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Evaluation of water hyacinth (*Eichhornia crassipes*) as a phytogenic diet for Nile tilapia (*Oreochromis niloticus*)

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Abstract
Water Hyacinth (Eichhornia crassipes) was cited among the major invasive plants currently threatening aquatic biodiversity in many parts of the world including Ethiopian freshwater lakes like Tana, Koka, and others which calls for an effective solution. Conversely, the replacement of fishmeal with locally available and cheaper plant feedstuffs is proved to be very essential for sustainable aquaculture. This study was conducted to assess the possibility of changing Water hyacinth collected from Lake Koka during January 2019 as fish feed. After analysis for its proximate composition, water hyacinth was mixed with fish meal, nug cake and wheat bran at 15%, 30%, 45% and 0% for treatment one, treatment two, treatment three and control group with equal isonitrogenous and isocaloric value of 32.2%CP and 376kcal GE/100g for each treatment. The feeding experiment was conducted in twelve plastic tanks of 60-liter capacity each stocked with 25 Nile tilapia fingerlings. The fish were fed three times per day at 5% of body weight. After termination of the experiment, results from one way ANOVA showed no significant difference in weight (P=0.69), length (P=0.96) and Fulton's condition factor (P=1.65) among treatment fish as compared to control group. By using 15%, 30% and 45% fermented WH, 9 % wheat bran, 14% wheat bran and 14% wheat bran with 17% nug cake can be replaced as in T1, T 2 and T 3 respectively. However, based on the value of Fulton's condition Factor and relative growth rate observed among treatments, 15%, and 30% WH were better than 45% WH.

Keywords: Fish feed, tilapia growth, physico-chemical parameters, water hyacinth

1. Introduction

Aquaculture (aquatic agriculture) is the fastest-growing food-producing sector in the world, which is constrained among other things by regular feed supply. Tilapia is the second most important farmed fish group in the world, only surpassed by carps. Tilapia culture is being practiced in most of the tropical, subtropical and temperate regions, and has received great attention in recent years (El-sayed, 2003) [11]. With the rapid growth in the aquaculture sector in recent years, the demand for quality fish feed is continuously increasing. Thus, providing quality fish feed has become the prime aim of every aqua culturist (Dorothy *et al*., 2018) [9]. The fish feed used in aquaculture is quite expensive, irregular and short in supply in many third world countries due to the unavailability of fish feed supplying organizations (Bag *et al*., 2011) [6].

Research in fish nutrition that will utilize locally available (alternative low-cost feed) ingredients of plant protein sources and fabricated equipment without reducing the quality of the feed is urgent and crucial to the overall success of aquaculture development, growth and expansion in Africa (Sulieman and Lado, 2011; Zenebe Tadesse *et al*.,2012) [29, 31]. One of the materials that could potentially be used as feed ingredients is water hyacinth (Zaman *et al*., 2017) [30].

Water hyacinth has become a major invasive alien weed invading different water bodies in Ethiopia posing a serious threat to the country's aquatic biodiversity which calls for urgent solution (Dereje Tewabe, 2015; Derje Tewabe *et al* 2017; Ferihun Yirefu, 2007; Ferihun Yirefu, 2013; Ferihun Yirefu *et al*., 2017) [7, 8, 13-15]. In the meantime, aquaculture is becoming the fastest food-producing sector in the world constrained by the absence of quality feed supply on regular basis at affordable prices (Zenebe Tadesse *et al*., 2012) [31]. Aquaculture is being developed in Ethiopia as far as it has the critical role of nutritional security for the rapidly growing population, income generation, job creation and lower production cost.

But the culture of fish in a confined environment is being challenged by limitation of fish feed. Thus, this study is an attempt to assess the possibility of converting water hyacinth to fish feed as part of solving the pressure on aquatic biodiversity and feed constraint in the aquaculture sector which is a kind of killing two birds with the same stone.

1.1 Objectives

- To determine the chemical composition of water hyacinth collected from Lake Koka
- To test the growth response of Nile tilapia fingerlings to different levels of feed formulated from water hyacinth collected from Lake Koka at Batu

2. Materials and Methods

2.1 Description of the study area

This research activity was conducted at Batu Fish and Other Aquatic Life Research Center. Batu is located in Oromia regional state East shewa zone Adami Tulu Jido Kombolcha district at 7.9180N and 38.727^{0}E and an altitude of 1650m.a.s.l. Batu Fish is 163 km and south from Addis Ababa. Batu Fishery is situated in Batu town onshore of Lake Zeway within the Ethiopian Rift Valley system which is characterized by arid agro-ecology.

2.2 Sample collection

2.2.1 Ingredients of fish feed

Water hyacinth was collected from Lake Koka while nug cake, molasses, iodized salt, vitamins and wheat bran were collected from the local market. Fish offal was obtained from fishery cooperatives around Hara Danbal (Lake Denbel) of ziway/Batu.

2.2.2 Experimental fish

Three hundred similar size Nile Tilapia finger lings were collected from Batu Fishery and Other Aquatic Life Research Center and transferred to experimental tanks at laboratory condition. The size of fingerlings used for this experiment was 6.4 ± 1.03 cm and 4.6 ± 2.36 g on average.

2.3 Procedures for fish feed formulation

2.3.1 Fish feed formulation from water hyacinth leaf

After collection and transportation to Batu Fish and Other Aquatic Life Research Center, Water hyacinth leaf was processed as shown in (Fig 1). WH leaf was fermented using molasses for one month to increase its palatability for the fish as a plant protein source is full of cellulose which is difficult for tilapia to digest because tilapia lacks cellulase enzyme. Ortho-phosphoric acid (H_3PO_4) was added to WH going to be fermented to reduce fungal contamination during the fermentation process.

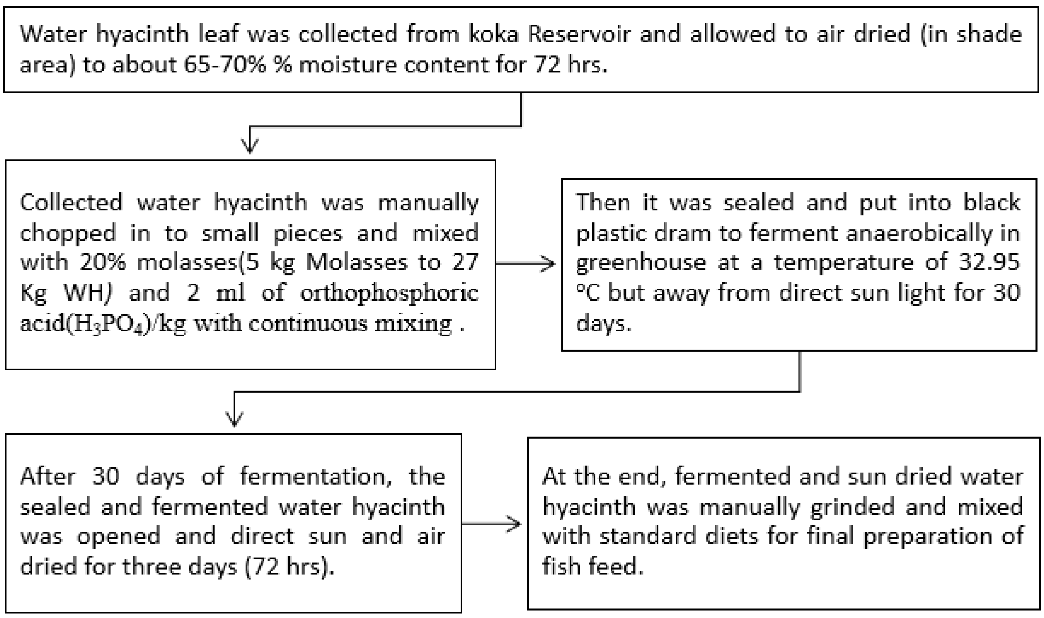

Fig 1: Flow chart of water hyacinth processing for fish feed.

2.3.2 Fish meal preparation from fish offal

After collection from fishery coopirates of Hara Denbel of Ziway/ Batu, fish meal was processed from fish offal and bones.

Raw material collection and transportation: 80 kg fresh Nile tilapia offal and wastes were collected from Batu fisher men-cooperatives and transported to Batu Fishery and Other Aquatic Life Research Center for processing.

Cooking: The fresh fish offal was traditionally-cooked-until the flesh opaque and separates to about 95 °C -100 °C for about 30 minutes (FAO,1986) [12]. In this step, oil from fat deposits and moisture content librated and un-wanted materials are also sterilized.

Pressing: In this stage, all liquid parts were removed from previosly cooked fish offal and wastes so that many moisture contents were lost here.

Drying: In this step, the pressed fish offal and wastes (typically Nile tilapia offal and wastes) were sun and air-dried for 4 days to remove the moisture content left during pressing so that it be-come ready for grinding.

Grinding, packing and Storing: In this step, the sun-dried fish offal and bones was ground by using a grinding machine, mixed with other ingredients based on treatment set up, packed and then finally stored to use as fish feed.

2.3.3 Formulation of fish feed from NUG cake and wheat bran.

Nug cake and wheat bran were purchased from the local market and then ground both by manual and machine and then prepared for analysis which was used as fish feed.

2.3.4 Final preparation of fish feed from all ingredients

To prepare final fish feed, a total of 3kg feed was formulated for each treatments as indicated in Table 1 below.

Table 1: Proportion of experimental diets for treatment fish.

No	Feed ingredients	T1	T2	T3	Control
1	Water Hyacinth	15%	30%	45%	0%
2	Wheat bran	24%	10%	10%	40%
3	Nug cake	31%	33%	14%	30%
4	Fish offal	27%	24%	28%	27%
5	Additive (Vitamins and mineral)	1.5%	1.5%	1.5%	1.5%
6	Additive (Iodized salt)	1.5%	1.5%	1.5%	1.5%

Note: T=Stands for treatment with the corresponding number.

Experimental design for treatment fish

Three hundred (300) similar age fingerlings of Nile tilapia were collected from hatchery ponds of Batu Fish and Other Aquatic Life Research Center and transferred to experimental tanks at laboratory conditions for a period of sixty (60) days in water circulation culture system. The average size of fingerlings used for this experiment was 6.4 ± 1.03cm with an average weight of 4.6 ± 2.36gm. The experimental fingerlings were fed water hyacinth based-feed and standard fish feed used in the research center according to assigned treatments. Accordingly, the feed was iso-nitrogenous and is calorific with values of 32.13 ± 0.3 crude protein and 376 kcal/100g for protein and energy, respectively for each treatment. The feeding frequency was three times per day at 5% of body weight throughout the experimental period. Accordingly, there were four treatments with replica where-by one treatment consists of twenty-five (25) fingerlings each throughout the experimental period in culture tank of similar size having 60-liter water capacity.

2.5 Experimental set up/system

Previously established twelve plastic tanks (12) of size 60-liter were used for this experiment. Refer to the design of (Akewake Geremew, 2015) [3]. Each tank was filled with dechlorinated tap water. To maintain water temperature, the heater was adjusted to 30 ^{0}C at the point where water collected in the tank of the circulation system so that the water was equally distributed by the motor pump to all experimental tanks. Additionally, the circulation system was filled with biofiliter so that it traps the ammonia waste coming from experimental tanks there-by changing the ammonia waste to nitrate which is a non-hazardous one. Accordingly, about 200 liters of water was removed with fish feces and other wastes like left-over feed once in three days and an equal amount of water was replaced to maintain the stability of the circulation system throughout the experimental period for 60 days. By this method, free and clean water was circulated through the system.

2.6 Sampling technique

The whole fish was sampled during data collection to increase the accuracy of the experiment throughout the experimental period due to the short duration of the experiment.

2.7 Laboratory work

2.7.1 Fish feed: Proximate composition of feed ingredients was analyzed according to the Association of Official Analytical Chemists (AOAC, 2005) [4, 5].

2.7.2 Estimation of total carbohydrate

The percentage of carbohydrate was calculated using the formula: 100-(percentage of ash + percentage of moisture + percentage of fat + percentage of protein) (Indrayan, *et al*., 2005) [18].

2.7.3 Estimation of Gross Energy

Nutritive value of the sample was determined by multiplying the values obtained for protein, fat, and carbohydrate by 4.00, 9.00 and 4.00, respectively and adding up the values (Indrayan *et al*., 2005) [18].

The water quality of the circulation system used to grow experimental fish was

[illegible]

A. B.

Fig 2: Fresh-water master test kit (A) and monitory for pH, NH_3^+/NH_4^+, NO_2^- and NO_3^-(B).

2.8 Data collection
2.8.1 Experimental fish
Weight gain and length data of the fish were collected at stocking time and at 15 days intervals throughout the experimental period as shown in (fig 3) below.

Fig 3: Fish sampling for their total weight (A) and total length (B).

2.9 Data analysis
The difference in weight, Length and condition factor of fish in different treatment groups were analyzed using one-way ANOVA using SPSS version 20. Duncan's multiple range test was applied to compare between means of final total weight, final total length and condition factor of fish. Differences were considered significant at $p < 0.05$. Accordingly, growth performances of fish were determined in terms of final individual weight (g). Survival rate (%), daily growth rates (DGR) and Fulton's condition factor (FCF) were also computed in the experimental study. Growth parameters of the fish were calculated according to the standard equation given by Adebayo *et al*. (2004) [2].
Accordingly: Daily growth rate of fish was calculated as (DGR) (g/day) = Final weight (g) – Initial weight (g)/culture period, Weight gain of fish in (g) was calculated as = Final weight (g) – Initial weight (g) and survival rate (%) = (Number of fish harvested/Number of fish stocked) x100.Fulton's Condition Factor (FCF) is calculated as = TW/TL3*100, where TW is final total body weight in g, TL final total length in cm.
The water quality of the circulation system was described in terms of descriptive statistics, tables and figures.

3. Results and Discussions
3.1 Proximate composition of fish feed
The analyzed proximate composition of fish feed is shown in Table 2. The dry matter proximate composition of formulated fish meal has mainly consisted of crude protein (54.2%), the ash content of (26.52%), the crude fat content of (12.3%), moisture content (6.69%) and a very little amount of carbohydrate (0.29%). When compared with previous work, the protein content of Nile tilapia meal is greater than a value reported by Abera Degebassa *et al*. (2008) [1] with a value of 50.77% and Kassahun Asaminew (2012) [20] with a value of 503 g/kg of dry matter which is compatible with 50.3 %. The variation in crude protein content of fish meal formulated from tilapia offal might be the difference in nutrient concentration of Ziway Lake from where tilapia offal collected as compared to the year 2008 and 2012 which indirectly affects the chemical composition of fish offal as tilapias relay on planktons grown by available nutrients in the lake.
However, the current value of crude protein formulated from tilapia was less than a value recorded by Akewake Geremew (2015) [3] with a value of 610 g/kg of dry matter which is also equivalent with 61% of cp. This great difference may be due to different fish meal processing system used. From the current processing method, there may be a loss of protein during the pressing time in the form of liquid. On the other hand, Akewake Geremew (2015) [3] used the oven to dry offal and wastes which may not generate a liquid as compared to the current processing system.
Nug cake was used as a protein source and its proximate composition has mainly consisted of carbohydrates and protein with values of 41.51% and 32.21%, respectively. The crude fiber was 24.6% and 14.64% of crude lipid followed by ash content with the value of 8.09 and moisture content with the least value of 3.55%.
When compared with previous work, the current protein content value of nug cake was similar with a value recorded by Kassahun Asaminew (2012) [20] with a value of 331g/kg of dry matter which is equivalent to 33.1% and a value recorded by Akewake Geremew (2015) [3] with a value of 324.2 g/kg of dry matter which is equivalent to 32.42%.
Wheat bran was used as a carbohydrate source in fish feed formulation. The proximate composition of wheat bran has mainly consisted of carbohydrates with a value of 70.88%. Another composition of wheat bran was crude protein 15.73%, crude fiber 13.4%, 5.17% moisture, 4.23% ash and 3.99% crude lipid. The current protein content value of wheat bran was slightly less than a value recorded by Kassahun Asaminew (2012) [20] with a value of 185g/kg of dry matter which is equivalent to 18.5% Water hyacinth was added to fish feed as a carbohydrate source like that of wheat bran. The proximate composition of WH consisted of carbohydrates with 63.56% followed by crude protein (19.57%), crude fiber (16.66%), ash content of (12.46%), moisture content (2.75%) and crude fat of (1.66%).
When compared with previous work, the protein content of WH was 21.1 % for fresh dry, 19.8 % for Molasses fermented, 18.2 % for rumen fermented and 18.1 % for yeast fermented as of El-Sayed (2003) [11] which was almost similar with the current value. On the other hand, the current protein content of WH was greater than a value recorded by Saha and Ray (2011) [26] with different method fermented values of protein as 13.37% for row WH leaf, 14.44% WH leaf meal fermented by *B. megaterium* CI3 and 16.88% WH leaf meal by *B. subtilis* CY5 + LAB. However, the value was less than a report made by Jubie *et al*. (2015) [19] and Stolu and Sule

(2011) [27] with a value of 223.5g/kg of dry matter which is equal to 22.35% crude protein and 28.20%, respectively.
According to Mako *et al*. (2011) [22], the composition of the plant is very variable as protein and the mineral content are extremely dependent on the composition of the water in which the plants are grown. According to this explanation, "the protein and phosphorus content in the plant is directly correlated to the nutrient loading rate of the water".

Table 2: Proximate composition of feed-stuff used as feed for Nile Tilapia fingerlings.

Ingredients	Proximate composition of feed-stuff (%)						
	CP	**CF**	**Moisture**	**Ash**	**Fiber**	**Carbohydrate**	**Gross Energy(kcal/100g)**
Water H.	19.57	1.66	2.75	12.46	16.66	63.56	347.46
Fish meal	54.2	12.3	6.69	26.52	0.3	0.29	328.66
Wheat bran	15.73	3.99	5.17	4.23	13.4	70.88	382.35
Nug cake	32.21	14.64	3.55	8.09	24.6	41.51	426.64

Note: CP is Crude protein and CF crude fat

3.2 Growth response of fish fed on the different proportions of WH mixed feeds.

From the current study, the mean value of fish weight and length after feed treatment of 60 experimental days were given in (Table 3). The highest mean weight value was attained at Control group WH free feed followed by T1, T2 and the least mean weight value recorded at T3. Inclusion of fermented WH in diets of Nile tilapia has no significant impact on tilapia growth both in terms of total weight and total length and there was almost similar growth trend observed in all treatments ($p>0.05$).
Even though statistically they were not different, there was slight mean variation with values of 8.52±1.96 g and 8.21 ± 0.59cm for T1 with inclusion of 15% WH, 8.45 ±1.94 g and 8.3 ±1.25cm for T2 with inclusion of 30% WH, 8.30 ±1.84 g and 8.22 ±0.67 cm for T3 with inclusion of 45%WH, 8.68 ±1.85 g and 8.26 ±0.6 cm for control group without WH.
From the values mentioned above, fish fed without WH inclusion grew more than fish fed WH included feed. The second and third higher mean value of weight was recorded at T1 and T2 with the lowest to low inclusion level of WH. The least weight value was recorded at T3 with the highest inclusion level of WH. According to Zaman *et al*. (2017) [30], "the ability of fish to digest the feed highly depends on the completeness of the digestive organs and the availability of digestive enzymes; the enzyme activity of tilapia declined with high use of *E. crassipes* in the feed".
The daily growth rate of all treatment was almost the same ranged from the least value (0.06 g/day) for T3 to the highest value (0.068 g/day) for control group Table 3. The survival rate was also similar among all treatments throughout the experimental period (Table3).

Table 3: Growth performance and survival rate of Nile Tilapia under different proportions of WH mixed feed.

Parameters	T1	T2	T3	Control
Initial weight(g)	4.6±2.36	4.6±2.36	4.6±2.36	4.6±2.36
Final weight(g)	8.52±1.96^{ab}	8.45 ±1.94^{ab}	8.30 ±1.84^{ab}	8.68 ±1.85^{ab}
Initial length(cm)	6.4± 1.03	6.4± 1.03	6.4± 1.03	6.4± 1.03
Final Length(cm)	8.21 ± 0.59^{ab}	8.3 ±1.25^{ab}	8.22 ±0.67^{ab}	8.26 ±0.6^{ab}
Weight gain(g)	3.92	3.85	3.62	4.08
DGR(g/day)	0.065	0.064	0.06	0.068
Survival rate (%)	84	83	84	83

Note: T1, T2, and T3 stand for treatment number, g=gram, cm=centimeter; DGR= Daily growth rate. Values with the same superscript are not significantly different.

Growth of Nile Tilapia fingerlings supplied with different proportions of WH incorporated feed is shown in (Fig 4 A and B). The rate of growth of fish was varied from the first four weeks to the next four weeks. The Nile Tilapia fingerlings grew slowly (from February 23 - March 25, 2019) during the first 4 weeks and grew rapidly the following four weeks (from March 26- April 24, 2019).

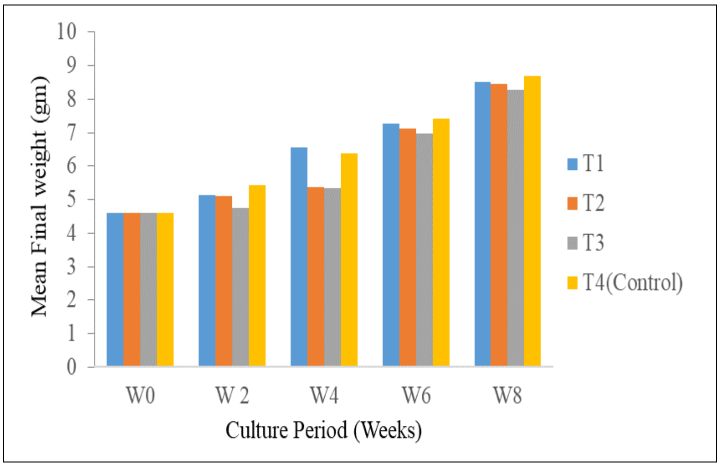

Fig 4A: Mean final weight of Nile tilapia fingerlings in eight weeks.

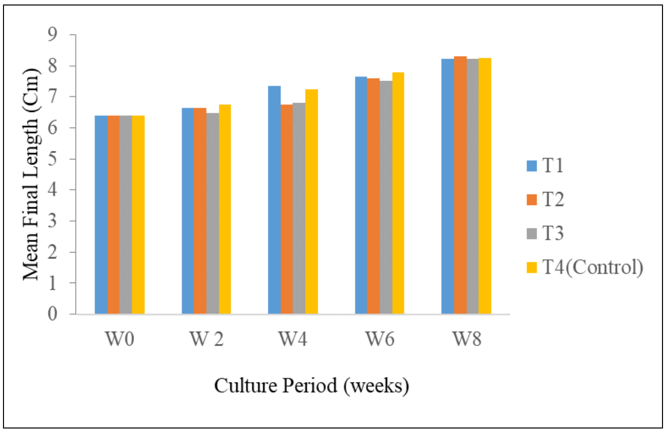

Fig 4B: Mean final length of Nile tilapia fingerlings in eight weeks.

Fulton's condition factor of all treatments of fish was not significantly different (fig 5). However, FCF of control group fish was slightly higher than the treatment groups. Accordingly, the FCF value of control group was 1.52 ± 0.1, followed by T1 with the value of 1.51±0.59 and T2 and T3 with values of 1.5±0.12 and 1.5±0.16, respectively for T2 and T3.

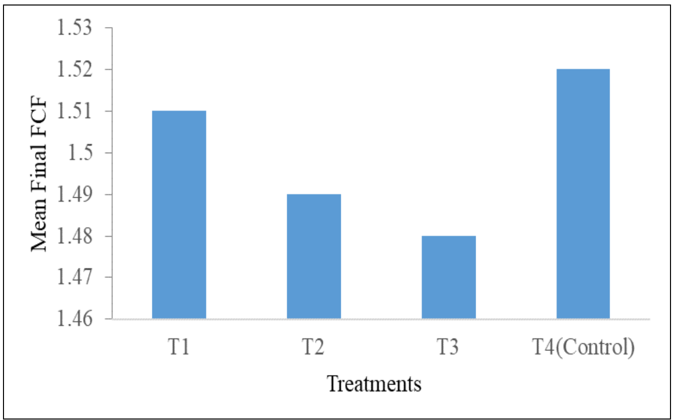

Fig 5: Final Fulton's condition factor of Nile tilapia fingerlings fed on different feeds.

When compared with other findings of the same species of fish, the current value has similar trend of gaining high growth rate at control diet as compared to WH inclusion level with El-Sayed (2003) [11], who record high growth rate at control group (WH-Free), followed by 10% and 20% inclusion level of WH as replacement of dietary wheat bran respectively. As of El-Sayed (2003) [11], the poor performance of Nile tilapia fed WH-based diets compared to the control diet may have been due to the relatively high fiber (cellulose) content of WH since these fish lack the ability to secrete cellulase. El-Sayed also reported that, fermented WH produced better performance than fresh WH. Molasses-fermented WH was utilized more efficiently than yeast-fermented and cow rumen-fermented WH, respectively and recommend fermentation of WH at 20% inclusion level.

Similarly, Edwards *et al*. (1985) [10] reported good growth and feed utilization efficiencies with diets containing up to 75% composted water hyacinth with no significant reduction in fish performance compared to the control diet. This indicates, fish performed better with diets containing composted than with diets containing dried water hyacinth, except for the 100% composted water hyacinth diet in which the pellet was exceptionally hard.

Zaman *et al*. (2017) [30] were also conducted research to substitute pollard with WH at a substitution level of 0%, 25%, 50%, 75% and 100%. They saw a similar trend of relative growth at 0% WH treatment with a 50% replacement rate of pollard yielded in their finding. According to Zaman *et al*. (2017) [30] the activities of protease, amylase and cellulase decreased due to the increase in water hyacinth in the feed and conclude that, water hyacinth flour can be used up to 50% as a pollard substitution with 12.5% of material quantity in the diet of tilapia.

Jubie *et al*. (2015) [19] also conducted a 90-day feeding trial to determine the effects of water hyacinth leaf protein concentrate (WHLPC) on survival, growth, feed conversion efficiency and carcass composition of the Nile tilapia juveniles meal at 0, 15, 30 and 45%. Their finding showed that survival rates (85-88%), feed intake, weight gain (WG), specific growth rate (SGR) and feed conversion ratios were all similar among dietary treatments and finally concluded that, WHLPC could replace up to 45% of the soybean meal (or an equivalent inclusion of 11.7% in the diet) without negative effects on survival, growth, feed conversion efficiency and in general, carcass composition.

Much research on WH utilization as fish feed was also conducted for different species of fish besides Nile tilapia. For instance, Stolu and Sule (2011) [28] conducted research on utilization of WH using whole water hyacinth plant meal (WPM), water hyacinth leaf meal (WLM) and soya bean meal (SBM) for African Catfish diets. Their result indicated that, fish fed all diets exhibited a marginal difference in total feed intake, but growth performance and nutrient utilization were significantly higher in fish fed WLM than fish fed WPM probably as a result of high fiber content present in WPM. Matthews and Kusemiju (2018) [16] were also evaluated the effect of WH in diets of African Catfish at proportions of 0%, 20%WH, 30%WH and 40%WH under four treatments. Their finding indicated that, the SGR value was significantly higher ($P<0.05$) in the control than all other treatments. A significant difference was observed in 20% and 30% WHT but there was no significant difference ($P> 0.05$) in the 40%WHT. By this, they concluded that the 20%WH inclusion is feasible and will yield profitable returns for the farmer as well as making resourceful use of the weed.

On the other hand, Mohapatra (2015) [23] evaluated inclusion of water hyacinth, *Eichhornia* at different levels (0%, 10%, 20%, 30%, and 40%) for *C. carpio* fry in place of fish meal and that, the different inclusion levels of water hyacinth supported the growth of *C. carpio* fry, but growth performance decreases as the level of water hyacinth increases. Mohapatra (2015) [23] reported that, no significant difference ($P\leq0.05$) between the weights gains recorded for the fish fed all the experimental diets, but weight gain growth rate was favored by low inclusion of water hyacinth meal and finally recommend up to 40% WH content as a replacement for fish meal in diet formulation for common carp fry. Sadique *et al*. (2018) [25] also found that, up to 40% molasses fermented WH can be replaced with rice bran in the diets for common carp fingerlings.

The research was also conducted on Siamese Gourami, *Trichogaster pectoralis* by Lee *et al*. (2016) [21] using different percentage combination of *E. crassipes* leaf and fish meal with five treatments. Based on the result, they concluded that, application of *E. crassipes* leaf had an adverse effect on the fish at higher proportion and show better growth performance on Siamese Gourami at a lower combination level of 20%.

3.3 Water quality of circulation system

Ammonia/Ammonium ion (NH_3/NH_4^+) value: The value of Ammonia/Ammonium ion (NH_3/NH_4^+) was ranged from 0.25 ppm – 0.5 ppm with average an value of 0.375 ± 0.11 ppm (Table 4). The value was high (0.5ppm) at the 14th day of fish entry to the system; 0.5 ppm at the month of fish entry to the system and then fall to 0ppm at the third and fourth round of water quality analysis. This indicated that, rate of ammonia nitrification was low at the beginning due to the low establishment of nitrifying bacteria's in bio-filters and then gradually the rate of ammonia nitrification increased, and which causes un-availability of ammonia in the system. According to fresh-water master test kit manual, the ammonia content of above zero is lethal to the fish and hence 0 ppm of ammonia/ammonium ion is recommended. https://www.apifishcare.com [17]. According to Sallenave (2016) [27], the total ammonia nitrogen (TAN) which consists of both ammonia and ammonium ion in aqua phonic circulation system should have to be maintained at <1 ppm.

pH value: The current pH value for the circulation system was ranged from 7.1 -8.2 with an average value of 7.5 ± 0.39. The pH value was high at the early beginning of the experiment and then gradually fall down due to nitrification and de-nitrification process/ activity. According to Pattillo (2014) [25], the ideal pH for aquaculture is 7.0; the acceptable range is 6.5 to 9.0 for most aquaculture species. According to Sallennave (2016) [27], tilapia require pH to be in the range of 5.0 to 10.0. According to fresh-water master test kit manual (https://www.apifishcare.com) [17]. 7.5 is the ideal for most live-bearing fish. When compared with the current value, 7.5 is the pH requirement of tilapia and hence good for tilapia.

Nitrite (NO_2^-): From the current monitory, the nitrite value was ranged from 0.25 -0.5 ppm with an average value of 0.19 ±0.18 ppm. The nitrite level was high during the first analysis time with 0.5 ppm; 0.25 at the second round water quality analysis, and then fall to zero at third and fourth water quality analysis time. This indicates that, the value of nitrite climb up before the biological filter established and gradually fall down as a biological filter developed (https://www.apifishcare.com) [17]. According to Sallennave (2016) [27], nitrite levels should be maintained at or below 1 ppm for tilapia which is the same as the current value.

Nitrate (NO_3^-): The nitrate value was ranged from 20 - 40 ppm with an average value of 27.5 ± 7.42 ppm. Unlike that of nitrite, the nitrate value was low early before the biological filter developed and gradually increased after bio-filter developed. "In new aquariums, the nitrate level will gradually climb as the biological filter becomes established; a nitrate level of 40 ppm (mg/l) or less is recommended for fresh water aquariums" (A manual for fresh water master test kit) or https://www.apifishcare.com .

The TDS value was ranged from 580-665 mg/l with average value of 598.40 ± 25.95 mg/l; Conductivity was ranging from 844 - 963µs cm^{-1} with average value of 867.13±37.05 µs cm^{-1}; on the other hand, the value of salinity and resistivity was ranged from 0.42 - 0.48 ppt with average value of 0.43 ± 0.02 ppt and 1.04 – 1.18 kΩ with average value of 1.14 ± 0.053 kΩ respectively.

The temperature of the water circulation system was ranged from 32 ºC - 25 ºC with an average value of 29.32 ± 1.06 ºC. According to Sallnave (2016) [27], Tilapia prefer temperatures of 81–85 °F (27–29 °C) which is equal with the current value. Dissolved oxygen was ranged from 3.6 - 4.3 mg/l with an average value of 4 ±0.21 mg/l. According to Sallenave (2016) [27], the oxygen requirement of fish in the circulation system especially aqua phonics should have to be 5ppm (5mg/l); however tilapia with stunted growth can tolerate Dissolved oxygen of above 1 ppm/mg/l. when compared to the present value, the DO was almost in the range of tilapias requirements.

Table 4: Mean and Standard deviation of water circulation system parameters used to grow Nile Tilapia fingerlings.

	Physico-chemical parameters of the water circulation system									
Items	**TDS. mg/l**	**Cond. µs cm^{-1}**	**Sal. ppt**	**Res. kΩ**	**Tem. ºC**	**NH_3/NH_4^+ ppm**	**NO_2^- ppm**	**NO_3^- ppm**	**pH**	**DO mg/l**
Max.	665	963	0.48	1.18	32	0.5	0.5	40	8.2	4.3
Min.	580	844	0.42	1.04	25	0.25	0.25	20	7.1	3.6
Mean	598.4	867.13	0.43	1.14	29.32	0.375	0.19	27.5	7.5	4
Std.	25.95	37.05	0.02	0.053	1.06	0.11	0.18	7.42	0.39	0.21

Note: Std =standard deviation, TDS=Total dissolved solid, Cond=conductivity, Sal. =Salinity, Res. =Resistivity, Tem. =Temperature, Max. =Maximum and Min. =Minimum.

4. Conclusion and Recommendations

4.1 Conclusion

The nutritional impact of WH on the growth of Nile tilapia fingerlings was studied at different proportions in this paper to change the nuisance of aquatic weed (WH) to the opportunity which may be a part of its invasion management system through utilization. Based on the current finding, it can be concluded that WH can replace 9% and 14% wheat bran by using 15% and 30% fermented WH respectively as in T1 and T2. It can also replace 17% nug cake and 14 % wheat bran by using 45% WH as in T3. However, based on the value of Fulton's condition Factor and relatively high growth rate observed among treatments, 15%WH and 30% WH were better than 45%WH.

4.2 Recommendations

- 15% and 30% fermented WH level of inclusion in fish feed are recommended as energy source (wheat bran) replacement in Nile tilapia fingerling feed.
- The environmental and socioeconomic impact of WH at Lake Koka might be minimized by using the plant as fish feed
- Further research on the possibility of using the plant as feed for other animals should be conducted
- Seasonal variation in plant nutrient content and the possibility of using other parts of the plant should be assessed

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