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RESEARCH PAPER

Assessment of the Proximate Composition of Tilapia Produced in Aquaponics System

Md. Tarequr Rahman[1], Kanij Rukshana Sumi[1*], Md. Rushna Alam[1] and Md. Roman Akon[2]

[1]Deaprtment of Aquaculture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.
[2]Deaprtment of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.

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*Corresponding author:
krsumi@pstu.ac.bd

ABSTRACT

An experiment was conducted to evaluate the proximate composition of *O. niloticus* under different aquaponics system in the Germplasm Center of Patuakhali Science and Technology University (PSTU), Bangladesh. Three different treatments were used with triplicates which designed with no bedding substrate (as a control), biochar based substrate and brick based substrate in T_1, T_2 and T_3, respectively. The results of proximate composition of the *O. niloticus* from no bedding substrate (control system), biochar based aquaponics system and brick based aquaponics system showed that the moisture content was within the range of 65.38–78.65 with the lowest value in T_2. The protein contents of *O. niloticus* were comparable among three treatments ranging from 14.34–18.56% and significantly higher ($p<0.05$) protein content was found in T_2, where biochar was used as a substrate. The fat content was the highest in T_2 (4.43%) while in T_1 and $T_{3,}$ it was 1.43 and 2.39%, respectively. Ash contents were 2.71, 1.32 and 3.77% in the T_1, T_2 and T_3, respectively. The results showed that *O. niloticus* from three different treatments had considerable content of nutrients. It can be concluded that the proximate composition of *O. niloticus* is slightly better in T_2 where biochar was used as a substrate for vegetable cultivation.

Key words: Proximate composition, *O. niloticus*, aquaponics

Introduction

For sustainable food production aquaponics is an ecologically responsive system (Salam *et al.* 2014). The growing concern of water pollution have raised the attention of people of developed countries for aquaponics system as an alternate choice for removing aquaculture wastes through the production of high-value vegetables (Rakocy *et al.* 2006, Diver 2006). In this system the wastes from one biological system serve as a nutrients for another in a symbiotic relation. The integration of fish and vegetable production increases the diversity and yields multiple products and water is reused through the process (Rakocy *et al.* 2006). Aquaponics technique is one of the valuable ways of using aquaculture site for the production of vegetables also and that may help to overcome the increasing nutrition demand of Bangladesh (Roy *et al.* 2013). With this system, water and nutrients can be reused maximally and environmental friendly manner and simultaneously producing two cash corps (Diver 2006, Tyson *et al.* 2011).

Tilapia, trout, perch and bass are adjusted to recirculating aquaculture systems among several warm water and cold water fish species (Diver 2006). In Bangladesh, most of the commercial aquaponic systems are centered on tilapia (Salam *et al.* 2014, Azad 2015, Bethe 2014) because it can tolerate a wide range of environmental conditions such as salinity, temperature, low dissolved oxygen levels and high ammonia concentrations (Bishop *et al.* 2009, Johanson 2009, Boyd 1990). While growing fishes in a system it produces nitrogenous compound mainly ammonia which is hazardous to fish, even in small quantities and toxicity increases in relation to pH and temperature in the water column. On the other hand, nitrosomonas bacteria break down ammonia to nitric oxide (NO) and nitrobacter convert the nitrite into nitrate which is food for the plants (Liang & Chien 2013). By contrast, NO is less harmful to fish. Eutrophication and other environmental problems could be resulted from untreated water containing ammonia discharged into the ecosystem (Hu *et al.* 2015).

Knowledge of the proximate composition of fishes is essential to estimate their energy value and to plan the most appropriate industrial and commercial processing (Hanna 1980). Generally, composition of whole fish on live-weight basis is 70 to 80% water, 20 to 30% protein, and 2 to 12% lipid (Das and Sahu 2001). However, in different environmental conditions, the composition of the fish may differ in relation to the differences in water quality, feeding conditions, sex, and state of maturity and capture condition (Brett *et al.* 1969, Craig *et al.* 1989, Javaid *et al.* 1992, Oliveira *et al.* 2003). Fish muscle is rich in protein, unsaturated fatty acids and mineral elements (Zhao *et al.* 2010, Ana *et al.* 2010). Now-a-days consumers have requirements of the nutritional variations in several fish species from different environments (Okonji & Afegbua 2004) mainly same fish species from different habitats. The proximate composition analysis of tilapia has been performed in different growth studies. However, there is no available information on the nutrient composition of tilapia produced in aquaponics systems using the various substrates. Therefore, considering the importance of the aquaponics system, this study was designed to assess the proximate composition of *O. niloticus* from the aquaponics system and to investigate the effect of the different substrates of the aquaponics system on the nutritional content of the fish body.

Materials and Methods

Experimental site and design

The experiment was conducted for a period of three months from 1 October to 30 December 2019 in the Germplasm Center of Patuakhali Science and Technology University (PSTU), Bangladesh. The experiment was designed into three treatments (50 fish per tank for T_1, T_2, and T_3) with triplicate (Table 1).

Table 1: The experimental design with three treatments

Treatments	Treatment description	Vegetable cultivation
T_1	No use of effluent treatment but aeration	No
T_2	Activated carbon-based (biochar) filter and aeration with combination with aquaponices	Yes, where biochar was used as substrate for vegetable production
T_3	Aquaponices and aeration	Yes, where brick dust was used as substrate for vegetable production*

*Brick dust assumed as inert materials which might have no effect on effluent filtratation.

Preparation of experimental system

Nine (9) water tanks each having a capacity of 500 L were used as experimental tank. Tap water was used as a source of water supply in the tank. The tanks were supplied dissolved oxygen with aerators in order to keep the dissolved oxygen level near to saturation. In case of treatment T_2 and T_3, the vegetable growing trays were filled with activated carbon-based (biochar) filter and brick dust as a substrate for vegetable production, respectively. Water pumps were used for elevating water from tank to tray. Treatment 1 was used as a control where no effluent treatment was performed.

Fish collection and stocking

Tilapia (*O. niloticus*) fingerlings were used as experimental fish. The tilapia fingerlings were collected from Chanchal Matchya Hatchery, Bauphal, Patuakhali, Bangladesh. After acclimatizing, the fingerlings were stocked in the rearing tank at a rate of 50 fish per tank. Floating pellets from Quality Feed limited, Bangladesh were fed twice a day up to satiation.

Sample preparation

At the end of 3 months of rearing period, eighteen (18) fish samples (2 fish of each tank) from different treatments were used for this experiment. The samples were taken in ice cold box to the laboratory where they were weighed, measured, and kept at −20°C until further analysis. All the samples of fish were washed thoroughly, and the fillets were taken for determination of the proximate composition.

Proximate Composition Analysis

The proximate composition of fish was determined at Fish Pathology and Nutrition Laboratory in the Department of Aquaculture, PSTU according to standard method given by the Association of Official Analytical Chemists (AOAC 2000).

Moisture Content

At first, the initial weight of the samples was taken. Then samples were dried in an oven at about 105°C for about 8 to 10 hours until a constant weight was reached and cooled in a desiccator and weighed again. Then the samples were minced in an electric grinder. The percentage of moisture content was calculated by the following equation:

Percentage (%) of moisture = (Weight loses/Original weight of sample) × 100

Protein Content

The protein content of the fish was determined by micro-kjeldahl method. It involves conversion of organic nitrogen to ammonium sulphate by digestion with concentrated sulphuric acid in a micro kjeldahl flask. The digest was diluted, made alkaline with sodium hydroxide and distilled. The liberated ammonia was collected in a boric acid solution and was determined. The percentage of protien in the sample was calculated by the following equation:

Percentage (%) of protein = (c-b) × 14 × d × 6.25/a × 1000 × 100

Where,

a = sample weight (g)

b = volume of NaOH required for back titration and neutralize 25 ml of 0.1 N H_2SO_4 (for sample)

c = volume of NaOH required for back titration and neutralize 25 ml of 0.1 N H_2SO_4 (for blank)

d = normality of NaOH used for titration

6.25 = conversion factor of N to protien

14 = atomic weight of N

Lipid Content

For the estimation of fat content, the dried samples left after moisture determination were finely grinded and the fat was extracted with a nonpolar solvent, ethyl ether. After extraction, the solvent was evaporated and the extracted materials were weighed. The percentage of fat content was calculated as:

Percentage (%) of fat = (Weight of extract/Weight of sample) × 100

Ash Content

The ash content of a sample is the residue left after ashing in a muffle furnace at about 550–600°C till the residue become white. The percent of ash was calculated as follows:

Percentage (%) of ash = (Weight of ash / Weight of sample) × 100

Statistical Analysis

The statistical analysis was performed using SPSS (version 12.0.1) software. The data was presented in the form of means and standard deviation for moisture, protein, lipid and ash of *O. niloticus* fish from different treatments of aquaponics system. The results for the proximate composition were analyzed using one-way analysis of variance (ANOVA). Tukey test was used to observe significant differences between treatments. The significance level used for all the tests was at 95% (p<0.05).

Results and Discussion

In this experiment, *O. niloticus* were analyzed for the proximate composition under different aquaponics system. These species were chosen because of fast growth rate, adaptability to a wide range of environmental variables, disease resistant and high flesh quality. They have the ability to reproduce under varying culture conditions and readily convert food low in plant protein to high quality flesh (El-Sayed 2006).

Table 2: Proximate composition of *O. niloticus* in different aquaponics system (Mean ± SD)

Treatments	Moisture	Protein	Lipid	Ash
T_1	75.51 ± 0.24^a	14.34 ± 0.16^b	1.43 ± 0.24^b	2.71 ± 0.27^b
T_2	65.38 ± 0.23^b	18.56 ± 0.22^a	4.43 ± 0.23^a	1.32 ± 0.29^b
T_3	78.65 ± 0.14^a	16.67 ± 0.23^b	2.39 ± 0.13^b	3.77 ± 0.13^a

Table 2 indicates proximate composition of *O. niloticus* in different aquaponics system. The results show that moisture content of *O. niloticus* was significantly lower in T_2 than the other two treatments (p<0.05). However, protein and lipid content of *O. niloticus* were significantly higher in T_2 compared to T_1 and T_3 (p<0.05). Ash content of O. *niloticus* was significantly higher in T_3 compared to T_1 and T_2.

Moisture

In this study, moisture was the highest element in *O. niloticus* under different treatments consisting more than 60% of wet weight. In the present experiment, the average moisture contents of *O. niloticus* were 75.51±0.24, 65.38±0.23 and 78.65±0.14 in T_1, T_2 and T_3, respectively. The highest moisture content was found in T_3 followed by T_1 and T_2 (Table 2). This results indicating that the percentage moisture in fish muscles was within the acceptable level. The level of moisture in *O. niloticus* in T_3 (brick-based aquaponics) was found to be statistically higher than that of T_2 (biochar) and T_1 (control) (p<0.05) in the present experiment. It is highest in brick based aquaponics system, followed by control, and lowest in the biochar based aquaponics system. Furthermore, the values of different aquaponics system are statistically (p<0.05) different.

Protein

The protein content was estimated as 14.34±0.16, 18.56±0.22, and 16.67±0.23 in T_1, T_2 and $T_{2,}$ respectively (Table 2). The highest value was found in T_2 and lowest value recorded in T_1. Table 2 states that the variation of protein contents among the studied fish is not so high and it ranged from 14.34±0.16 to 18.56±0.22. Significant differences (p<0.05) in protein content were observed among the three different treatments. The most probable reason for the differences of protein observed in fish from the three treatments was effluents from different bed of vegetable. That, in turn, biochar caused higher amounts of nutrients in the waters. The relatively high to moderate proportion of protein may be attributed to the fact that fishes are good source of pure protein, but the differences observed in values obtained could also be as a result of fish consumption or absorption capability and conversion potentials of essential nutrients from their diets. This variation may be occurred due to water recirculation that contain nutrient loading from bed (bricks, biochar) in aquaponics system.

Lipid

The average lipid content of fish under different treatments varied from 1.43±0.24 to 4.43±0.23 (Table 2). The highest lipid content (4.43±0.23) was recorded in T_2 whereas the lowest lipid content (1.43±0.24) was recorded in T_1 (Table 2). The average values of lipid under different treatments were varied significantly (Table 2). Lipids are an alternative energy source in times of fasting and starvation (Marqueze *et al.* 2018). Treatment T_2 had the highest fat content 4.43±0.23 and T_1 had the least 1.43±0.24 (Table 2). Kamler *et al.* (2001) reported that lipid in fish is derived from diet and its biosynthesis. Fat varies to a greater extent compared to other proximate component of fish and it reflects the differences in the way fat is stored in species (Ababouch 2005). Therefore, it can be suggested that water recirculation from biochar bed bring more nutrition and food for *O. niloticus.*

Ash

The average ash content under three different treatments varied from 1.32±0.29 to 3.77±0.13 (Table 2). The highest ash content (3.77±0.13) of fish sample were recorded in T_3 whereas the minimum ash content (1.32±0.29) was recorded in T_2 (Table 2). The average values of ash under different treatments were different from each other. Ash measures the mineral content in an organism. It is the inorganic remnant of burnt organic matter. The level of ash content of *O. niloticus* in brick based treatment (3.77±0.13) was found significantly (p<0.05) higher than that of samples of control system and biochar based treatment with the value of 2.71±0.27 and 1.32±0.29, respectively. The variations of ash content were observed may be due to presence of bone element in tilapia fish. The results in Table 2 showed ash content in the three treatments in the order $T_3 > T_1 > T_2$. The observed range of ash content from the three different treatments indicates that the species is a good source of minerals.

Variation of biochemical composition of fish flesh may also occur within same species (*O. niloticus)* depending upon the different bedding substrate (brick, biochar), age and size of the individual. The ranges of values of the proximate composition of the *O. niloticus* from the T_2 were slightly different from T_1 and T_3.

It can be concluded that the proximate composition of *O. niloticus* was slightly better in T_2 where biochar was used as a substrate for vegetable cultivation. Because biochar represents a low-cost renewable filtration media in aquaponics. Biochar clarifies fish effluent through removal of suspended particles and turbidity (Khiari *et al.* 2020). However, the nutritional potential of *O. niloticus* from different aquaponics systems was within the nutritional range required by humans.

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