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A comparative study on growth, composition and sensory quality between farmed and wild Nile tilapia (*Oreochromis niloticus*)

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ABSTRACT

This study was conducted at Moi University, Kenya, to investigate the effect of fish diets on growth, chemical composition and organoleptic quality of farmed Nile tilapia (*Oreochromis niloticus*), and compared with wild tilapia from Lake Victoria. Fish were grown for six months in triplicates using three feeds: (i) maize bran, (ii) formulated diet containing maize bran, freshwater shrimp, soya bean and cotton seed cake and (iii) control without supplemental feed. Fish were weighed fortnightly, chemical composition was done monthly and sensory quality was carried out at the end of the experiment. There was significant difference ($P < 0.05$) in growth between fish fed on different diets. Fish fed on formulated diet recording the highest weight, while control fish had lowest weight. Diet had significant effect ($P < 0.05$) on the lipid content but no effect on the other constituents. Taste and texture of the cooked meat were significantly affected by diet type ($P < 0.05$), with wild tilapia being most preferred and maize bran fed fish being least preferred. This study shows that with proper diet formulation, acceptable composition quality, sensory characteristics and growth rate of farmed tilapia can be achieved without using expensive commercial feeds. Cheap, locally available fish feed is likely to increase uptake of fish farming, thus increasing protein sources for rural communities living far from fish sources such as lakes and seas.

Keywords: Aquaculture, Nile tilapia, fish feed, carcass quality, sensory quality.

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INTRODUCTION

Most developing countries are faced with major challenges of alleviating hunger and malnutrition, which affects about one fifth of the world population (FAO, 2000). Due to food-deficit, countries are faced with the major challenge of introducing and sustaining ways of increasing availability of safe and nutritious food, especially protein source. Kenya, being one of the developing countries is committed to provision of adequate nutrition for her people and meeting basic health needs (GoK, 1999). One way of doing this is the encouragement of fish consumption through development of aquaculture. Tilapia species are the most important of all aquaculture fish in the 21st century (Fitzsimmons and Filho, 2000) and it is widely distributed in Kenyan lakes and rivers (Okeyo, 2004). There are many species of tilapia, but Nile tilapia (*Oreochromis niloticus*) is among the most popular species due to its ability to cope with variable nutrition, environment, being cheap, disease resistance and requiring low technology in the farming systems. Tilapine species are mainly vegetarian and have a short maturity time of 7 to 8 months, and thus do not accumulate significant quantities of heavy metals such as mercury (Karuga, undated). About 96% of the wild fish caught in Kenya comes from inland water bodies with Lake Victoria contributing nearly 90% (Karuga and Abila, 2006; GoK, 2012). Kenya has about 420 km coastline in a straight line but up to 880 km when the landscape is taken into account. With the 200 nautical

miles exclusive economic zone, this translates into about 230,000 square kilometers of sea. However most of the fishing is performed by foreign vessels, which pay loyalties to the Kenyan Government, while the majority of Kenyan fishermen are small scale using un-motorized boats (GoK, 2012). The inland fish stocks are getting depleted due to overfishing (Gichuki, undated), thus making fish expensive and out of reach for poor families. Aquaculture, the farming of fish and other aquatic organisms offers a cost effective solutions of improving livelihood by increasing production of quality food and providing an avenue of an income generating activity (Fitzsimmons and Filho, 2000). Aquaculture contributes about 1% of Kenya's national fish output but the government is aggressively encouraging aquaculture through the Ministry of Fisheries Development (GoK, 2012). However, one of the greatest challenges in fish farming is the cost of fish feed. There is therefore need to develop cost effective fish feeds without compromising the growth rate and quality of the fish flesh.

Previous studies have shown that the composition of the fish carcass is not only genetically controlled, but that the type of diet affects significantly both the composition and sensory quality of the meat (Oliveira, 2002). Fish feeds formulated using agricultural by products is economically viable (Harvey et al., 2008; Liti et al., 2002).

Replacement of commercial fish meal with economically feasible agricultural by-products is being widely explored in aquaculture. Past research has revealed that total replacement of animal based feeds with plant-derived feeds has significant effect on growth performance of fish (Kaushik et al., 2004). Fish farming is a profitable business but the cost of fish feed has a significant negative effects on profitability (Ugwumba and Chukwuji, 2010). On-farm formulation of fish feed using locally available agricultural byproducts could therefore reduce costs of fish farming and increase profits.

This study was conducted to determine the effect of single source plant derived fish feed (maize bran) and formulated feed containing animal flesh (fresh water shrimp) on growth, composition and sensory quality of Nile tilapia.

MATERIALS AND METHODS

Study site

The study was carried at Chepkoilel University College Campus of Moi University. The campus is located near Eldoret town, Rift Valley province of Kenya at latitude 0° 30′ North and longitude 35° 15′ East and an altitude of 2180 m above sea level (Muui et al., 2007). The mean maximum temperature is 23°C and a mean minimum temperature is 10°C. The area experiences a bimodal rainfall pattern with maxima in April/May and July/August.

Fish diets and feeding

A six months study was conducted to raise Nile tilapia in triplicate in nine randomly assigned fertilized earthen ponds using three feeds treatments of: (a) maize bran, (b) on farm formulated diet containing 50% maize bran, 25% lake shrimp (*Caridina niloticus*), 12.5% soya bean and 12.5% cotton seed cake and (c) the control whereby the fish relied on natural food in the ponds. Fingerlings of the fish of mean weight of 2 g were stocked in the ponds and fed twice a day at 2% body weight.

Measurements

The fish were weighed on fortnight basis and proximate analysis was done on monthly basis. The fish was transported on ice to Egerton University, Dairy and Food Technology laboratory for sensory and chemical analyses. Moisture was determined using the oven drying method, protein content was determined using the micro-Kjeldahl method, lipid content determined by the Sohxlet extraction method and ash content determined by incinerating at 550°C as described by Nielsen (1994). Sensory quality of cooked fish was evaluated at the end of the six months by trained panelists using a 7 point hedonic scale. At the end of the feeding period, Tilapia species of comparable size to the experimental fish were caught from Lake Victoria and analyzed for chemical composition and sensory characteristics for comparison with the experimental fish.

Statistical analysis

Growth and proximate composition data was analysed using one-way ANOVA, while the non- parametric sensory quality data with Kruskal Wallis test ($P < 0.05$). Data was analyzed using Statistical Package for Social Science (SPSS) version 17. Treatment means were compared for significance of difference using the Duncan's multiple range test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The proximate composition of maize bran and formulated feed used as the diet for the fish in the experiment are shown in Table 1. Formulated feed had a protein content of 24.77%, which was significantly higher ($P < 0.05$) than maize bran feed, 11.76%. Lipid content for the formulated feed was 7.62, which was significantly higher ($P < 0.05$) than that of maize bran of 3.99%. There was no significant difference between the moisture, ash and fibre contents of the two diets (Table 1).

Fish growth

The growth rate as indicated by weight gain was similar for all the fish for the first month but fish fed on the formulated feed had a significantly higher growth rate towards the end of the six months, while the fish that received no supplemental feed had the lowest weight (Figure 1).

From this study, it is evident that Nile tilapia can be farmed with the correct diet formulations and proper husbandry to achieve the desirable size (150 to 250 g) within 6 months, with very minimal nutrition quality variation from those growing wildly from Lake Victoria.

Table 1. Proximate composition of maize bran and formulated feed (mean ± SE).

Type of feed	Moisture	Protein	Lipids	Ash	Fibre
Maize bran	10.13 ± 0.26	11.76 ± 0.19[a]	3.99 ± 0.17[a]	4.05 ± 0.17	12.28 ± 0.16
Formulated feed	8.85 ± 0.45	24.77 ± 0.26[b]	7.62 ± 0.25[b]	6.92 ± 0.25	13.30 ± 0.16

Means along the same column followed by similar superscripts or without superscripts are not significantly different ($P < 0.05$).

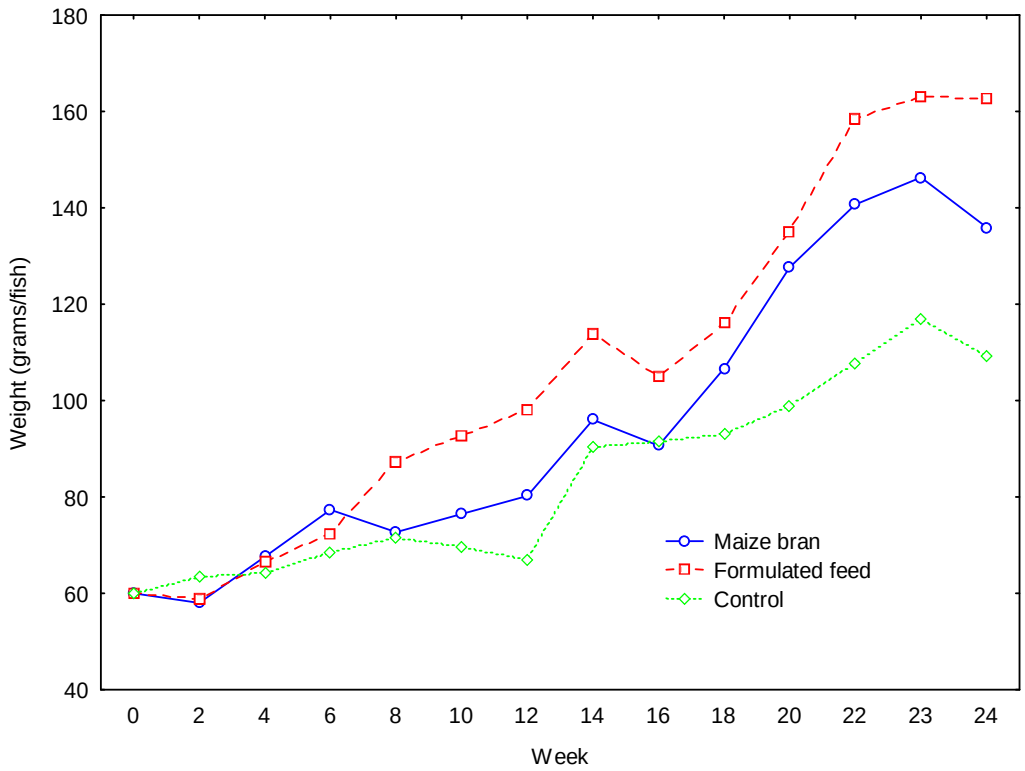

Figure 1. Growth rate of fish fed on different diets for 24 weeks.

The significantly higher weight in fish fed using animal protein and with higher protein content indicates that weight gain was depended on the feed formulation. These results are in agreement with the findings of Gomes et al. (1993) and Olvera-Novoa et al. (2002). Cowey (1993) concluded that there should be constant supply of bio-available dietary protein, digestible carbohydrate and micronutrients for optimum fish growth. Previous observations by Liti et al. (2002) using plant based wheat bran diet resulted in lower growth than animal based formulated feed. This observation is crucial in not only increasing food production but also in the utilization of agricultural by products that are otherwise under utilized in livestock feed formulation or burnt. Liti et al. (2002) also observed that supplementing with cereal bran was a cost effective feeding strategy for tilapia that had a great potential and increased profitability by up to 18%. Tilapia has also been successfully produced without supplemental feeding using primarily planktonic algae and to a lesser extent, zooplankton and drifting invertebrates as food source. The fish flesh had increased omega fatty acids (Tepe, 2005). Increased dietary protein content of fish feed has been reported to increase growth rate but to be negatively correlated to feed conversion ratio and body fat content of Nile tilapia (*Oreochromis niloticus*) (Al Hafeth, 1999).

Proximate composition of edible fish flesh

There was significant difference ($P < 0.05$) in lipids content of the fish fed on different diets at the end of the six months experiment. Fish fed on formulated feed and wild fish from Lake Victoria had significantly higher ($P < 0.05$) lipid content that those fed on maize bran only and control (Table 2). Fish fed on formulated diet had the highest lipid content throughout the experiment. The amount of lipid fluctuated throughout the experiment, but

Table 2. Proximate percentage composition of whole edible flesh of wild and farmed tilapia fed on different diets for 6 months (mean ± SE).

Treatment	Moisture	Protein	Lipid	Ash
Maize bran	77.25 ± 0.38	18.96 ± 0.37	1.67 ± 0.30[a]	1.41 ± 0.12
Formulated	77.52 ± 0.39	18.67 ± 0.31	3.26 ± 0.31[b]	1.31 ± 0.12
Control	78.21 ± 0.36	18.47 ± 0.34	1.49 ± 0.28[a]	1.38 ± 0.11
Wild	78.98 ± 1.05	17.71 ± 1.02	2.51 ± 0.84[b]	1.14 ± 0.32

Means along the same column followed by similar superscripts or without superscripts are not significantly different (P < 0.05).

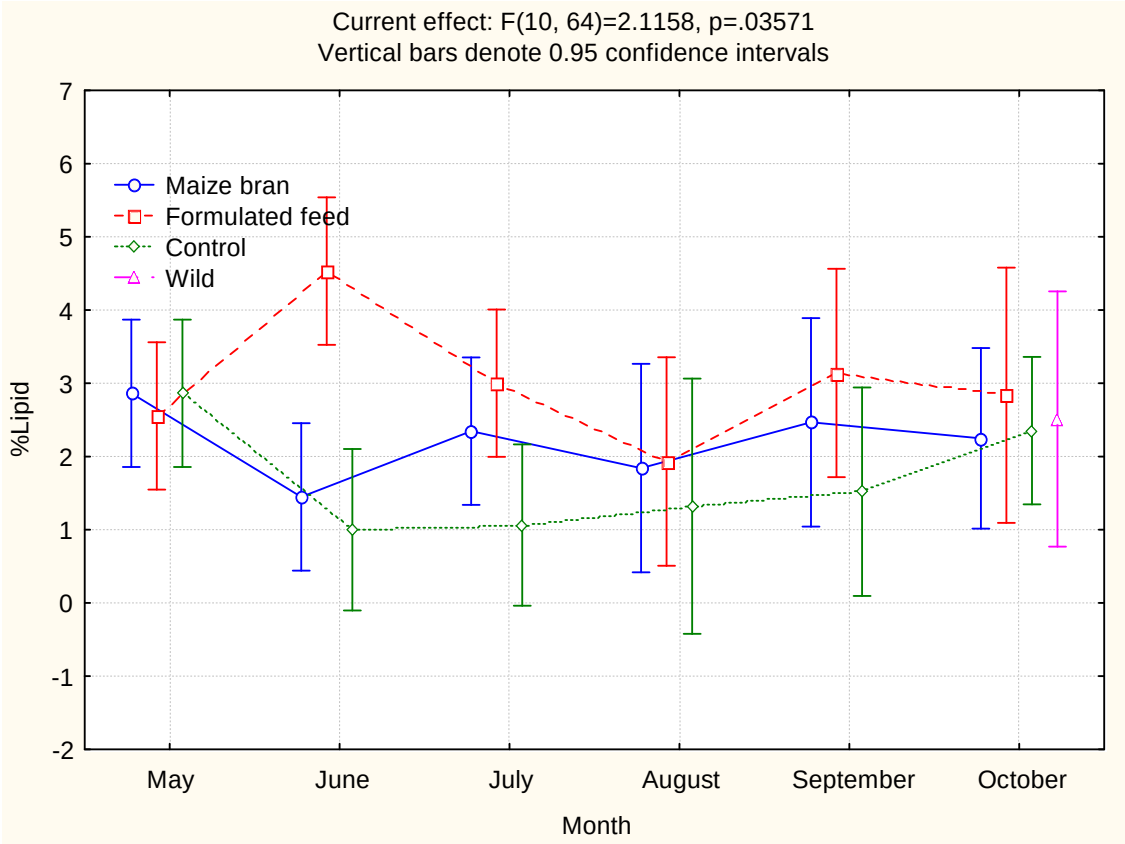

Figure 2. Lipid content of edible flesh of tilapia grown on different feeds over 6 months.

was highest between the 2nd and 3rd months (Figure 2). There was no significant difference in moisture, protein and ash contents of the fish fed on different diets.

Figure 2 shows variation in the lipid content over the six experimental months between the farmed fish. The greatest variation was seen at the first 2 months of growth.

Table 3 shows variation on composition on different edible parts of fish as is served in a normal family setup. Only the moisture and Lipid content of different anatomical parts of the fish showed significant difference (P < 0.05). The head had significantly higher lipid content than the middle and tail portions, while the middle portion had a higher moisture content than the tail portion (P < 0.05).

The study revealed that proximate composition of fish is dependent on composition of the feed. Hepher et al. (1983) observed that composition of fish meat is dependent on the composition of the feed, the season and environmental conditions. Oliver (2002) reported that the type of feed significantly affected the lipid content and fatty acids profile but not the overall proximate composition for the other constituents of sturgeon flesh. Moisture content decrease with time in the six months translates to better food value due to increase in dry matter content. According to Huss (1995), lipid content is

Table 3. Mean proximate percentage composition of different edible parts of fish (mean ± SE).

Fish part	Moisture	Protein	Lipid	Ash
Head	77.38 ± 0.31[ab]	18.97 ± 0.41	4.49 ± 0.34[a]	2.41 ± 0.34
Middle	78.36 ± 0.24[a]	18.55 ± 0.39	2.16 ± 0.34[b]	1.42 ± 0.31
Tail	76.82 ± 0.22[b]	18.30 ± 0.42	0.72 ± 0.29[b]	1.55 ± 0.36

Means along the same column followed by similar superscripts or without superscripts are not significantly different (P < 0.05).

Table 4. Mean sensory evaluation scores for cooked fish fed on different diets.

Sensory parameter	Type of diet			
	Control	Formulated	Maize bran	Wild fish
Texture	4.4[b]	5.5[a]	3.8[c]	5.6[a]
Taste	4.5[b]	5.3[a]	4.2[b]	5.9[a]
Smell	4.8	5.3	5.3	5.3
Appearance	5.5	5.5	5.4	5.5

Means along the same row followed by similar superscripts or without superscripts are not significantly different (P < 0.05).

seasonal and is highest in fish just before spawning. Further comparison on proximate composition of different parts of the fish anatomy showed that servings of fish in a meal have nutritional implication. The head is higher in fat content, which is a carrier for fat soluble vitamins such as vitamin A, than the other portions. Vitamin A is often deficient in the diets of many poor communities (WHO, 2012). Fish oils are also good sources of omega-3 fatty acids which have been reported to have health benefits (Washington State Department of Health, 2011).

Sensory characteristics

Table 4 shows the sensory score of taste, texture, appearance and smell of the cooked fish at the end of the 6 experimental months. Only the texture and taste of the cooked meat showed significant different (P < 0.05) between treatments. The score for texture of the wild fish was significantly higher (P < 0.05) than that of control and maize bran fed fish but was not different from that of formulated diet fed fish. Taste scores for fish fed on formulated diet were not different from the wild tilapia but were significantly higher (P < 0.05) than those of the control and fish fed on maize bran.

Fresh fish has a mild delicious taste and smell that is attributed by various volatile and non-volatile organic compounds (Grosch, 1996). The difference in texture and taste scores for the fish fed purely on plant based diet indicate that there is need to incorporate animal based diet in the fish feed if sensory attributes are to be re enhanced. According to Givens (2002), feeding fish with vegetable based diet produces a 'flat taste' to the cooked meat and over softens the texture that lead to oozing out. Since sensory panelist could not detect differences in organoleptic attributes between the cooked meat from fish fed on formulated fed from wild tilapia then farmed fish can be introduced to the market as a substitute for the indigenous wild catch without adversely affecting consumer acceptability. This can reduce the reliance on the wild catch, hence reducing over fishing and increasing fishermen's incomes that have been reported to be low in traditional fishing communities (Etim and Patrick, 2010).

CONCLUSION AND RECOMMEDATIONS

From this study, it was observed that the type of diet affected growth rate and composition farmed fish. However, the composition of farmed fish fed on formulated diet did not vary significantly from wild stock from Lake Victoria; hence proper formulation of fish diet has direct bearing on the sensory quality of the cooked meat. More research on the diet formulations that could optimize on growth rate, with minimal change on nutritional and sensory quality, need to be done.

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