Proximate composition of freshly caught Tilapia from Chia Lagoon and Lake Malawi

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AbN

There is an old notion that taste of fish caught from Chia Lagoon is different from fish in the adjacent Lake Malawi - two water bodies separated by a sand bar and connected by a short river. This study attempted to determine if this perception could be explained by the type of food in the two water bodies. Proximate composition of fish from the two water bodies was analyzed to establish if taste variations between the two populations of fish were due to diet. Water quality was also assessed. Mean moisture, crude protein, crude fat, ash and pH for the fish were 92.02±0.18, 63.71±0.26, 22.23±0.41, 16.35±0.79, 6.31±0.31; 92.04±0.19, 62.84±0.16, 20.80±0.47, 19.10±0.26, 6.35±0.78 respectively, for Chia Lagoon and Lake Malawi. Significantly higher Chlorophyll "a" levels (0.57μg/g), and soluble reactive phosphorous (SRP, 62.28 μg/g), were reported for Chia Lagoon than Lake Malawi (0.31μg/g), (3.82μg/g) ($P<0.05$) respectively. Chia Lagoon contains twice as much zooplankton as Lake Malawi. Study results suggest a higher nutrient composition of fish from Chia Lagoon than those from Lake Malawi supported by richness in primary productivity. It is concluded that the taste differences between the Tilapia fish of the two water bodies could be linked to the type of food. It is suggested that the effect of seasonal variability in natural food on proximate composition of fish should also be studied to establish a comprehensive tropho-dynamic model of the two water bodies.

Keywords: Proximate composition, Tilapia, Chia Lagoon, Lake Malawi

Introduction

An old tradition exists that the taste of fish from Chia Lagoon in Nkhotakota district, is different from fish in Lake Malawi, separated from the lagoon by a sand bar and joined by a small stream (Figure 1). Most of the fish species in two water bodies are similar due to their close proximity (Sipawe *et al.*, 2001).

One way of determining if the taste differences are due to the food items ingested by the fish, is by conducting proximate analysis of the fish meat. Simultaneous differences in proximate composition and food items in the two fish populations, could confirm whether the taste differences are linked to nutrition or not. Proximate composition of fish varies with their dietary composition, which in turn, determines taste and flavour of the fish (Kumar *et al.*, 2012). Analysis of proximate composition provides quantitative levels of proteins, lipids, water content, carbohydrate and ash in fish and other organisms. Estimating body composition is also integral to understanding the energy sources consumed by fish and therefore, provides a biologically meaningful way of evaluating diet composition (Braccinia *et al.*, 2005). Total energy content, a useful measure of the condition or health of fish, comes from the contributions of carbohydrate, lipid and protein, whereas ash and water only make up mass of the organism.

Chia lagoon receives significant amounts of nutrients from the inflowing rivers and is shallow enough to allow sediment re-suspension from the bottom to the water column (Bunderson *et al.*, 2008). This may lead to higher primary production in the lagoon than in the oligotrophic Lake Malawi. Nutrient availability through river inflows and mixing of the bottom with epilimnetic waters enhances primary production (Wasmund *et al.*, 2005). Higher primary production may in turn lead to quantitative and qualitative changes in secondary production which may manifest in flavour and taste variations in fish (Makwinja *e*, 2013). Phytoplankton, the machinery of primary production, contains various types of nutrients such as proteins, carbohydrates, fats, water, and mineral such as iron, calcium and vitamins. Fish obtain similar types of nutrients in their bodies as they ingest phytoplankton. The nutrient composition in the muscle of a particular species of fish varies from one fishing ground to another, due to changes in the amount and quality of natural food that the fish eats (FAO, 2001). Reduction in basic type of food leads to reduction in body nutrient profile, and vice versa (Hossain, 2014). The differences in proximate composition of fish meat are thus linked to variation in food availability in natural habitats of fish (Lucas and Watson, 2002). Therefore, this study was carried out to test the hypothesis: Do the differences in consumer taste in the freshly Tilapia fish caught from Chia Lagoon and Lake Malawi as a result of type of natural foods in the two aquatic systems? Findings suggest that the food resource base in the Chia Lagoon influences the taste of the fish accepting the hypothesis.

Methods and Materials

Description of the fish sample collection sites

Chia Lagoon, the fifth largest water body in Malawi, is located on the shores of Lake Malawi at a latitude of 13° 08' 00" S and a longitude of 34° 18' 00" E in Malawi's central district of Nkhota-kota (Figure 1).

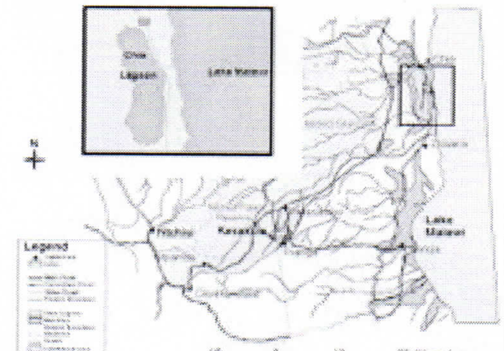

Figure 1: Part of catchment area of Chia Lagoon showing the lagoon and Lake Malawi (adapted from Bunderson et al., 2008)

Covering a surface area of 17 km^2, the lagoon forms an important fishery resource for the surrounding communities (Bunderson *et al.*, 2008). The lagoon drains into Lake Malawi to the east through a stream outlet.

Sample collection

Ten fresh Tilapia fish (14 – 20 cm TL measured using a measuring board) from Chia Lagoon and ten of similar size from Lake Malawi were bought directly from fishermen on the beaches along these water bodies in the month of February. The fish samples were transported in cooler box containing ice (to maintain its freshness) to the laboratory for proximate composition analysis. pH of the fish samples was also measured. 1000 ml of water samples from each site were collected in opaque sampling bottle for the analysis of Chlorophyll *"a"* and phosphorous using a zooplankton net. From each site, water samples were collected from the surface of the water using opaque bottles. The samples were filtered in the field through GF/F 47 mm glass fiber filters under low pressure using a peristaltic pump and inline filtration. Whole-water samples for determination of total phosphorus (TP) were collected in acid-washed polyethylene bottles. Discrete TP samples were collected from 20 cm below the water surface and 1 m above the bottom of the water using a peristaltic pump. Samples were kept on ice until return to the laboratory and then preserved using Optima HCl. Zooplankton samples were collected in triplicate from Chia Lagoon and Lake Malawi using vertical net hauls of a standard Wisconsin zooplankton net with an anterior reducing cone (80 mm Nitex mesh, 0.22 m diameter mouth). The net was lowered to 2–5 m above the bottom of the water and raised at a speed of approximately 0.33 m/sec. Zooplankton were anesthetized and preserved in 70% ejN

Proximate composition analysis

Crude protein, moisture content, energy, ash, and crude fat of the collected fish samples were analysed following the methods outlined by AOAC (2012).

Water quality analysis

a) Determination of Chlorophyll "a"

Chlorophyll "a" concentration was determined as a measurement of algal biomass. Filters were frozen and later extracted in Optima methanol before fluorometric analysis according to US Environmental Protection Agency standard methods (Arar and Collins, 1997). Measures were taken during Chlorophyll "a" analysis to avoid exposure to light. Final pigment concentrations were corrected for the influence of phaeo pigments.

b) Determination of Phosphorus

TP concentrations were analyzed using a Technicon Auto analyzer following persulfate digestion (American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1995).

c) Determination of Zooplankton

The micro-organisms were counted under the microscope using 600 x magnification. Identification of the zooplankton was based on the list published by Witty (2004).

d) Statistical analysis

Data was entered into Microsoft Excel and analysed in SPSS for Windows version 15.0. Treatment means for proximate composition, zooplankton, chlorophyll "a" and phosphorus abundance from the two water bodies were compared using a Simple t-test. Histograms for zooplankton and Chlorophyll "a" were plotted using Microsoft Excel.

Results

a) Proximate composition

Proximate composition results of the fish from the water bodies (Table 1) showed that there were significant differences ($P<0.05$) in all the nutrients with an exception of moisture and pH.

Table 1: Proximate composition of Tilapia fish from Chia Lagoon and Lake Malawi

Site	Moisture	Crude Protein	Crude Fat	Ash	Energy	pH
Chia Lagoon	92.02 ± 0.18^a	63.71 ± 0.26^a	22.23 ± 0.41^a	16.35 ± 0.79^b	20.02 ± 0.16^a	6.31 ± 0.03^a
Lake Malawi	92.04 ± 0.19^a	62.84 ± 0.16^b	20.80 ± 0.47^b	19.10 ± 0.26^a	18.01 ± 0.21^b	6.35 ± 0.07^a

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

Fish collected from Chia Lagoon had higher levels of crude protein, crude fat and energy suggesting better nutrient content than fish from Lake Malawi.

Water quality

b) Chlorophyll "a" and soluble reactive phosphorus (SRP) levels

Results for Chlorophyll "a" and soluble reactive phosphorus are presented in Figure 2. Chia Lagoon had significantly higher Chlorophyll "a" levels (0.57μg/g) than Lake Malawi (0.31μg/g) ($P<0.05$).

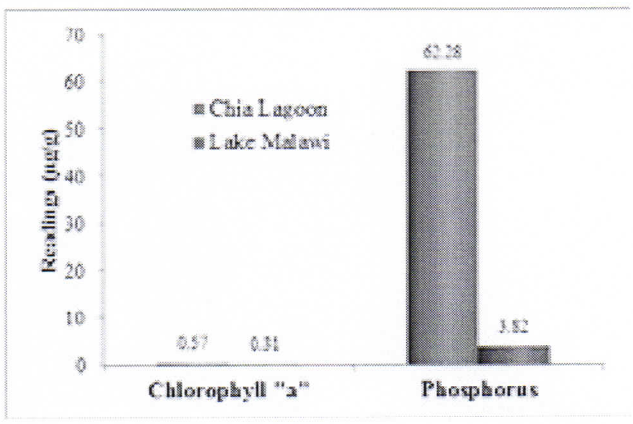

Figure 2: Chlorophyll "a" (μg/g) and soluble reactive phosphorus (μg/g) levels per g of water in Chia Lagoon and Lake Malawi

c) Zooplankton

Results for zooplankton analysis (Figure 3) showed that Chia Lagoon contains T. cunningtoni, M. aequatorialis, T. neglectus, B. longirostris, Diaphanosoma spp. and Nauplii; while Lake Malawi contains T. cunningtoni, M. aequatorialis, T. neglectus, Diaphanosoma spp. and Nauplii (larval stage). Chia Lagoon had twice as much number of zooplankton per ml (116) than Lake Malawi (71), an indication that the lagoon is rich zooplankton diversity.

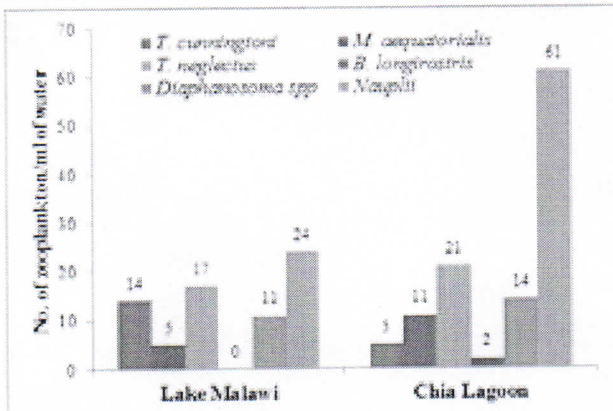

Figure 3: Number of zooplankton species per ml of water from Chia Lagoon and Lake Malawi

All species of zooplankton were higher in numbers in Chia Lagoon except T. cunningtoni. The least available zooplankton species in numbers was B. longirostris which was only recorded in Chia Lagoon.

Discussion

Analyses of composition provide important information regarding fish population fitness, habitat quality, and trophic relations (Vollenweider et al., 2011). Proximate composition data reported in this study are within the range for Tilapia (Kapute et al., 2013; FAO, 2001) suggesting that the fish has high nutrient content. The higher crude protein, crude fat and energy content in the Chia Lagoon fish reflects a food resource enriched in these nutrients (Hossain, 2012; Lucas and Watson, 2002).

The greater algal biomass in Chia Lagoon observed in this study suggests an ecosystem with high primary productivity. Livingstone (2006) noted that chlorophyll "a" concentrations are correlated with biomass and nutrient content of phytoplankton and fish. High chlorophyll "a" concentrations indicate high phytoplankton bloom while low chlorophyll "a" concentration is indicative of low phytoplankton levels. The high algal biomass in Chia Lagoon supports a high zooplankton abundance in this site as shown by the findings of this study. The high algal biomass in Chia Lagoon is, in turn, supported by the high soluble reactive phosphorus (SRP) because this nutrient is key to the growth and abundance of algal populations (Roman et al., 2011; Conley et al., 2009). Phosphorus likely enters the lagoon through high sediment loads delivered into Chia Lagoon from its catchment area via the inflowing rivers of Lifuliza, Likoa and Bambara (Bunderson et al., 2008). In addition, Chia Lagoon is shallow, allowing re-suspension of bottom sediments and associated nutrients to water column where they support algal growth. Shallow water bodies are relatively rich in nutrients, resulting in more phytoplankton growth and large amount of decaying organic material at the bottom (Hunter, 1970).

The implication of the findings in this study is that fish in Chia Lagoon thrive on a quantitatively and qualitatively enhanced food resource that ensures superior health, condition, flavor and taste of the fish. This is borne out by high energy content in the Chia Lagoon fish, as energy levels can be used as a measure of fish health and condition (McPherson et al., 2011; FAO, 2001; Craig et al., 1978). In addition, the high ash content implies that Lake Malawi fish are bonier than the meaty Chia Lagoon fish.

Conclusion

Chia Lagoon contains twice as much zooplankton as Lake Malawi thus, high primary productivity due to the abundance of soluble reactive phosphorus - a key nutrient for algae growth. The nutrient rich waters of Chia Lagoon probably explain the proximate composition of fish in the lagoon. It is concluded that the taste differences between the Tilapias of the two water bodies could be linked to type of food that are ingested by the fish.

Results in this study may provide new insight and knowledge especially regarding acceptance of fish that are raised in captivity (aquaculture) where most consumers suggest that pond raised fish has a muddy flavour and/or taste. Knowledge that nutrition and the type of plankton ingested by fish may affect the taste is therefore important so that fish farmers can properly manipulate the pond system to produce fish of the sought after consumer taste.

It is suggested that the effect of seasonal variability in type of food on proximate composition of fish should also be studied to establish a more comprehensive tropho-dynamic model of the two water bodies on a temporal scale.

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Author Contributions

Chrissie Banda authored this work as part of her undergraduate (BSc) research project at Mzuzu University, Department of Fisheries Science, and supervised by Dr. Fanuel Kapute. Other co-authors adequately provided valuable comments during the preparation of the manuscript.

Conflict of Interests

Authors have not declared any conflict of interests in this manuscript.

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