29±0.03$^{b}$ | 2.29±0.02$^{ab}$ | 55.77±0.00$^{b}$ | 2.22±0.04$^{ab}$ | 56.22±0.02$^{ab}$ |

*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 6. Effect of sterilization time and temperature to sensory score**

| Sterilization temperature ($^oC$) | Sterilization time (minutes) | Sensory score |
|---|---|---|
| 110 | 5 | 3.87±0.04[ab] |
| | 10 | 4.02±0.00[a] |
| | 15 | 3.63±0.01[b] |
| **115** | **5** | **4.59**±0.02[a] |
| | 10 | 4.20±0.03[ab] |
| | 15 | 3.90±0.00[b] |
| 120 | 5 | 4.25±0.04[a] |
| | 10 | 3.88±0.01[ab] |
| | 15 | 3.49±0.03[b] |

*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%).*

One study evaluated the shelf life of minced tilapia to replace synthetic preservatives with Hijiki and Nori seaweeds extracts. The application of the extracts had no effect on the chemical composition of the minced tilapia. The seaweed extracts had inhibitory effect on total volatile base nitrogen. The minced tilapia complied with the microbiological standard. The panelists detected no differences in the rancid aroma and only minor differences were detected in the color of the products.[16]

One study analyzed the influence of quinoa flour on the physicochemical properties, texture and oxidative stability during storage and sale of Frankfurter sausages made with red tilapia fllet waste when adding quinoa flour. The addition of quinoa flour at a concentration of 10 g/kg presented the best water holding capacity, water binding ability, lighter coloration and cooking yield, as compared to the control sausage. By contrast, the sausages with 20 g/kg were harder and required greater effort to cut than the control ($p < 0.05$). The addition of quinoa flour increased fat oxidation after 6 days of monitoring. The addition of 10 g/kg of quinoa flour was the best concentration for the production of sausages made with red tilapia fllet waste.[18]

**3.3 *Effect of sterilization time and temperature to the sausage gelation***

Textural characteristics such as gel strength are the major determinant of sausage price and quality. Upon heating, the denaturation and degradation of muscle proteins can occur with varying degrees depending on temperature and time. Fish sausage was then sterilized in different temperatures (110, 115, 120$^oC$) and in different times (5, 10, 15 minutes). Our results were elaborated in table 3, 4, 5 and 6. We noticed the optimal sterilizing temperature at 115$^oC$ in 5 minutes was appropriated.

One research evaluated the physicochemical and microbiological stability of sausages produced from mechanically separated fish meat (MSM) obtained from Nile tilapia filleting residues. Different heat treatments (pasteurization or smoking) and packaging systems (conventional or vacuum) were used. No presence of *Escherichia coli*, *Salmonella* sp. or coagulase-positive *Staphylococcus* was detected; however, the psychrotrophic count in pasteurized sausages exceeded the limits allowed for consumption. pH and lipid oxidation speed (TBARS) values were reduced when vacuum packaging was used. Volatile nitrogenous bases remained virtually constant during the storage period, and higher values were observed in smoked products. Pasteurized sausages remain stable for 10 and 15 days in conventional and vacuum packages, respectively, and smoked sausages remain stable for 25 and 45 days in conventional and vacuum packages, respectively.[19] One study demonstrated that surimi sausage had better textural and chemical characteristics than minced fish sausage during cold storage.[20]

## 4. Conclusion

Aquaculture has been considered as the future source of high quality proteins, due to its increased growth as a productive activity and opportunity for income generation. Sausage is a product widely consumed worldwide and contains basically meat and fat (solid phase) dispersed into ice/water (liquid phase) forming a stable mass that will be submitted to a moderate heat treatment. Fish sausages can be made from fish meat produced from different species, adding flavorings and preservatives. We have successfully investigated the effect of gelling agents (carrageenan and modified starch), sterilization temperature and time on the the physicochemical properties and sensory characteristics of fish sausage. The addition of carrageenan and modified starch can improve the textural and sensory properties of red tilapia sausages. Thermal treatment also strongly affected to texture characteristics of this fish sausage.

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