

Sensory and nutrient quality of wild captured *Oreochromis shiranus* (Boulenger, 1897) stored at ambient temperature

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Abstract

Sensory and nutrient quality was determined for *Oreochromis shiranus* – a tilapia endemic to the Shire River, southern Malawi. Fish had highest sensory (when deep fried in edible vegetable cooking oil) and nutrient content (raw) up to 3 hours. Organoleptically, processed fish were still liked by consumers up to 12 hours of ambient storage. Deterioration in acceptability of the fish significantly increased between 6 and 9 hours by a difference of 2 while changes between 3 to 6 hours, then 9 to 12 hours had a difference of 1. A strong linear correlation between sensory scores and storage time at ambient temperature ($R^2 = 0.916$) may suggest the importance of time in maintaining freshness quality of fish. Moisture fluctuated with storage time but without significant changes ($P > 0.05$). Ash content increased with storage time while crude fat and crude protein decreased ($P < 0.05$). Significant increase in ash and moisture content ($P < 0.05$) were only reported at sensory rejection of the fish. There were no significant changes ($P > 0.05$) in crude fat content between 3 and 6 hours while changes were observed at 0 (initial) and 12 hours (rejection time) of ambient storage ($P < 0.05$). Crude protein content did not significantly change during the first 3 hours of ambient storage ($P > 0.05$) but significant changes were recorded after 6 hours till sensory rejection of the fish ($P < 0.05$). Nutrient levels remained high after 6 hours despite the drop in sensory quality after 3 hours suggesting that an organoleptically rejected product can still be nutritionally wholesome underscoring the need to validate sensory data with other tests.

Keywords

Sensory,
Nutrient quality,
Wild *Oreochromis shiranus*,
Ambient temperature

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Introduction

Oreochromis shiranus (local name: makumba), is an indigenous tilapia species in the Shire River (Malawi) and parts of southern Lake Malawi. In fact, the species name “shiranus” is adopted from the name of the river “Shire”. *O. shiranus* forms an important fishery in the Shire River mainly at the Liwonde Barrage where fishers catch the fish using a variety of gears predominantly, scoop nets when the barrage water doors have been opened. Due to lack of fresh fish preservation facilities, the fish are usually sold on open grounds near the river or carried in baskets and sold to motorists along the road without any form of preservation creating favourable conditions for spoilage micro flora. Fish is however, ranked among highly perishable food commodities due to its high water activity and protein content, neutral pH and presence of autolytic enzymes which support post mortem bacteria (Huss, 1995; Gram and Huss, 2001; Jay *et al.*, 2005). Further, consumers have nowadays become more aware of the benefits of eating fish that has high quality (Doyle, 2007). Spoilage of

fresh fish also results into loss in freshness and nutrient quality (Huss, 1995; Kapute *et al.*, 2013; Makawa *et al.*, 2014) hence the need for these quality attributes to be determined to ensure consumption of high quality fish. Freshness and nutrient quality is collectively described as shelf life which is defined as the maximum length of time a given product is fit for human consumption (Doyle, 2007). It is imperative therefore that fishers, processors, retailers and consumers are aware of shelf life of fish and fish products before consumption in order to safeguard the health of the people. Many studies on shelf life of sea food have been carried out (Bao *et al.*, 2007; Oramadike *et al.*, 2010; Kapute *et al.*, 2013; Abraham-Olukayode and Oramadike, 2015). These studies have pinpointed temperature and handling of fresh fish immediately after catch as the most important factors that determine shelf life of all fish (Huss, 1995; Doyle, 2007). This study was carried out to determine freshness (sensory) and nutrient (proximate analysis) quality of wild *O. shiranus* caught from the Shire River and kept at ambient temperature.

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Materials and Methods

Fish sample collection

About sixty (60) live *O. shiranus* fish of average weight of 90g were collected from the Upper Shire River in the southern part of Malawi. At the laboratory, the fish were left to die naturally while displayed at ambient storage condition (without any form of preservation) while periodically sprinkling them with clean water using a broom to emulate the real local market situation. A sample was then taken for sensory (3), proximate (3) and pH (3) analyses every three hours thus, nine (9) fish at each sampling time.

Sensory analysis

Fish were deep fried in edible vegetable cooking oil for 15 minutes then later, an organoleptic test carried out involving a pre-trained seven member panel (at every sampling interval). Scores for organoleptic test were attributed as follow: 5 = extremely like, 4 = like moderately, 3 = neither like nor dislike, 2 = dislike moderately and 1 = dislike extremely. Panelists analysed the processed fish samples using the following sensory descriptive attributes: taste, colour, flavour and texture according to Joram and Kapute (2016). Prepared fish samples were presented to the panelists without adding salt to maintain its natural taste and avoid influencing sensory scores.

Proximate analyses

The proximate composition of fish samples was determined following AOAC (2005) guidelines. Crude protein content was determined using the Kjeldahl procedure and multiplied by 6.25 (Protein contains 16% nitrogen thus 6.25 is 100/16.). To determine moisture content, the sample was dried in an oven at 105°C; and moisture content was calculated as loss in weight of the sample. Fat content was determined by Soxhlet extraction using the formula: % crude lipid = (wt of residue/original wt of sample) x 100. Determination of ash content involved heating the fish samples in a muffle furnace at 550°C for 16 hours then, calculating ash values by dividing the weight of ash by the weight of the sample. All the proximate values were reported in g/100g of the fish sample.

Determination of pH

A 10g fish sample flesh (muscle) was homogenized in 50 ml of distilled water and the mixture centrifuged using a Yamato Mag-mixer model MH800 (Yamato scientific company Limited Japan) then filtered

using Whatman filter paper No.1. pH of the filtrate was measured using a pH meter (WTW-820, West Germany).

Ethical considerations

All the panelists were briefed before the exercise explaining the type of fish species, cooking oil used, length of storage period of the samples and purpose for carrying out the study. Samples were also prepared in their view and there was no blind scoring. Panelists therefore participate at will and with full information regarding the exercise.

Data analysis

Data were analyzed using SPSS for Windows Version 16.0. One way analysis of variance (ANOVA) was used to compare treatment means as standard deviation (\pm SD) at 5% level of significance. Significantly different means were separated using the Duncan's Multiple Range Test (DMRT).

Results

Sensory evaluation

Fried fish were highly acceptable up to 3 hours and thereafter, organoleptic scores started to decline until complete rejection of the fish after 12 hours (Figure 1). Deterioration in the acceptance of the fish significantly increased between 6 and 9 hours by a difference of 2 while changes between 3 to 6 hours, then 9 to 12 hours had a difference of 1. There was a strong correlation between sensory scores and storage time at ambient temperature ($R^2 = 0.916$). Although acceptance of the fish declined after 3 hours of ambient storage, nutrient content remained high up to 6 hours suggesting that nutritive and sensory quality do not always go together.

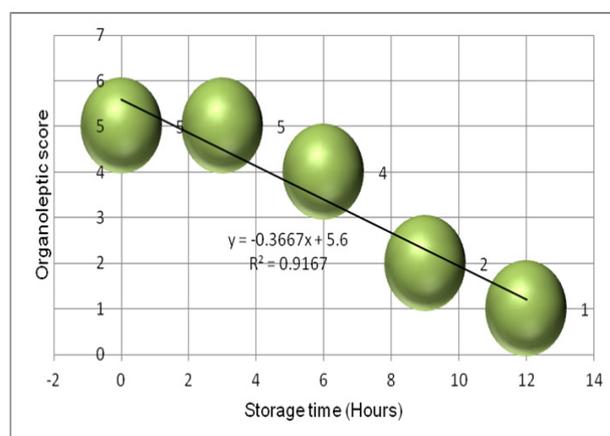


Figure 1. Organoleptic scores for fried wild *Oreochromis shiranus* stored at ambient temperature

Table 1. Mean proximate composition for freshly caught wild *Oreochromis shiranus* stored at ambient temperature

Storage time (Hours)	Moisture (%)	Ash (%)	Crude fat (%)	Crude protein (%)
0	93.49±0.35 ^{ab}	14.29±1.25 ^b	20.89±0.64 ^a	63.69±0.33 ^a
3	93.67±0.22 ^{ab}	15.58±0.24 ^b	19.28±0.29 ^b	63.59±0.18 ^a
6	93.24±0.99 ^{ab}	14.25±1.12 ^b	19.23±0.20 ^b	63.23±0.15 ^b
9	93.43±0.39 ^{ab}	15.79±0.77 ^b	17.86±0.14 ^c	62.76±0.11 ^c
12	94.37±0.24 ^a	17.66±0.39 ^a	16.45±0.10 ^d	62.21±0.10 ^d

Values along the same column with different superscripts are significantly different ($P < 0.05$).

Proximate composition

Results for proximate composition of the fried fish are presented in Table 1. Moisture content fluctuated with storage time but without significant changes ($P > 0.05$). Ash content increased with storage time while crude fat and crude protein decreased ($P < 0.05$). Significant increase in ash and moisture content ($P < 0.05$) were only reported after 12 hours when the fish were rejected by the sensory panel. There were no significant changes ($P > 0.05$) in crude fat content between 3 and 6 hours while changes were observed at 0 and 12 hours of ambient storage ($P < 0.05$). Crude protein content did not significantly change during the first 3 hours of ambient storage ($P > 0.05$) but significant changes were recorded from 6 hours till sensory rejection of the fried fish samples ($P < 0.05$).

pH

Initial pH of the fresh fish (Figure 2) was close to neutral (6.8) but decreased linearly with storage time to 6.2 at the time of sensory rejection (12 hours).

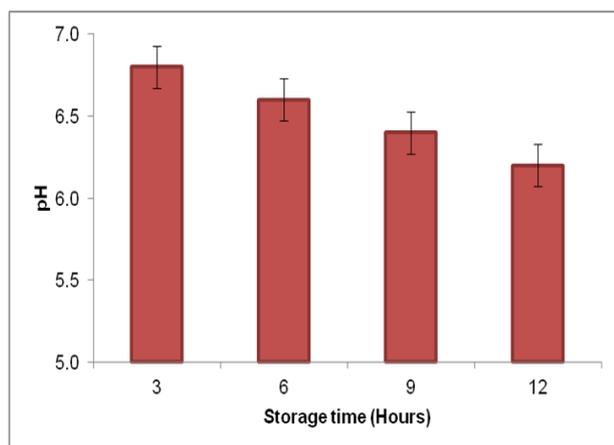


Figure 2. Changes in pH for freshly caught wild *Oreochromis shiranus* stored at ambient temperature

Discussion

Sensory evaluation

Sensory rejection time of 12 hours for pan fried wild *O. shiranus* in this study has been reported by Makawa *et al.* (2014) for pond raised *O. shiranus*,

Adoga *et al.* (2010) for *O. niloticus* and Abraham-Olukayode and Oramadike (2015) for *T. guineensis*. Findings show that *O. shiranus* like other tilapia species, have a longer storage life confirming earlier reports that it is a lean (less than 20% fat) fish (Kapute *et al.*, 2013). The process of rigor mortis which sets in immediately after death of fish (Huss, 1995) may have had an effect on the findings in this study. As an initial process in spoilage of fish, rigor mortis precede microbial spoilage. Though microbial analysis was not carried out on the samples, rapid deterioration in sensory acceptability of the fish between 6 and 9 hours could be due to spoilage influenced by bacterial action (Huss, 1995). Adoga *et al.* (2010) reported significant changes in TVB-N in *O. niloticus* stored at ambient temperature within the same time period indicative of increased microbial activity (Wu and Bechtel, 2008; Howgate, 2010; Abraham-Olukayode and Oramadike, 2015). Unlike catfish, tilapia fish die a few minutes after being taken out of the water. Although acceptance of the fish declined after 3 hours of ambient storage, nutrient content levels remained high up to 6 hours suggesting that nutritive and sensory quality do not always match probably due to subjectivity in sensory evaluation (Huss, 1995). This was earlier observed by Kapute *et al.* (2012) concluding the likelihood that a nutritionally wholesome food product can be sensorily declared as unfit for consumption underpinning the need for validating sensory evaluation with other methods. Due to increased demand for fish which is also prevalent to all areas in Malawi, most of the fresh fish are sold in less than 12 hours suggesting that fish are bought while in acceptable condition. However, the longer sensory acceptability of the fish may be due to the fact that the samples were presented as deep fried which usually affects consumer perception earlier reported by Joram and Kapute (2016). Sensory acceptance or rejection of food has a multi-factorial nature (Claret *et al.*, 2016). It is therefore likely that acceptability could have been lower than observed if fish were cooked (not fried) or presented unprocessed (raw). Processing therefore improves taste and acceptability of foods.

Proximate composition

Knowledge of proximate profiles such as protein content, lipid, ash and other nutrients is necessary to ensure that these are within the range of dietary requirement and commercial specifications (Fawole *et al.*, 2007). Nutrient losses increase with decreasing freshness quality due to chemical changes as well as response to bacterial activity (Pigott and Tucker, 1990; Huss, 1995). General observation in this study is that moisture and ash increased while fat and protein decreased respectively, with ambient storage time. Moisture and ash generally increased with ambient storage.

Fish were sprayed with cold water periodically in storage to keep the fish fresh emulating the ideal local market situation as practiced by the fresh fish vendors which may explain the high moisture content of the fish earlier reported by Makawa *et al.* (2014). Size of fish is probably one of the major factors that influence ash content in that, smaller sized fish species exhibit higher ash content due to the higher bone to flesh ratio (Daramola *et al.*, 2007). High ash content is thus consistent with bony fish such as tilapia species (Devi and Sarojnalini, 2012). Fish used in this study were of small size (average weight of 90 g).

Reduced protein content may be attributed to leaching of soluble components especially water proteins and urea as fresh fish spoil in storage (Osibona and Ezekiel, 2014). Continued addition of water may also have caused reduction in protein in the fish because washing increases loss of protein (Pigott and Tucker, 1990; Ordonez Ramos *et al.*, 2011). Further, prolonged exposure to ambient temperature (sun's radiation) may result into protein breakdown through release of volatile organic nitrogen compounds to the atmosphere as the product spoils (Phan *et al.*, 2012). Autolytic enzymes also accelerate protein hydrolysis due to formation of free amino acids from protein (Pigott and Tucker, 1990; Daramola *et al.*, 2007).

Fish contain high levels of polyunsaturated fatty acids (PUFA) which are recommended for preventing cardiovascular and other diseases (Hossain, 2011). Decreased fat with ambient storage of fresh fish has been previously reported by Makawa *et al.* (2014) attributing loss in fats to oxidation of poly-unsaturated fatty acids found in fish tissue into products such as peroxides, aldehydes, ketones and the free fatty acids. Despite the health importance, one potential hazard of the highly unsaturated fatty acids in crude fish oil is that they easily oxidize when exposed to atmospheric oxygen (Hossain, 2011). Oxidation of lipids produces rancid flavor/ odour (Ozogul *et al.*, 2011) which is consistent with spoilage in fresh fish explaining the decline in

consumer acceptability of the fish with increasing ambient storage period.

High nutrient content of the fish before 3 hours appears to correspond to maximum sensory (organoleptic) scores at the same time period confirming the fact that nutrients are lost during spoilage of fresh fish (Huss, 1995). This may suggest that despite the longer sensory acceptability of wild captured *O. shiranus*, better freshness and nutrient quality is obtained when the fish is consumed before 3 hours.

pH

pH is a reliable, simple and quick method of assessing freshness in fish and widely used in nutritional studies due to the fact that muscle pH of live fish is generally neutral and increases as deterioration of the quality of the fish progresses in storage (Huss, 1995; Liu *et al.*, 2010). Initial pH of the fresh fish was close to neutral which is normal for fish (Huss, 1995; Gram and Huss, 2001). Decreasing pH values with storage time in this study have been previously reported (Obemeata *et al.*, 2011; Kapute *et al.*, 2013; Makawa *et al.*, 2014). pH decreases during anaerobic formation of lactic acids from glycogen during the first hours after death when rigormotis ensues (Huss, 1995; Howgate, 2010). Further, accumulation of alkaline compounds such as ammonia and trimethylamine derived from microbial action during fish spoilage increases with storage period (Özyurt *et al.*, 2009). Though lowest postmortem pH of the fish at sample rejection was not very low (6.2), small changes in pH may result into drastic effects on the properties of muscle connective tissues (Huss, 1995). The post mortem pH (6.8) in this study has been earlier observed by Khalafalla *et al.* (2015). Declining pH values during ambient storage may explain increasing disliking of the fish in the organoleptic testing suggesting deteriorating freshness earlier reported by Kapute *et al.* (2013).

Conclusion

Fresh wild captured *O. shiranus* stored at ambient temperature can remain sensorily acceptable for up to 12 hours when presented as deep fried. However, the best or maximum freshness and nutrient quality can be obtained if the fish is consumed not more than 3 hours after catch. Nutrient and sensory quality of the fish nevertheless, started declining after 6 and 3 hours respectively, suggesting that a food product declared to be of poor quality organoleptically, can still be nutritionally wholesome. It is therefore necessary to validate sensory data with other objective methods.

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