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EFFECT OF DELAYED PROCESSING ON NUTRIENT COMPOSITION, pH AND ORGANOLEPTIC QUALITY OF POND RAISED TILAPIA (*Oreochromis shiranus*) STORED AT AMBIENT TEMPERATURE

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ABSTRACT

Fish are a nutrient rich food but highly perishable due to its high water activity, protein content, neutral pH and presence of autolytic enzymes. This explains why fresh fish quality deteriorates rapidly if not properly stored after catch such as use of low temperature. The implication is that delayed processing of fresh fish negatively influences consumer taste of fish. Further, fresh fish that are not processed on time lose nutrients due to spoilage. In Malawi, most fresh fish are sold in the open due to lack of storage facilities such as refrigerators – a condition that accelerates spoilage of fish. This study was carried out to assess the effect of delayed processing on nutrient composition, pH level and organoleptic quality of pond raised tilapia - *Oreochromis shiranus* which is the commonest grown tilapia in Malawi. Thirty freshly pond harvested *O. shiranus* fish (average weight 100g) were cleaned then deep fried in edible cooking vegetable oil at time intervals of 0, 6 and 12 hours from catch and stored at ambient temperature. A pre-trained sensory evaluation panel consisting six members described changes in the sensory quality of the fresh and fried fish at every sampling time interval. Crude protein, crude fat, ash, moisture content and pH were also determined at each sampling time. Determined crude protein and crude fat decreased while ash content increased with storage time though these were not significantly different from baseline ($P>0.05$). Moisture content decreased from 0 (fresh) to 6 hours then increased again up to 12 hours of storage. Ash and moisture content correlated positively (0.93 and 0.79% respectively), whilst crude protein, crude fat and pH were negatively correlated (-0.91, -0.05 and -0.97, respectively) to sensory quality demerit scores. pH decreased from 5.94 at 0 hours to 5.92 after 6 hours then increased sharply to 5.98 after 12 hours of ambient fish storage. Consumers started to significantly ($P<0.05$) dislike the fish after 7 hours and eventually rejected the samples after 12 hours of ambient storage time. The study recommends that for optimum consumer satisfaction and nutritional benefit, fresh *O. shiranus* should be processed at most 7 hours after harvesting.

Key words: Nutrients, taste, Tilapia, ambient storage

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INTRODUCTION

Oreochromis shiranus is among the most reared tilapia by small scale fish farmers in Malawi because of its ease in breeding and hardiness. Due to poor market and storage facilities in rural areas of Malawi, the fish are usually harvested and displayed in the open places for sale around the pond or at local markets without any form of preservation. Most often, the fish are harvested early in the morning and may remain on display till evening in times of low consumer demand. However, due to lack of information regarding fish quality and safety coupled with poverty in villages (now even in most urban areas), people still buy and consume the fish even during the late hours of the day after harvest. The same scenario is observed in fish captured from the lake where fish are caught at mid night and brought to the beach in the morning. Later, middle men, buy and sell to wholesalers who in turn sell to retailers. Retailers may decide to process the fish or sell to consumers. The fish are thus processed very late after catch. Studies have shown that most fresh fish sold even in super markets in cities of Malawi are in an unacceptable condition due to delayed preservation [1]. Another old tradition is that subjectively, stale fish taste better than freshly caught fish. Because of this, some people deliberately leave the fresh fish for some time to spoil before processing them. In Malawi, this is fairly common with small cichlids such as Utaka (*Copadichromis* species).

However, fish is a highly perishable product due to its high water activity and protein content, neutral pH and presence of autolytic enzymes, which cause spoilage [2]. As a nutrient rich food, the implication is that delayed processing of fresh fish has a major impact on nutritional quality and organoleptic qualities of fish [3, 4] amongst other problems such as accelerating spoilage [1].

This study was, therefore, carried out to assess the effect of delayed processing on nutrient composition, pH level and organoleptic quality of pond raised tilapia - *Oreochromis shiranus*.

MATERIALS AND METHODS

Fish sample preparation, organoleptic tasting and proximate composition determination

Thirty *O. shiranus* fish with an average weight of 100g were harvested from a pond and stored at ambient temperature. Three fish were prepared, cleaned and deep fried in edible cooking vegetable oil for approximately 15 minutes at a 6 hour interval starting from 0, 6 and 12 hours from catch (Figure 1).

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Figure 1: Preparations of fresh *Oreochromis shiranus* for organoleptic tasting (Left=Fresh and Right=Deep frying)

A six pre-trained sensory panel tasted the fried fish samples. All assessors rinsed their mouths with clean water before moving to the next sample to avoid bias. Organoleptic taste was mainly based on flavour of the samples. Different levels (1 to 5) represented the degree of acceptability of the samples by the assessors where 1 and 5 represented the most liked (fresh fish) and least liked (spoiled fish), respectively. According to Gelman [5], the flesh becomes neutral but has no off-flavors in phase 1. In phase 2, the texture is still pleasant. In phase 3, the fish has a sign of spoilage and a range of volatile, unpleasant-smelling substances is produced depending on the period the fish has stayed before processing. At the beginning of the phase, the off-flavor may be slightly soured, fruity and slightly bitter. In Phase 4, the fish is characterized as slightly spoiled and phase 5 as spoiled. These phases were further summarized as: phase 1 - excellent, phase 2 - very good, phase 3 - good, phase 4 - not bad and phase 5 - spoiled. The study was conducted within ranges when the fish were assumed to be in the conditions acceptable to consumers to allow organoleptic taste without endangering the panelists.

A sample was also drawn for proximate composition to determine crude protein, crude fat, ash and moisture content using analytical standard methods [6].
Determination of pH used a procedure applied elsewhere [7] as follows: Ten (10) g of the fish flesh (muscle) was removed, weighed and homogenized in 50 ml of distilled water. The sample was then centrifuged using a Yamato Mag-Mixer Model MH 800 (Yamato Scientific Company Limited, Japan) and the mixture was filtered using Whatman filter paper No.1. A pH meter (Model No. WTW-8120, West Germany) electrode was then inserted into the homogenate to measure the pH at ambient temperature after calibration using standard buffers of pH 7 and 4 at 25^{o}C.

DATA ANALYSIS

Data were entered into Microsoft Excel and analyzed using SPSS version 16.0. One-way analysis of variance (ANOVA) was performed to compare treatment means at 5% level of significance. Duncan's Multiple Range Test (DMRT) was used to separate means that were significantly different.

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RESULTS

The organoleptic scores of the fried fish increased significantly ($P<0.05$) with storage time at ambient temperature and correlated highly ($R^2=0.96$) suggesting decreasing consumer acceptance of the fish (Figure 2 and Table 1).

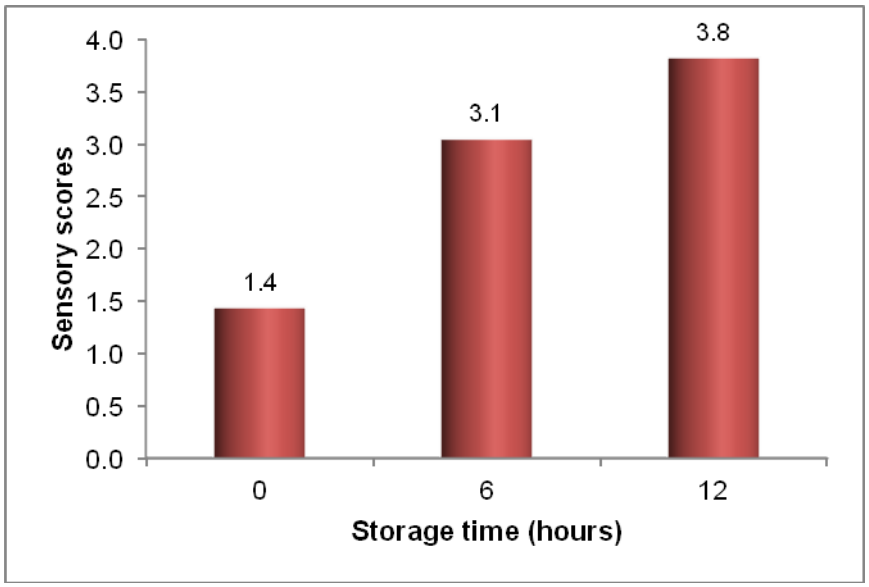

Figure 2: Sensory taste demerit scores against storage time of *Oreochromis shiranus* kept at ambient temperature

The consumers started significantly disliking the fish after 7 hours and eventually rejected the samples after 12 hours. The fried samples gave a sour odour with mushy texture and the predominant flavour was bitter at the 12th hour resulting in rejection by the sensory panel.

Crude protein and crude fat decreased while values for ash increased with storage time (Table 2) but these were not significantly different from baseline ($P>0.05$). The initial proximate composition at time zero did not differ significantly from the rest of the results at different processing times ($P>0.05$). Moisture decreased from zero to six hours then increased again up to 12 hours of storage. Ash and moisture content correlated positively (0.93 and 0.79% respectively) with sensory taste demerit scores; whilst crude protein, crude fat and pH were negatively correlated (-0.91, -0.05 and -0.97, respectively) to sensory taste demerit scores (Table 3).

The pH of the fresh fish slightly decreased from 5.94 at 0 hours to 5.92 after 6 hours then increased sharply to 5.98 after 12 hours of ambient fish storage (Figure 3).

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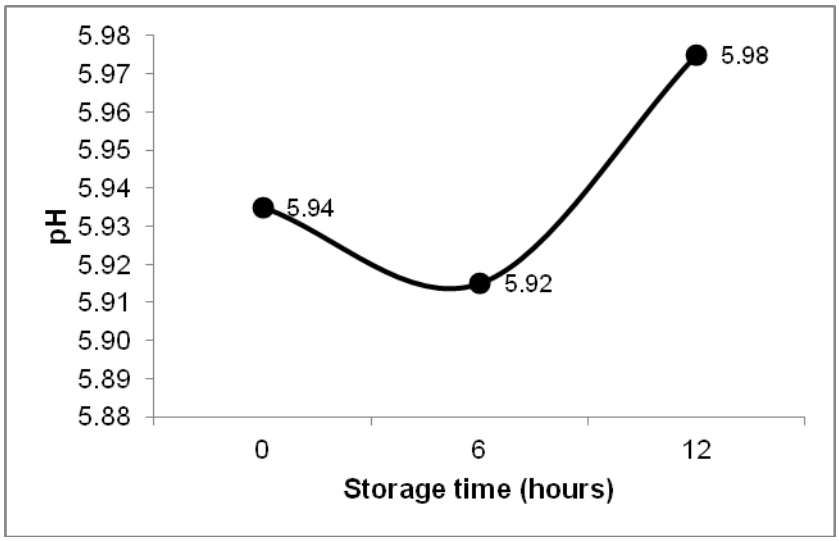

Figure 3: Changes in pH of *Oreochromis shiranus* stored at ambient temperature. However, these changes were not significantly different across the three time intervals of ambient storage (P>0.05).

DISCUSSION

Storage life of up to 12 hours for *O. shiranus* at ambient temperature observed in this study has previously been reported in other tilapia species [8]. Others [9] also reported fresh fish quality within acceptable limits up to 12 hours of ambient storage before processing. It was worth to note that sensory panelists rejected the processed (fried) fish at around 12 hours only by using organoleptic (sensory) test despite the subjectivity of such quality assessment methods [7] hence validating previous findings. As a perishable commodity, unprocessed fish kept at ambient temperature starts spoiling due to a series of biochemical reactions which in turn causes an increase in bacterial count [2, 10]. Frying improves the taste of food hence it is likely that the fish could have been declared not fit for consumption much earlier than 12 hours had other methods of cooking such as boiling been used. The strong correlation (R^2=0.99) between ambient storage time and sensory demerit scores reported in this study affirms the notion that fresh fish should not be stored unprocessed for more than 12 hours when kept at ambient temperature. Similar observations have been previously made by several authors [11, 12, 7]. Though samples were not analyzed for microbiological quality, there is high correlation between higher sensory demerit scores and spoilage of fresh fish by the fact that most of the off odours are a result of bacterial action [2, 7]. Therefore, the sale of freshly pond harvested *O. shiranus* by small scale fish farmers who display the fish in open space without any form of preservation is of concern regarding the quality of the fish as perceived by the ultimate consumer.

Proximate composition is a reliable objective indicator for determining nutritional value and quality of fish [13, 14, 15]. Declining changes in proximate composition of fresh fish, therefore, appear to denote loss in nutrient content and quality. The

degradation of nutrients in the fish consequently affects its flavour. Though not statistically significant, results for this study agreed with previous studies [16, 17, 18] that crude protein decreases with increase in storage time of fresh fish. This has been attributed to a gradual degradation of the initial crude protein to more volatile products such as total volatile bases, hydrogen sulphide and ammonia [10]. Protein forms the largest component of dry matter in fish [19] and its amount in fish muscle is usually between 15 and 20% [20]. Reduction of crude protein with ambient storage is, therefore, a nutritional concern.

Decreased crude fat levels in the fish have previously been reported and implicated the oxidation of poly-unsaturated fatty acids found in fish tissue to products such as peroxides, aldehydes, ketones and the free fatty acids [21]. Oxidation of these lipids gives the fish a rancid flavour hence may explain the decline in consumer acceptability of the fish with increasing period of storage at ambient temperature.

Despite being not significantly different, the trend in ash in this study showed an apparent increase with increasing storage time with rapid increase noted after the 6^{th} hour. Changes in ash content are generally influenced by size in that, smaller sized fish species have higher ash content due to the higher bone to flesh ratio [17]. Fish with high ash content are considered to be lean (less fat) hence maintaining a longer shelf life [7]. Sizes of fish samples in this study were not significantly different hence the changes could have resulted from loss of moisture during burning. The results could have also been due to variation in the amount and quality of food that the fish eats in the pond. Highly nourished fish tend to be fatty resulting into quick sensory quality degradation as a result of fat oxidation [22].

Similarly, there was an apparent decline in water content from 0 to 6^{th} hour then an increase from 6^{th} hour to 12^{th} hour though not significantly different. The higher values reported in this study could be due to the fish absorbing more water from the water that was continuously sprayed on them during storage to emulate the real open market situation.

Another quick indicator of freshness widely used in fish nutritional studies is pH 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 [23]. Values reported in this study agree with other reports [24] that post-mortem pH may vary considerably from pH 5.4-7.2. Initial decrease in pH levels followed by a rise towards rejection in fresh fish observed in this study has been previously reported [7, 12, 17]. It is known that even though the changes in pH were generally small, they have drastic effects on the properties of the connective tissue [2]. For example, the mechanical strength at pH 7.1 is four times stronger than that at pH 6.2 [25]. pH decreases during anaerobic formation of lactic acids during the first hours after death [26]. It has been reported that tropical fish species attain a very low post-mortem pH explaining why they have a longer shelf life [2]. Increased pH values towards and after sensory rejection (12 hours) in this study, were also previously reported underpinning accumulation of alkaline compounds as well as volatile bases produced by autolytic activities and

metabolism of spoilage bacteria [23, 26]. Increased pH towards the 12th hour of storage may probably explain the rapid spoilage of the fish as demonstrated by high sensory demerit scores. The important link between increased pH and spoilage of fish is that it favours more microbial activity [2].

CONCLUSION

This study confirms previous findings that storage period, from catch to processing, is critical to the sensory and nutritional quality of fish. The study established that though freshly harvested pond raised *O. shiranus* can be kept up to 12 hours at ambient storage, the nutritional quality and consumer acceptance may be compromised after 7 hours. It is likely that with other processing methods such as boiling, the acceptance of the fish may be much lower than reported in this study since consumer tastes may have been overshadowed by the deep frying. It is recommended that microbiological analysis is necessary for a study such as this so as to determine bacteria species and degree of contamination at each level of storage as these are key to safety of food products.

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Table 1: Analysis of variance (ANOVA) for sensory test scores of *Oreochromis shiranus* processed at 0 (mean = 1.4), 6 (mean = 3.1) and 12 (mean = 3.8) hours and stored at ambient temperature

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	13.57037	2	6.785185185	22.34146	9E-05	3.885294
Within Groups	3.644444	12	0.303703704			
Total	17.21481	14				

Table 2: Proximate composition of raw *Oreochromis shiranus* stored at ambient temperature

	Ambient storage time sampling interval (hours)		
Nutrient (%)	**0**	**6**	**12**
Crude protein	62.54±0.72	61.22±0.72	60.86±0.72
Crude fat	16.00±0.03	13.00±0.03	09.67±0.03
Ash	16.37±3.17	17.18±3.17	19.95±3.17
Moisture content	90.84±3.47	80.87±3.47	82.73±3.47

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Table 3: Pearson Correlation coefficients (r) between moisture, ash, crude protein, crude fat, pH and sensory scores of *Oreochromis shiranus* stored at ambient temperature between 0, 6 and 12 hours

	Moisture	*Ash*	*Crude protein*	*Crude fat*	*pH*	*Sensory score*
Moisture						
Ash	0.9564958					
Crude protein	-0.705494	-0.4680376				
Crude fat	0.3092931	0.5732783	0.455760294			
pH	-0.817365	-0.6137255	0.984951744	0.295065		
Sensory score	0.9337532	0.7887101	-0.91241937	-0.051564	-0.9694207	

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