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# Effect of Prolonged Storage in Ice on Nutrient Composition and Sensory Quality of Whole Fresh Pond Raised Tilapia Fish (*Oreochromis shiranus*)

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**Abstract** A study was conducted to determine the effect of prolonged storage in ice of fresh pond raised Tilapia fish (*Oreochromis shiranus*) on its nutrient composition and quality. Live fish were collected from Bunda College Fish Farm ponds and stored in clean block ice. Sensory, proximate and pH analyses were conducted at a three day interval to determine changes in nutrient composition and quality of the fish while kept in ice. Crude protein and crude fat decreased significantly ($P<0.05$) while ash increased significantly ($P<0.05$) with storage time in ice. pH increased with storage time in ice ($R^2=0.815$). Fish remained in acceptable freshness condition up to day 15 while highest sensory demerit score was recorded on the 18$^{th}$ day suggesting complete rejection. Sensory demerit scores of the fish increased with storage time in ice ($R^2=0.886$) indicative of a decline in acceptability with storage time in ice by the sensory panel. This study demonstrated that fleshly harvested *Oreochromis shiranus* from ponds stored in ice can remain acceptable for purchasers for up to 15 days. This is an advantage especially to rural small scale fish farmers who can hardly afford to preserve their fresh fish in refrigerators but may locally access ice. However, there is need for future research to assess the microbiological load to ascertain safety of the product beyond 15 days storage period.

***Keywords:*** *nutrient composition, quality, ice storage, Oreochromis shiranus*

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## 1. Introduction

The species of fish that were used in this study is *Oreochromis shiranus* - a tilapiine endemic to Lake Malawi and the Upper Shire River in Malawi. It is the commonly cultured fish in ponds by small scale farmers in all parts of the country due to its ease of breeding and tolerance to harsh conditions. Due to poor fish holding facilities in markets that result into spoilage of fresh fish, most farmers in Malawi are exploring the idea of preserving fish in ice because it is locally available. An earlier study on Lake Malawi tilapia revealed that fresh fish can remain in acceptable condition while kept in ice for no less than two weeks [1]. This notion stems from the background that temperature plays a key role in fresh fish spoilage which directly causes changes in the nutritional composition of fish [2]. In the high ambient temperatures of the tropics, fresh fish will spoil within 12 hours [3]. It is widely reported that chilling or icing of fish immediately after catch reduces its spoilage [4,5]. On the other hand, physical properties of fresh fish such as firmness and appearance of the skin are greatly influenced by storage time due to cellular flaking of autolytic and microbial changes [6,7]. The most obvious change in fresh fish flesh after capture is rigor mortis due to loss of the elastic texture of the muscle as a result of a series of complicated chemical changes in the muscle of a fish culminating into spoilage [4]. Fish undergoing spoilage has one or more of the following signs: slime formation; discolouration; changes in texture; off-odours; off-flavours and gas production [8,9].

Since spoilage causes changes in the freshness and nutritional composition of fresh fish, it is necessary to assess the extent of the changes with respect to time so that consumers have maximum nutritional benefits from fish. This is also important for fish processors to avoid processing fish which has compromised nutritional and fresh quality.

The objective of the study was to assess the effect of prolonged storage in ice on nutrient composition and sensory quality of whole fresh pond raised Tilapia fish (*Oreochromis shiranus*).

## 2. Materials and Methods

### 2.1. Fish Sample Collection

Live fish samples, with an average weight of 100g were collected from Bunda College Fish Farm (Malawi), stored in a cooler box and preserved in block ice. Initially, three fish samples were taken for proximate composition, sensory analysis and pH before storing them in ice and later at intervals of three days. The melted ice water in the cooler box was decanted periodically and fresh clean ice was added throughout the experimental period.

## 2.2. Fish Sample Analysis

### 2.2.1. Sensory Analysis

Sensory analysis was carried out by a pre-trained sensory evaluation panel consisting of 6 members. A developed quality index scheme (QIM) [7] was used to assess the quality changes of the fresh fish at a 3 day interval involving the following parameters: skin appearance, slime, fresh firmness, odour, colour of the eyes and colour of the gills. The sensory demerit scores ranged from 0 to 3 where 0 and 3 represented very fresh and spoiled fish, respectively (Table 1).

**Table 1. Quality Index Method (QIM) Scheme developed for the assessment of whole fresh pond raised *Oreochromis shiranus* stored in ice**

| **Quality parameter** | | **Description** | **Scores** |
|---|---|---|---|
| Appearance | Skin | Shiny grey | 0 |
| | | Grey, not shiny | 1 |
| | Scale | Firm | 0 |
| | | Loose | 1 |
| Eyes | Cornea | Very clear (glass-like) | 0 |
| | | Cloudy | 1 |
| | | Milky | 2 |
| | | Opaque pupil | 3 |
| Gills | Colour | Bright red | 0 |
| | | Pale red | 1 |
| | | Dull red | 2 |
| | | Brown | 3 |
| | Smell | Fresh, cut grass, aquatic weed | 0 |
| | | Neutral | 1 |
| | | Musty | 2 |
| | Mucus | Clear | 0 |
| | | Cloudy | 1 |
| | | Milky | 2 |
| | | Brown-reddish | 3 |
| Texture | Backside | Firm & elastic (in-rigor) | 0 |
| | | Soft | 1 |
| | | Very soft/ depression when pressed | 2 |
| | Belly | Firm | 0 |
| | | Soft | 1 |
| **Quality Index (QI)** | | | **0-16** |

### 2.2.2. pH Determination

Ten grams of fish muscle (flesh) was removed, crushed in a mortar and weighed. Fifty (50) millilitres of distilled water was added to the paste and mixed for 5 minutes. pH values were checked and recorded for each set of fish samples using a pH meter (Model No. WTW-8120, West Germany) by inserting the electrode into the mixture of fish muscle and distilled water as earlier followed by Kapute *et al*. [1,10].

### 2.2.3. Proximate Analysis

Proximate composition was done using analytical standard methods developed by AOAC [11]. Three fish samples were collected for analysis at a three day interval. Crude protein, crude fat, moisture and ash were analysed.

## 2.3. Data Analysis

Data was analyzed using a statistical package SPSS version 16.0. Changes in mean proximate composition, pH and sensory scores were compared using one way analysis of variance (ANOVA). Means and standard errors (±SE) were reported at 5% level of significance. Duncan's Multiple Range Test (DMRT) was used to separate significantly different means. A linear regression was plotted on sensory quality data to show the relationship between fish spoilage and ice storage time.

# 3. Results

## 3.1. Sensory Analysis

The sensory scores increased with storage time with a strong correlation ($R^{2=}$0.890) indicating the increased rejection of the fish by the panellists with time (Figure 1).

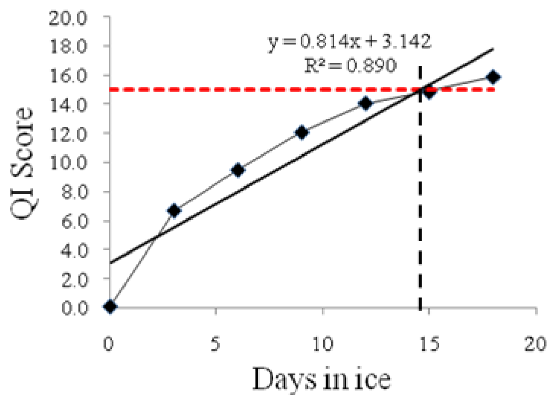


**Figure 1.** Sensory Quality Index scores of fresh *Oreochromis shiranus* stored in ice for 18 days

The highest total demerit score of 15.9 was observed on the 18th day and the results implied that *Oreochromis shiranus* should be kept for no more than 15 days (Figure 1).

## 3.2. pH

The initial pH was 5.59 rising sharply from day 0 to day 15. pH on day 15 was 7.02 then dropped to 6.92 on the 18th day (Figure 2).

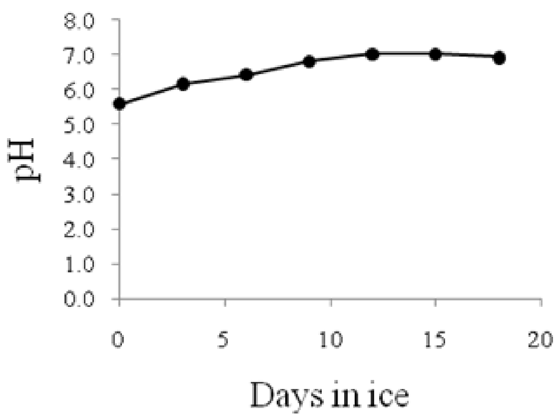


**Figure 2.** Changes in pH of *Oreochromis shiranus* stored in ice for 18 days

A strong linear correlation ($R^2$=0.815) was observed suggesting an increase in pH with increase in ice storage time.

### 3.3. Proximate Composition

There was a significant decrease in crude protein and crude fat with increase in the number of days of storage in ice (P<0.05). Initial moisture content increased from day 0 up to day 6 then decreased significantly up to day 18 (P<0.05). However, ash content increased significantly with time. Highest ash content was recorded on day 18 (Table 2).

**Table 2. Proximate composition of *Oreochromis shiranus* stored in ice for 18 days**

| Days | Moisture (%) | Ash (%) | Protein (%) | Fat (%) |
|---|---|---|---|---|
| 0 | $94.66 \pm 0.30^{c}$ | $16.91 \pm 0.20^{f}$ | $63.72 \pm 0.16^{ab}$ | $16.80 \pm 0.04^{a}$ |
| 3 | $96.77 \pm 0.14^{b}$ | $16.6 \pm 1.15^{g}$ | $63.69 \pm 0.06^{ba}$ | $16.00 \pm 0.05^{b}$ |
| 6 | $97.23 \pm 0.36^{a}$ | $21.49 \pm 0.62^{b}$ | $63.69 \pm 0.04^{c}$ | $15.63 \pm 0.23^{c}$ |
| 9 | $92.83 \pm 0.29^{d}$ | $17.81 \pm 1.53^{d}$ | $63.37 \pm 0.08^{d}$ | $14.66 \pm 1.45^{d}$ |
| 12 | $91.85 \pm 0.26^{fe}$ | $21.11 \pm 1.29^{c}$ | $62.07 \pm 0.03^{e}$ | $10.56 \pm 0.08^{e}$ |
| 15 | $91.02 \pm 0.33^{g}$ | $17.64 \pm 5.12^{e}$ | $61.76 \pm 0.10^{f}$ | $10.43 \pm 0.05^{f}$ |
| 18 | $91.88 \pm 0.49^{ef}$ | $22.24 \pm 2.68^{a}$ | $61.56 \pm 0.14^{g}$ | $9.45 \pm 0.09^{g}$ |

Means with same superscript in a column are not significantly different (P>0.05).

## 4. Discussion

The accepted limit for acceptability of *O. shiranus* by the sensory panellists was observed between 14 and 15 days while the highest total demerit score of 15.9 was observed on day 18. This is close to the values reported by Kapute *et al.* [1] where shelf life of Lake Malawi Tilapia (Chambo - *Oreochromis* species) was estimated between 16 and 18 days with a highest demerit score observed on the 16$^{th}$ day. Other workers [12], estimated shelf life for *O. mossambicus* at 14 days. The longer shelf life of fresh fish stored in ice could be attributed to the low temperature of ice that hinders microbial growth [13].

The natural/normal fresh colour of the fish became discoloured during storage. The pigments may have been oxidized or affected by some other factors. It is known that lipids convert to peroxides, aldehydes, ketones and lower aliphatic acids when they are oxidized [14]. Although hydro-peroxides are tasteless, they can cause brown and yellow discolouration of the fish tissue [15]. Some browning discoloration also occurs in fatty fishes due to hydrolytic changes between fats and proteins [16]. These facts may therefore also explain the observed colour changes of the fish gills in this study.

Texture became harder at the beginning due to stiffening of the muscle during rigor mortis process. The concave appearance of the eyes and scales becoming loose could be as a result of prolonged storage in ice earlier reported by Uchoi *et al.* [13].

Low initial pH during storage in ice may have contributed to the longer shelf life because low pH is not favourable for bacterial growth [5]. After death of the fish, the glycogen present in the tissues gets oxidized to lactic acid and the creatine phosphate in the muscle breaks down releasing phosphoric acid [4]. A release of both lactic acid and phosphoric acid triggers rapid change in pH of tissue fluids [16] hence the rise in pH after day 0 approaching the phosphoric acid range. The further increase in pH after day 0 may reflect the production of alkaline bacterial metabolites in spoiling fish [6]. Increase in pH is accompanied by the completion of rigormortis ending up in softening of the muscle [4]. The increase in pH after day 12 correlated with rapid spoilage of the fish. Increased pH values after sensory rejection have previously also been reported by Liu *et al.* [17] implicating accumulation of alkaline compounds as well as volatile bases produced by autolytic activities and metabolism of spoilage bacteria. Decomposition of fresh fish occurs as its constituent compounds break down [18]. Hydrolysis of proteins, nucleotides and sugar releases bases causing a drop in pH [18] which could explain the fall in pH beyond day 15 from 7.02 to 6.92.

Reduction in the percentage of crude protein during the period of ice storage could be due to gradual degradation of the initial crude protein to more volatile products such as Total Volatile Bases (TVB), Hydrogen sulphide and ammonia [19]. Changes observed in protein and lipid content during storage may have been due to leaching out of some extractable soluble protein fraction and hydrolysis of some of the lipid fractions [20]. The reduction in fat content could also be due to oxidation and breakdown of other fat components during storage [18]. The reduction in protein and fat content agrees with Arannilewa *et al.* [21] where the highest crude protein and fat content was observed in fresh samples that were not subjected to frozen storage while the least was observed in samples that were subjected to frozen storage throughout the period of the experiment.

Initial increase in moisture content of the fish with increase in ice storage time could be due to the fact that the fish absorbed moisture during the first days of storage. The decrease in moisture after day 6 could be attributed to the difference in the moisture of the fish relative to its surrounding. This was also reported by Daramola *et al.* [18] who also concluded that dehydration of the fish is an important physical reaction caused by the evaporation of ice due to differences in vapour pressure over the product surface and the air of the store room. Loss of moisture by evaporation of ice causes the fish surface to dry resulting in dull appearance and even discoloration as observed by Singh *et al.* [5] and earlier reported in this study.

Ash content is mainly determined by bone to flesh ratio [18]. The increase in ash percentage during the experiment might also be attributed to increase in the proportion of bones as compared to the flesh since the flesh was being degraded with increase in time of ice storage.

## 5. Conclusion

It can be concluded that sensory quality of fresh *O. shiranus* declines with time when stored in ice and that storage for not more than 15 days could maintain acceptable quality. It can also be concluded that the nutritional quality of *O. shiranus* deteriorates with time when stored in ice. pH increases with time of storage in ice until *O. shiranus* becomes of unacceptable quality. The general conclusion is that like other tilapias, *O. shiranus* has a relatively longer shelf life kept in ice.

## 6. Recommendations

The study recommends that *Oreochromis shiranus* fish stored in ice should be kept for a limited number of days of no more than 15 days. While these findings provide preliminary knowledge regarding storage time of *O. shiranus* in ice, the sensory data could be more meaningful if validated with microbiological analyses. Not all that is sensorily acceptable is safe to consume due to pathogenic microbial loading.

While refrigeration is not available to most fish farmers in rural areas of Malawi, the long shelf life of *O. shiranus* in ice could be an advantage in preserving fresh pond harvested fish while in markets to maintain quality.

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