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Effect of frozen storage on the chemical and sensory properties of red tilapia (*Oreochromis niloticus*)

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Abstract

Tilapia is one of the fastest growing aquaculture productions in the world and understanding of its storage to ensure the quality of the fish before the product reaches consumer is important. Freezing changes a food physical state by changing water into ice when energy is removed in the form of cooling below freezing temperature and its effect on the quality of fish is widely studied. This present study evaluated the effect of frozen storage of tilapia fillet at -18°C over 120 days. The study revealed that all the chemical quality indices studied like pH (6.60±0.02 to 6.98±0.05), TVB-N (11.81±0.03 N/100g to 22.98±0.18 N/100g), TBA (0.03±0.02 mg malondialdehyde/Kg to 0.18±0.06 mg malondialdehyde/Kg) and PV (0.02±0.00 mEq/kg to 0.80±0.07 mEq/kg) increased in value over the 120 days of storage period. Meanwhile the sensory attribute of the fillet decreased for all parameters evaluated, but were still considered acceptable at the end of the storage period.

1. INTRODUCTION

The tilapia was once considered a poor man's fish due to its fast growth, is now one of the fastest growing aquaculture productions in the world. Tilapias tolerate a wide range of environmental conditions such salinity, oxygen tension and overcrowding. Tilapias are advantageous and highly applicable for selective breeding to its relatively short reproductive cycles, breed prolifically under culture conditions without any hormonal induction for spawning and reaches sexual maturity early (Yue et al. 2016). The fish is easy to breed and is considered highly resistant to diseases. The flesh of tilapia is mild in flavour and is widely accepted as a food source. Various tilapia species and its hybrid has been produced over the decades and were identified and improved to fit the various market's needs. In Malaysia, the red tilapia or *Oreochromis niloticus* fetches a much higher commercial value. The red colour fish is highly valuable as it was developed through selective breeding to later acquire the red coloration. The color red, is highly prized as it is associated with premium marine fishes such as red snapper, and sea bream which was why the price of red tilapia are higher than the common tilapia. Due to its high demand, red tilapia hybrids are now the most commonly used breed in intensive aquaculture production, both brackish and low-input farming systems.

The global commercial demand for tilapia increases every year, mostly due to health awareness from eating fish (Fitzsimnons, 2000). In addition, rising production costs, lack of skilled labour, threat of arising diseases, and food safety and quality of aquaculture produce have become issues of concern towards the aquaculture industry. The immediate concern mostly lies with the maintenance of the quality of tilapia during storage and transportation.

Freezing has been successfully employed long term preservation of many foods by significantly extending the shelf life. Freezing is still one of the most widely used methods of food preservation even though several new technologies, such as high pressure, infrared irradiation, pulsed electric field, and ultrasound have been adapted in the extension of food shelf life, and is also important to ensure good quality assurance (La, et all, 2016).

The objective of this study was to evaluate the effect of freezing on the several chemical qualities associated with oxidation and several sensory values of red tilapia.

2. MATERIALS AND METHODS

2.1 Source of fish

Oreochromis niloticus (average 800g) was transferred in an ice box to the food lab in Jeli Kelantan within 10 minutes from the breeding ponds. The fish was descaled, its inner removed and rinsed before filleting. The fillet (150g) was later individually packed in a clear plastic, air removed using vacuum pack machine, sealed, and stored at -18°C before being used. Storage duration used were 0 days, 3 days, 10 days, 30 days, 60 days and 90 days.

2.2 Chemical analysis

Peroxide value (PV) expressed as milliequivalents of oxygen/kilogram of lipid were determined according to American Oil Chemist Society, (AOCS) (1994) from a sample of 5g from each filet. Thiobarbituric acid value (TBA, mg malondialdehyde/Kg) was determined according to the method proposed by Kirk, 1991. Total Volatile Basic Nitrogen (TVB-N, N/100g) value was estimated by the micro-diffusion method Goulas and Kontominas (2005). pH was determined for the homogeneous mixture of fish and distilled water (1:10, w: v), using a digital Metter Toledo pH meter Jamaludin et al. (2013).

2.3 Sensory analysis

Sensory analysis was conducted at the Food Laboratory, Faculty of Agrobased Industry, Universiti Malaysia Kelantan, Malaysia. The experiment was designed according to rules of performing the sensory laboratory tests described by Resurreccion (2007). The analysis was conducted on 30 untrained panelists aged 21–30 years old, who were neither vegetarians, nor allergic to fish and seafood. The respondents were informed that they should not consume any meals or drinks, smoke or use gums or mints for at least 30 min before the session. Each panelist was placed in individual cubical and instructed not to talk to other panelists during testing. Before the main analysis respondents were given a questionnaire, with preliminary questions like age, gender, weekly expenditures on food, and weekly fish consumption. At the end of questionnaire, the panelists were supposed to mark their knowledge about fish and fish products. The same panelist was used for every sample interval of 0 days, 3 days, 10 days, 30 days, 60 days and 90 days.

Frozen fish fillets used in sensory evaluation were thawed, wrapped in aluminum foil and baked in the oven in 180°C until the temperature in the thermal center of the fish reached 80°C. Afterward, the fillets were cut into uniform transverse strips of 2–3 cm width, put into a lidded plastic container and distributed to the panelists together with fresh mineral water.

The sensory evaluation consisted of two trials—blind and informed. In the first trial (blind) consumers were given five different fish samples, and asked to evaluate four sensory parameters: color, odor, texture, taste, and overall acceptability on the 5-point unipolar hedonic scale, where 1 meant totally unacceptable and 5 meant perfect. Afterward, the respondents were asked to perform a preference test and mark which sample they thought was the best. After cutting the cooked fish fillets onto transverse strips, those strips were cut in half. The samples were then evaluated by respondents for their odour, colour, texture and taste using a 5-point unipolar hedonic scale, where 1 meant "not acceptable" and 5 "perfect."

2.4 Statistical analysis

Statistical software Minitab ® Release 16, (Minitab Inc, Pennsylvania) was used to analyze the data in two- and one way analysis of variance (ANOVA) for TBA, PV, TVB-N, pH in samples, and sensory Likert values.

3. RESULT AND DISCUSSION

3.1 Chemical degradation

TBA index is a widely used biochemical quality indicator for assessing the level of lipid oxidation in food. TBA index gives a measure of malonaldehyde formed in the muscle as a result of oxidation of lipid peroxides. PV value also measures the degree of lipid oxidation in fats and oils but not their stability. Meanwhile TVBN levels were monitored as the main parameter of fish muscle freshness. TVBN are produced by decomposition of proteins into simpler substances (ammonia, trimethylamine, creatine, purine bases and free amino acids). All three parameters (TBA, PV and TVBN) increased over the storage period (Table 1), and has been reported in various other studies (Duarte, 2020; Nakazawa, 2020). Freezing of foods does not stop, but slows down the physicochemical and biochemical reactions associated with food deterioration (George, 1993). Slow changes in organoleptic quality, maintain the quality of the food product to a certain acceptable extent (Sebranek, 1996). The loss of quality of frozen foods depends primarily on storage temperature, length of storage time, and thawing procedure. Although microbial growth may be completely stopped –18°C, and both enzymatic and nonenzymatic changes still continues, but at a much slower rates during frozen storage (Moharram and Rofael, 1993; Duarte et al, 2020). The effect of freezing reduces the random motion and rearrangement of molecules in the body matrix (Hung and Kim, 1996; Kumar et al, 2020; Moharram and Rafael, 1993). Freezing involves the use of low temperatures, and reactions take place at slower rates as temperature is reduced. The presence of ice and an increase in solute concentration can have significant effects on the reactions and the state of the matrix (Rahman, 2007).

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Table 1: TBA, PV, TVB-N and pH value of tilapia fillet over 120 days of frozen storage (-18°C).

Days	TBA	PV	TVB-N	pH
0 (Control)	0.03±0.02[a]	0.02±0.00[a]	11.81±0.03[a]	6.60±0.02[b]
3	0.03±0.02[a]	0.03±0.01[a]	13.24±0.04[b]	6.62±0.06[b]
10	0.05±0.08[a]	0.09±0.03[a]	18.33±0.11[c]	6.50±0.05[a]
30	0.08±0.12[a]	0.17±0.06[b]	20.01±0.17[d]	6.56±0.04[a]
60	0.18±0.06[b]	0.31±0.13[c]	21.47±0.01[e]	6.62±0.00[b]
90	0.74±0.05[c]	0.66±0.07[d]	22.74±0.11[f]	6.79±0.03[c]
120	0.94±0.05[d]	0.80±0.07[e]	22.98±0.18[f]	6.98±0.05[d]

[a, b, c, d, e, f] Means in the same column followed by different superscripts are significantly different ($p < 0.05$)

Regardless of the type of aqueous system, concentration during freezing causes the unfrozen portion to undergo marked changes in physicochemical properties such as ionic strength, pH, viscosity, water activity, surface and interfacial tension, and oxidation–reduction potential. It is important to note that oxygen is almost totally expelled from ice crystals as they are formed (Rahman, 2007; Kumar et al, 2020).

The pH of freshly caught fish is 7 or slightly lower than 7 immediately. The low pH is an indicator of stress which the fish might have encountered during harvesting (Mohan et al, 2008). The pH showed a slight decrease at day 10, followed increase from day 60 until day 120, but still within acceptable range. The initial decrease in pH can be attributed to the dissolution of CO_2 in the fish muscle, and the subsequent increase in pH values can be due to the production of volatile nitrogen bases (ammonia, Trimethylamine and other) in dependence of enzymatic activity (Duarte et al, 2020; Kung et al., 2008; Sun et al, 2009).

3.2 Sensory analysis

The meat of fish is more delicate, and more prone to degradation both chemically and physically, especially after frozen storage. Decreasing in sensory score indicated the loss of freshness in samples (Table 2). This could be due to lipid oxidation and rate of rancidity (Connel, 1995; Duarte et al, 2020) which was observed to also decreased in quality in this study. The sensory data show that the samples were still in acceptable condition at the end of storage of 120 Days. Quality control and assurance of quality are important for the food industry (Lau et al, 2016) and quality decrease due to extended storage has been reviewed extensively (Duarte et al, 2020; Nakazawa and Okazaki, 2020) is in line with the outcome of this study.

Table 2. Sensory analysis of red tilapia for odour, colour, texture and taste over 120 days of frozen storage (-18°C) using the 5-point unipolar hedonic scale.

Days	Odour	Colour	Texture	Taste
0 (Control)	5.00±0.00[a]	5.00±0.00[a]	4.32±0.46[a]	4.43±0.51[a]
3	4.31±0.30[b]	4.41±0.60[ab]	4.21±0.51[ab]	4.38±0.51[a]
10	3.75±0.82[c]	4.11±0.81[bc]	3.95±0.78[ab]	4.22±0.64[ab]
30	3.61±0.54[c]	3.76±0.74[c]	3.81±0.53[bc]	3.96±0.81[ab]
60	3.40±0.40[d]	3.44±0.35[d]	3.35±0.74[c]	3.44±0.64[bc]
90	2.83±0.74e	3.03±0.53[de]	3.01±0.22[c]	2.97±0.50[c]
120	2.27±0.51[f]	2.25±0.78[e]	2.70±0.38[d]	2.80±0.42[c]

[a, b, c, d, e, f] Means in the same column followed by different superscripts are significantly different ($p < 0.05$)

4.0 CONCLUSION

The present study was undertaken to evaluate the effect of freezing of *Oreochromis niloticus* fillets at -18°C. The chemical parameter qualities were similar to other studies and was expected. The sensory analysis revealed even after 120 days of frozen storage, the quality was still acceptable although it was reduced by almost half after the end of the storage period.

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