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DEPARTMENT OF BIOLOGY

Evaluation of Various Fruit-Vegetable Leftover as Alternative Feedstuff on Nile Tilapia (*Oreochromis niloticus*) Growth Performance and Survival in Hapa, Jimma University, Southwestern Ethiopia

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Approval

Approved by the boards of examiners:

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Co-Advisor	Signature	Date
Examiner	Signature	Date

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List of Acronyms

CF	Crude Fiber
CP	Crude Protein
DGR	Daily Growth Rate
DO	Dissolved Oxygen
EC	Electric Conductivity
FAO	Food And Agricultural Organization
FCR	Feed Conversion Ratio
FVLO	Fruit-Vegetable Leftover
RGR	Relative Growth Rate
SGR	Specific Growth Rate
TDS	Total Dissolved Solid
WG	Weight Gain
PP	Papaya Peel

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First of all I like to thank my God who helped me in every step and activities of my life. Next no words are good enough to extend my heartfelt gratitude to my advisor Tokuma Negisho (PhD) and co-advisor Mulugeta Wakjira (PhD) for their encouragement, positive critics and constant guidance during this study and thesis write-up. I would like to thanks the Jimma University for financial support for this research. I also like to extend my thanks to my best friend, Gezhagni Gelsimo who supported me a lot and was aside of me when I need his help. Many other people not mentioned here assisted me in different ways and to all of you, I say thank you very much really

Abstract

Nile tilapia (Oreochromis niloticus) is the most preferred cultured fish species in many tropical and subtropical countries of the world. Nile tilapia is commercial importance in aquaculture because of highly resistant to diseases, exhibit rapid growth, and efficient feed conversion, are easy to breed, and have good consumer acceptance. However feed sources are main bottlenecks for its aquaculture development. A three month's feeding experiment was conducted to assess the effects of various fruit vegetable leftover as alternative feedstuff on growth performance, survival and proximate composition of Nile tilapia (Oreochromis niloticus) fingerling in fish hapa. Each treatment was carried out in duplicate, using 12Nile tilapia fingerling with an initial mean weight of 9.7 ± 0.2 g. The basal diet and treatment feed was formulated at 35% crude protein from the local available ingredients and treatment feed) used for this study was prepared from banana, papaya, cabbage and potato. Four diets were formulated containing 0% fruit vegetable leftover T_1 *, 25% as* T_2 *fruit vegetable leftover and 50% fruit vegetable leftover as T3 and 75% fruit vegetable leftover as T4 The fish were fed at 10% body weight twice per day. The water quality parameters in the hapa were monitored once every two weeks. Fish growth was also assessed by fortnightly sampling, the quantity of feed given being readjusted based on the increase in weight. On termination of the study, all surviving fishes were collected and their length and weight recorded. Fish whole tissues were analyzed for proximate composition using standard methods. The tests revealed that, the weight gain values of all treatments had a significant* ($p < 0.001$) *difference between each group. The weight gain results obtained showed 37.00 ± 0.14g fish that fed on 75% fruit vegetable leftover and was lower gained, while fish that fed on 25% fruit vegetable leftover gained 53.67±0.47g was highest gained among the groups. The survival rate of fish during study was good in all treatments, being 100 ± 0.00 in* T_2*. The lowest survival was recorded in T4 (87.5± 0.007). The dietary inclusion 25% of fruit-vegetable leftover, improved each of fish weight gain and other growth performance as well as the whole fish body composition (crude protein and moisture) than control and other ratio of fruit-vegetable leftover. So, it is possible to feed fish the diets containing fruit-vegetable leftover (25%) as replacement for dietary basal diet.*

Keywords: *earthen pond* fruit-vegetable leftover, growth performance, hapa, Nile tilapia

1. Introduction

Aquaculture is defined by the UN's Food and Agriculture Organization (FAO) as the 'farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants'. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators and it can also include encouraging of accessible market chain. This farming can be ran by individual or corporate ownership for planning of stock being cultivated, sites selection, development and operation of aquaculture systems, providing of facilities and practices, the production and transporting of the products (FAO, 1996).

Aquaculture production has increased steadily in recent years and is the fastest growing food production sector and has become a valuable component of national development and poverty reduction plans in many areas of the world (Prabu & Santhiya, 2016). According to FAO (2020), from the total fish production in 2018 world total fish production reached to 178.5 million metric tons of which 82.1 and 96.4 million metric tons were produced from aquaculture and capture fisheries respectively. Therefore, aquaculture is an alternative method to increase food production for people in a reasonable cost, produce diversified food items and promote agro-industrial development.

The contribution of African aquaculture to the world aquaculture is still insignificant (~ 2.7%) (Halwar, 2020) and significantly increasing with larger-scale investments in Egypt, Nigeria, Uganda and Ghana producing substantial quantities of fish (Cai *et al*., 2017). The expansion of *Oreochromis niloticus* farming is due to its tolerance to a wide range of environmental conditions including factors such as consume wide types of feed, pH, temperature, nitrogen wastes, low dissolved oxygen concentration and its easiness for handling practices (Noor *et al*., 2010).

Aquaculture activities in Ethiopia have started around 1970`s with establishing pond cultures for different indigenous and non-indigenous fish species for experimental purposes by the National Fisheries and Other Aquatic Resources Research Center (FAO, 2003). The production of aquaculture in Ethiopia is still insignificant which is rather potential than actual practice

(Bostock *et al*., 2010). Fish production in Ethiopia both by capture and culture is dominated by tilapia which account for about 50% followed by African catfish and common carp.

To increase the production and quality of tilapia continues to the future; therefore, feed is an important key factor in increasing the growth and production of Nile tilapia (Amin *et al.,* 2019; Dawood *et al.,* 2019c). In aquaculture, the cost of purchasing fish feed is quite high, so an alternative ingredient is needed that is cheap, easily available, and environmentally friend (Sithara and Kamalaveni, 2008). Fruit processing wastes and vegetable wastes are the potential source of energy in urban areas, which should be exploited to use as ingredients in fish feed.

There is a growing massive generation of cafeteria food leftover from Ethiopian public higher education institutions, hospitals, hotels, restaurants and other cookery providers that could be diverted into economic opportunities. Converting cafeteria food leftover in to livestock feed is an alternative and feasible option to reduce feed cost, enhance livestock productivity and reduce environmental and health impacts (Ebrahim, A. (2023).

1.2 Statement of the problem

There are enormous water resources and diversified ago-ecologies in the Ethiopia, however aquaculture is relatively new to Ethiopia and it has many challenges, some of these are it has limited fish feed industry and feed preparation experience (Temesgen *et al.,* 2021). Fish feeds are expensive and constitute up to 60% to 70% of the total production cost in the aquaculture industry. Thus, there is a need to replace this with cheaper and easy to culture plant protein source (Chepkirui, *et al.,* 2022).

Vegetable-fruit by-products are a major component of municipal solid waste, presenting an unresolved environmental menace. These wastes are secondary products often discarded or wasted during manufacturing or other stages of food processing. Up to one-third of vegetables could be wasted during the preparation process. Interestingly, certain parts of vegetables are knowingly wasted due to their unfavorable taste or texture. Fruit-Vegetable Waste represents a significant economic issue for companies and poses environmental problems, due to its high moisture and biodegradability (Plazzotta *et al*., 2020). Therefore, utilizing agricultural by-products not only helps farmers and the economy but also increases food sustainability and reduces food insecurity, especially in underdeveloped countries. In this regard, investigating ways to transform these wastes into usable forms is a significant research gap in Ethiopia. To date, no studies have been reported in the country on converting these wastes into fish feed.

Therefore, this study aimed to test the hypothesis that fruit-vegetable leftovers can effectively support the growth and health of Nile tilapia, in which various fruit-vegetable leftovers were used to replace a basal diet to improve the growth performance, survival, and proximate composition of Nile tilapia fingerlings in fish hapa at a lower cost.

1.3. Objective

1.3.1. General Objective

To assess the various fruit- vegetable leftover as alternative feedstuff on Nile tilapia (*Oreochromis niloticus*) growth performance, survival and proximate composition.

1.3.2 Specific Objectives

- To evaluate the growth performance of Nile tilapia juveniles fed on fruit-vegetable leftover as a supplementation of feed ingredients.
- To evaluate the survival rate of Nile tilapia juveniles fed on fruit-vegetable leftover
- To evaluate the effect of fruit-vegetable leftover supplementation on water quality of Nile tilapia reared in hapa.
- To evaluate the effect of fruit-vegetable leftover on proximate composition of Nile tilapia fed on fruit-vegetable leftover in varying level

1.4. Significance of the Study

The results of this study will provide scientific information on the effects of dietary supplementation of fruit and vegetable left over on the growth performance of Nile tilapia in fish hapa, proximate composition and water quality parameters of the earthen fish pond. In addition, it will contribute to practical knowledge on feed preparation for aquaculture development in Ethiopia.

2. Literature Review

2.1 Global Aquaculture

Aquaculture has sustained a global growth and can fill the shortage in aquatic food products due to decline in capture fisheries (Gutierrez-Wing, 2006). Fish has long been valued as a highly nutritious food source for humans. The demand of fish food is increasing throughout the world due to the recognition of its nutritional value (Tingman *et al.,* 2010).

Therefore, aquaculture is an alternative method to increase food production for people in a reasonable cost, produce diversified food items and promote agro-industry development. According to FAO (2020), from the total fish production in 2018 world total fish production reached to 178.5 million metric tons of which 82.1 and 96.4 million metric tons were produced from aquaculture and capture fisheries respectively. Most of the production came from extensive /semi-intensive systems in developed countries, particularly Asia, rearing mostly organisms low on the feed chain such as omnivores and herbivores.

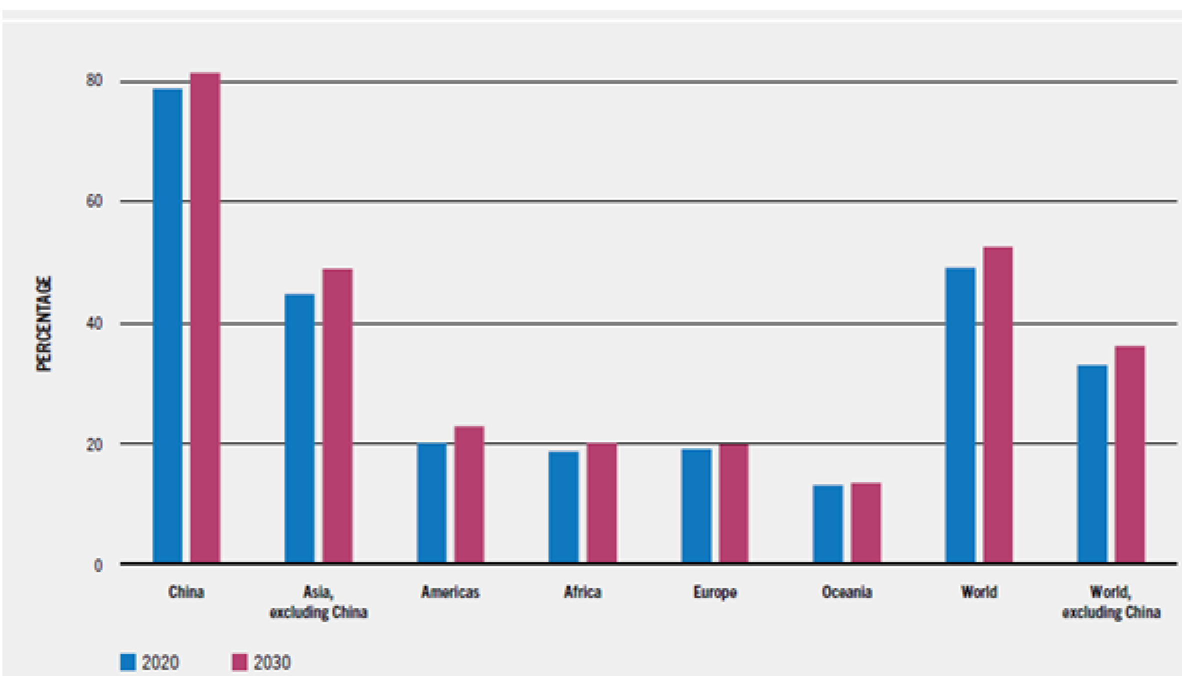


Figure 1 Contribution of aquaculture to regional fisheries and aquaculture production

The demand of fish food is increasing throughout the world due to the recognition of its nutritional value (Tingman *et al.,* 2010). In addition, the rise of food price and rapid human world population growth increase the demand of fish consumption (FAO, 2010; 2012). For these reasons, there are varieties of farming fish species get a special consideration to increase the world fish production.

Tilapia is the second largest farmed fish group in the world next to carp (El-Sayed, 2006; FAO, 2012). The most commercially cultured fish species in the global tilapia farming is dominated by Nile tilapia (El-Sayed, 2006). The expansion of *Oreochromis niloticus* farming is due to its tolerance to a wide range of environmental conditions including factors such as consume wide types of feed, pH, temperature, nitrogen wastes, low dissolved oxygen concentration and its easiness for handling practices (Noor *et al*., 2010).

2.2 African Aquaculture

The volume of aquaculture production in Africa increased almost five-fold over the past two decades while its value rose almost ten-fold. At the sub-regional level, the highest production levels are found in North Africa, particularly Egypt. Production levels in West and East Africa follow at a distant second and third position respectively (Hinrichsen *et al*., 2022).

Aquaculture production on the continent is lowest in Southern and Central Africa. In absolute numbers, production levels in Africa are still low, accounting for just 2.7 percent of global production in 2018, highlighting a significant potential for expansion. The contribution of aquaculture to national GDP increased in most African countries between 2009 and 2018, but it is still negligible at less than 2 percent in 2018. Capture fisheries remains the dominant source of fish on the continent, with aquaculture accounting for 16-18 percent of total fish production in 2018 (FAO, 2020a).

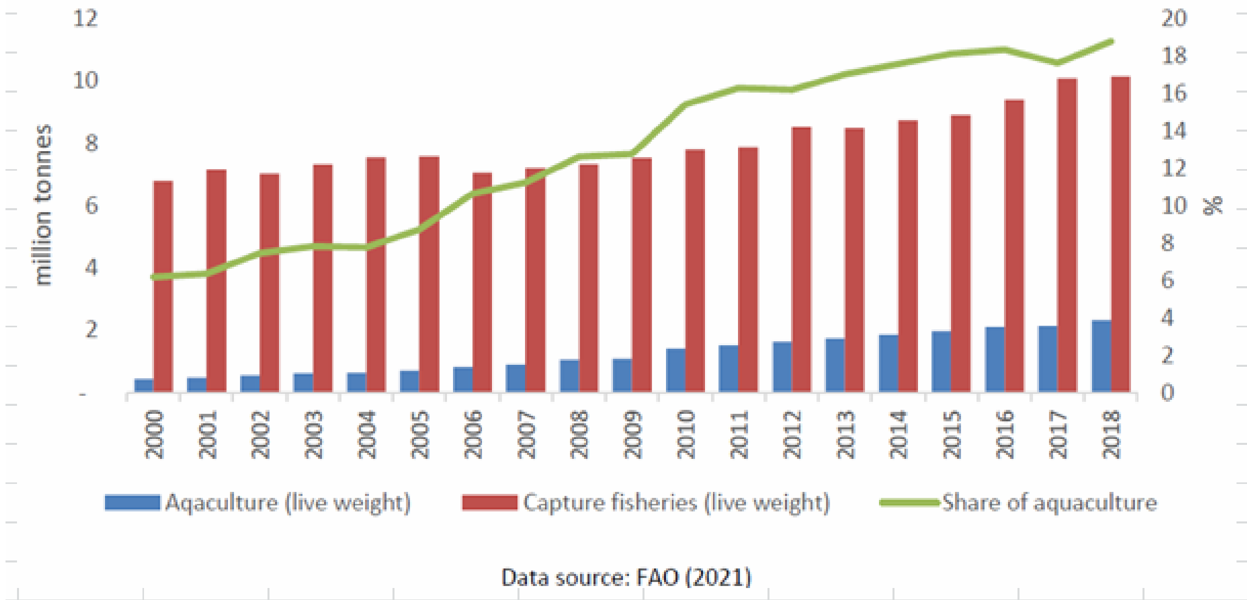


Figure 2 Contribution of aquaculture in total production of aquatic in Africa

The contribution of African aquaculture to the world aquaculture is still insignificant (~ 2.7%) (Halwar, 2020) and significantly increasing with larger-scale investments in Egypt, Nigeria, Uganda and Ghana producing substantial quantities of fish (Cai *et al*., 2017). Total aquaculture production increased from 7.2 to 11.9 million tons from 2000 to 2017.

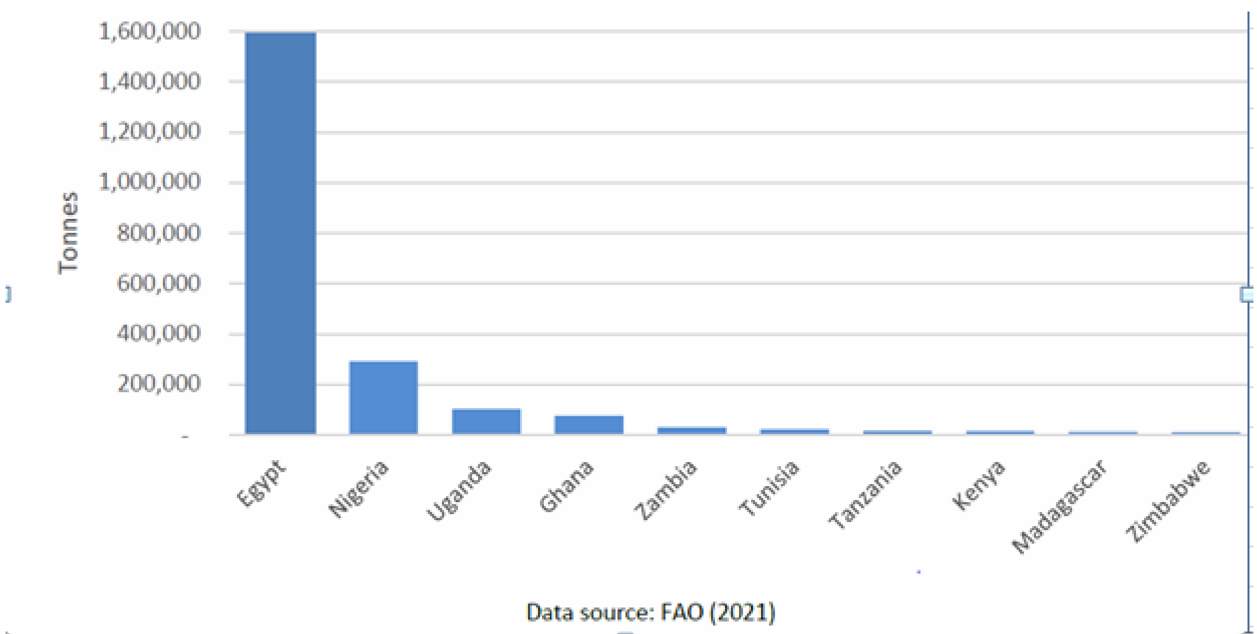


Figure 3 Top10 African countries by aquaculture production Volume (2018

The growth of aquaculture production was due to the advent and intensification by the contribution of the private sector (Satia, 2016). Most of the production (99%) is from the inland freshwater systems and is mostly dominated by the culture of indigenous and abundant species of tilapia and African catfish while Mari culture only contributes approximately to 1% to the total production quantity, although it is an emerging and promising sub sector (FAO, 2018). The aquaculture sector employs about 6.2 million people in Africa, with a large share of the employees being women that are engaged in large scale commercial farms (Satia, 2016). The aquaculture sector, therefore, has the potential to significantly contribute to food security, reduce unemployment rates and economic development in Africa.

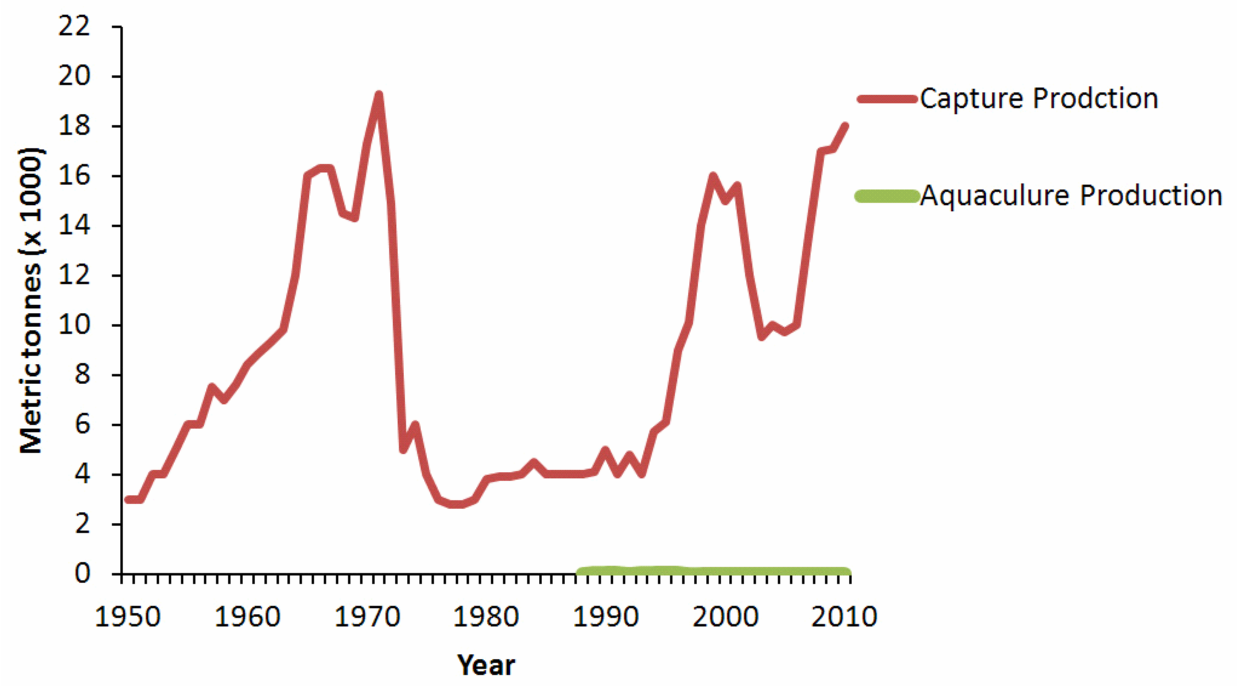
2.3. Aquaculture in Ethiopia

Ethiopia is endowed with a number of natural lakes, reservoirs and large rivers containing substantial qualities of fish stock. Water bodies of Ethiopia have a surface area estimated at 7,334 km2 of major lakes and reservoirs, and 275 km2 of small water bodies, with 7,185 km of rivers within the country Tedla, S. (1973)..

Tilapia is the most exploited species constituting about 80 % of the total fish capture in Ethiopia (Breuil, 1995). It is one of the most important species in the ecology and fisheries of almost all Ethiopian inland waters (Tedla, 1973). Therefore, fish resources became depleted from time to time because of over exploitation of capture fisheries (FAO, 2008). Fish culture is assuming greater popularity as an alternative means to capture fisheries for increasing fish supply due to habitat degradation, over-exploitation, and pollution of natural water bodies in developing countries (Sing *et al*.,2007). Therefore, the current increasing market demand for fish protein in Ethiopia can be met only when the capture fishery is improved by culture fishery.

Aquaculture in Ethiopia, like most countries of the continent, remains more potential than actual practice, despite the fact that the country's physical and sociolect-economic conditions support its development. Ethiopia is endowed with abundant aquatic resources but has not been able to realize substantial production from aquaculture due to lack of educated labor and technology in all aspects (Wakjira *et al*., 2013).

(Source *Wakjira et al*., 2013



(Source *Wakjira et al*., 2013

Figure 4 Capture fishery and aquaculture production of Ethiopia

2.4. Nile tilapia culture

Next to carps, tilapia has become one of the most common cultured fish in the world (El-Sayed, 2002) and is likely to be continued being the most important cultured fish in the 21st century (Fitzsimmons, 2000). Most tilapia species of the family Tilapia now being used in aquaculture were grouped initially into one genus, Tilapia. The classification of the genus Oreochromis was based on the difference on their reproduction, feeding habits, and bio geography.

Tilapia culture is advantageous for the reason that tilapia feeds on low trophic level. The members of the genus Oreochromis are all omnivores, feeding on algae, aquatic plants, small invertebrates, detritus, and associated bacterial films (Diana *et al*., 1991).The expansion of *Oreochromis niloticus* farming is due to its tolerance to a wide range of environmental conditions including factors such as consume wide types of feed, pH, temperature, nitrogen wastes, low dissolved oxygen concentration and its easiness for handling practices (Noor *et al*., 2010).

2.5 Environmental requirements of Nile Tilapia

Tilapia can tolerate a wider range of environmental conditions such as salinity, dissolved oxygen, temperature, pH, and ammonia levels than most cultured freshwater fishes can. In general, most tilapia is highly tolerant of saline waters, although salinity tolerance differs among species. Nile tilapia is thought to be the least adaptable to marked changes (direct transfer, 18 parts per thousand in salinity); Mozambique, blue, and red belly (*T. zilli*) are the most salt tolerant (El-Sayed 2006).With the exception of Nile tilapia, other tilapia species can grow and reproduce at salinity concentrations of up to 36 parts per thousand, but optimal performance measures (reproduction and growth) are attained at salinities up to 19 parts per thousand (El-Sayed 2006). Tilapia are, in general, highly tolerant of low dissolved oxygen concentration, even down to 0.1 mg/L (Magid and Babiker, 1975), but optimum growth is obtained at concentrations greater than 3 mg/L (Ross, 2000). Temperature is a major metabolic modifier in these fish. Optimal growing temperatures are typically between 22° C (72° F) and 29° C (84° F); spawning normally occurs at temperatures greater than 22° C (72° F). Most tilapia species are unable to survive at temperatures below 10° C (50° F), and growth is poor below 20° C (68° F). Blue tilapia are the most cold tolerant, surviving at temperatures as low as 8° C (46° F), while other species can tolerate temperatures as high as 42° C (108° F; (Sarig, 1969; Morgan, 1972; Caulton, 1982; Mires, 1995).Other water quality characteristics relevant to tilapia culture are pH and ammonia. In general, tilapia can tolerate pH range of 3.7 to 11, but best growth rates are achieved between pH 7 to 9 (Ross, 2000). Ammonia is toxic to tilapia at concentrations of 2.5 and 7.1 mg/L as unionized ammonia, respectively, for blue and Nile tilapia (Redner and Stickney, 1979; El-Sherif et al., 2008) and depresses feed intake and growth at concentrations as low as 0.1 mg/L (El- Sherif et al., 2008). Optimum concentrations are estimated to be below 0.05 mg/L (El-Sherif et al., 2008)

Table 1 Limits and optima of water quality parameters for tilapia

Parameter	Range	Optimum for growth	Reference

Salinity, parts per thousand	Up to 36	Up 19	*El-Sayed (2006)*
Dissolved oxygen, mg/L	Down to 0.1	> 3	*Magid and Babiker (1975)*
Temperature, C°	8–42	22–29	*Sarig (1969)*
PH	3.7–11	7–9	*Ross (2000)*
Ammonia, mg/L	Up to 7.1	< 0.05	*Redner and Stickney (1979)*

2.6 Locally Available Fruit vegetables Leftover

2.6.1Banana peel

Banana is an important crop worldwide; plantation generates tons of residues after each harvest season and during processing to obtain banana pulps. The depositions may include leaves, pseudo stem, stalk and inflorescence, but 35%–50% of the total mass fruit represents the banana peel (Gomes *et al*., 2020). Banana peels are typically dumped into the environment without any treatment. In some cases, banana peel may be used as organic fertilizer and animal feed because of its low tannins and high fiber content (Pereira & Maraschin, 2014). Approximately 36 million tons of banana peel is produced every year, and their current endpoint is associated with adverse environmental impact and economic losses (Gomes *et al*., 2020). Every day, several tons of banana peel wastes is generated in fruit markets and home garbage, causing an unpleasant odor because of anaerobic digestion of the biomass, which produces gases that disturb the natural balance of air. Although ripe bananas are consumed unprocessed, significant quantities of bananas are industrially processed into banana flour, chips and other processed goods, resulting in vast banana peel waste. Previously, banana peels were disposed of in a landfill by food manufacturing industries. The agriculture industry would benefit financially from the conversion of banana peel into a valuable product. Peel has traditionally been used as a remedy for a variety of ailment such as burns, anemia, diarrhea, ulcers, inflammation, diabetes, cough, snakebite and excessive menstruation (Pereira & Maraschin, 2015).

Banana peel is used as animal food. However, there are some concerns about the effect of tannin in the husks on the animals that consume it Emaga, *et al.,* 2011). Banana peels are also used as an ingredient in cooking, water purification, the manufacture of many biochemical products, and inorganic waste production (Babatunde, 1992).Banana peels are sometimes used as feedstock for livestock, goats, monkeys, poultry, rabbits, fish, zebras, and many other species (Hikal, *et al.,* 2022).

One of the efforts to reduce banana peels' crude fiber content is to carry out biological fermentation using cellulolytic microbes (Hidayat, *et. al.,* 2006). Fermentation is a process of changing organic matter both physically, chemically, and biologically from a complex structure to a simpler one, thereby increasing livestock digestibility (Nista, *et. al.,* 2007). Fermentation is carried out with the help of probiotics.

2.6.2 Papaya Peel

Papaya (*Carica papaya* L.) is the most economically important fruit among the Caricaceae family and cultivated throughout the year. The production areas are mostly tropical and subtropical countries, with India, Brazil, Indonesia, Nigeria, and Mexico as major producers of papaya. In 2014, papayas were harvested on 418,604 ha, with global total production of 12,822,014 tonnes worldwide. Papaya is mostly used in the production of tutti frutti, powder, papaya chips, skin care products, papain, candy, jam, jelly, pickle, sauce, squash, etc. (Pathak & Kulkarni, 2019).

Papaya peel (PP) and papaya seeds (PSs) are the major by-products of papaya processing and represent approximately 12 and 8.5%, respectively, of the fruit weight. PP and PSs have some value added bioactive compounds which can be used as dietary additives; nutraceutical supplements new food and pharmaceutical products. Traditionally, PP are used in animal feeds, cosmetics, and many home remedies. Papaya peel discarded into the environment can cause environmental pollution if not properly handled (Pathak *et al.,* 2019)

The discarded waste from papaya industries can be used as a potential food source for animals (Koubala *et al.,* 2014). Papaya peel contains polyphenols and minerals, which have health benefits for animals, so it can be added to their diet formulations. To make it cost-effective, fruit wastes, which are available free of cost, can be used as a feed ingredient/supplement.

Papaya has proteases, which increase the secretion of digestive enzymes. These enzymes enhance the digestion and absorption of nutrients in fish, which in turn eventually stimulates the growth of *M. rosenbergii PL* (prawn). Incorporation of PP in prawn diet increases their quality in terms of total protein, fatty acids and essential amino acids, vitamin C, and vitamin E along with sodium and potassium (Aarumugam *et al.,* 2013). Replacing fish (catfish) meal with PP containing exogenous enzymes in blood meal in diets improves growth rate, net weight gain, food conversion, and protein efficiency. Papaya peel also contains lectins, which are toxic to fish and other animals; however, it can be removed by heat treatment followed by aqueous methanol extraction. The toxic compound can also be removed by soaking Papaya Peel in water under refrigerated conditions for 24hr (Munguti, *et al.,* 2006).

2.6.3 Cabbage (*Brassica oleracea* var capitata) leftover

About 30% of total cabbage production is discarded as waste, which consists mostly of leaves (Choi and Park, 2003). As cabbage production increases, there is a concomitant increase in the quantity of residues produced. These residues are often discarded into the environment where they pose major environmental concerns (e.g., landfill and nitrate leaching to water sources). Consequently, there is growing interest in alternative and nonpolluting methods of management such as compositing and recycling through livestock feeds. Cabbage leaves are characterized by high crude protein (CP) and mineral concentrations. On a dry matter (DM) basis, cabbage leaves contain more CP (17.0 to 17.2%) than stems but less than heads (Rosa and Heaney, 1996).

2.6.4 Potato leftover

Potato (*Solanum tuberosum L.)* is ranked among one of the chief crops producing worldwide. As per the statistics of the Food and Agriculture Organization (FAO), the annual production of potato was over 300 million tons in 2016 (FAO, 2013, 2016). Besides, food processing industry is one of the most important businesses worldwide produces a large number of byproducts as organic waste that need to be handled and managed in appropriate way not only to avoid environmental pollution but also extend further apart by contributing towards economic boost from byproduct utilization (Paleologou *et al*., 2016). Potato peel as a byproduct of food processing industry poses to be totally inexpensive, valuable and affordable starting material for the production of economically important substances, value addition, and product extraction including dietary fiber, biopolymers, natural antioxidants, and natural food additives (Chiellini *et al*., 2004). Industrial processing generates between 70 to 140 thousand tons of peels worldwide annually (Chang K, 2019). Traditionally potato peel waste is used for producing low-value animal feed (Nelson, 2010). Fertilizer or being the raw material of biogas, which causes waste of abundant nutritive materials within it having the properties of antioxidant, antibacterial, apoptotic, chemo preventive and anti-inflammatory (Liang *et al*.,., 2014). Potato peel is being studied in various manuscripts as an effective feed for animals. Although it has to be treated prior to utilization in animal feed as for non-ruminants feed it is not well suited because of having too much fiber to be digested. On the other side, the same has been used successfully in various studies for the feed of multi-gastric animals. The present review recapitulates applicable endeavors of potato peels exploitation in food as well as nonfood purposes including the extraction, verification and utilization of bio active components, nutritional aspects, biotechnological usage, livestock feed and other miscellaneous use of potato peels as major potato processing industrial waste.

Table 2 Nutritional attributes of some fruit- vegetable waste

Sample types	CP (%)	MC (%)	Ash (%)	CF (%)	Fat (%)	Carbohydrate (%)	Starch	References
Banana	5.5-8		9-11	47-53	2-12	59-77	3.5-6.	(Emaga *et al*., 2007).
Papaya	6.89	68	3.15	9.67	0.33	20		(Pathak *et al*., 2019).
Cabbage	14		12.1	18.9	2	3.8		(Mustafa& Baurhoo, 2017)

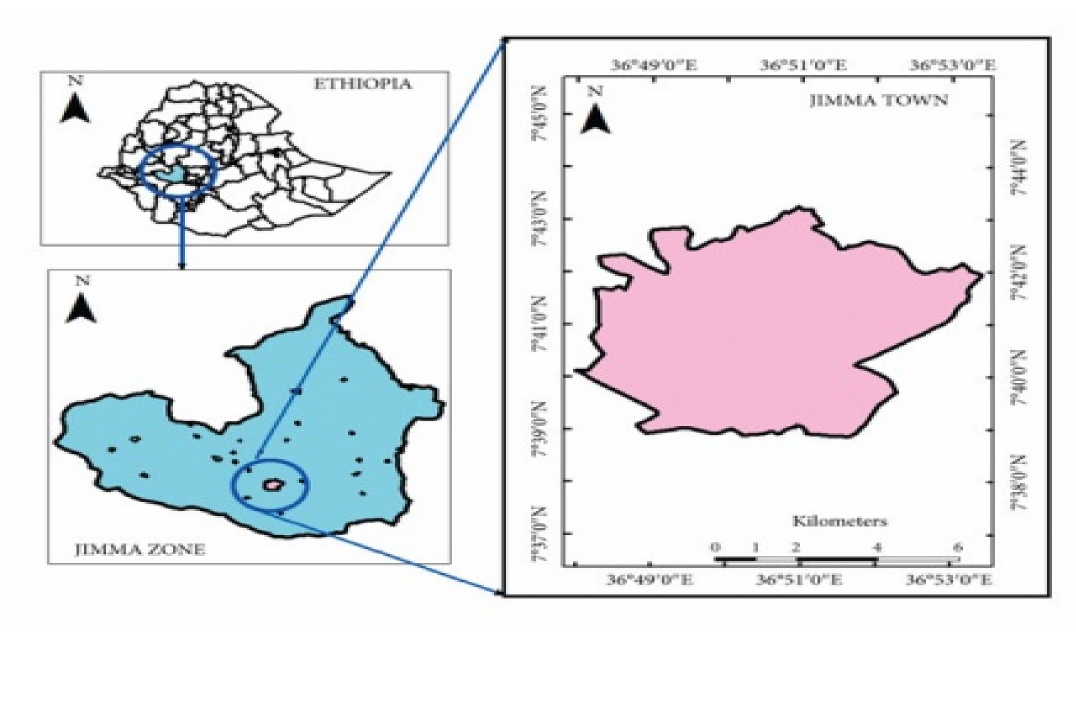
2.7 Impacts of Fruit-vegetable Waste on Environment

According to the estimation of the United Nations Food and Agriculture Organization (FAO), every year, one-third of the food produced in the world (about 1.3 billion metric tons) is wasted (FAO, 2014). The waste generated by the fruit and vegetable sector (fruit and vegetable waste, FVW) is estimated to represent up to 60% of the food waste generated annually in the world (Gustavsson *et al*., 2011). In this regard, roughly one-third of all fruits and vegetables produced worldwide are wasted before reaching the consumer (Kader, 2005). Fruit-Vegetable Waste represents a significant economic issue for companies and poses environmental problems, due to its high moisture and biodegradability (Plazzotta *et al*., 2020)

3. Materials and Methods

3.1. Description of the Study Area

This study was conducted at Jimma University main campus, College of Natural Sciences, Department of Biology in the aquaculture site. Jimma University is located in the city of Jimma, situated around 352 km southwest of Addis Ababa, Ethiopia, at latitude of 7°40´N and a longitude of 36°50´E. It has an altitude of 1780 m above mean sea level (masl) with an average temperature ranging from 14.5°C to 34.7°C, and a mean annual rainfall of about 1529 mm (FIKADU, 2021).



(Source: (Desye *et al*., 2022)

3.2. Experimental Design

Four treatments were arranged to evaluate effects of fruit-vegetable (banana, papaya, cabbage and potato) leftover supplementation with the basal diet on the growth performance of Nile tilapia fingerling in the earthen pond. The 100% basal diet which formulated at 35% crude protein fed with 0% of fruit-vegetable leftover as T_1, 25% as T_2, 50% as T_3 and 75% as T_4 of fruit-vegetable leftover was as supplementary feed. The treatments were conducted over a 90-day period to evaluate the effects of varying ratios of fruit-vegetable leftover supplementation on the fish growth and water quality.

3.3. Basal Feed preparation and formulation

The basal diet was prepared from locally available ingredients based on the optimum productivity reports by various studies (Abdulkarim and Yusuf, 2015, and Mark, 2018), at 35% of crude protein (CP). These feed ingredients were identified based on availability and cost effectiveness. These ingredients are poultry manure (Ghaly *et al*., 2012), dried rumen liqueur Agbabiaka *et al*. (2012), and dried cattle blood. The amount of each ingredient was estimated by the Pearson square method before mix.

Table 3 Crude protein in % and amount of feed ingredients out of 30Kg to formulate at 35% CP for Nile tilapia fry

Ingredient	Crude protein in %	Information sources
Poultry manure	24.5	Ghaly *et al*., 2012
Dried rumen liquor	19.56	Agbabiaka *et al*.(2012)
Dried cattle blood	80	Hasan *et al*., 2019
Total		

Those ingredients were prepared in different ways and place. For instance, poultry manure was dried using sun light by poultry farm workers themselves (Ghaly *et al*., 2012). The cattle blood collected from Jimma City Abattoir and dried using tent dry that we were constructed in 2m width, 4m length, and 0.7m height from ground at aquaculture site. It was taken seven days to dry (Hasan *et al*., 2019).

Figure 5 Drying cattle blood

Rumen liquor was also collected from Jimma City Abattoir and dried in one of house which found there by air and it taken two weeks to dry.

3.4 Experimental feed collection and preparation process

Fruit-vegetable leftover used for this study are banana, papaya, cabbage and potato. These were collected from local market, cafeteria and Jimma prison. There nutritional value spatially CP were referred from different literature review as showed in Table 2. The Fruit-vegetable leftover was rinsed thoroughly in tap water, to remove any contaminants. It was chopped into pieces of 3-5mm separated by using kitchen knife and air dried in the aquaculture site in Jimma University main campus. Then the leftover pieces were ground into fine powder by using laboratory grinders. The obtained flour was stored in refrigerator for 24hrs to remove *lectin* from papaya peel (Munguti*, et al.,* 2006).The FVLO fine powder was sieved and added to other basal diet according to their proportion based on the (Wagner & Stanton (2012).Feed formulation was made by Pearson square method looks as follow.

Table 4 Percent Crude Protein Contributed by the Feed Ingredients in the Experimental

Ingredient	T1(0%FVW	T2(25%FVW)	T3(50%FVW	T4(75%FVW)
CB	22.41%	25%	28.5%	31%
FVLO	0%	19%	35.7%	52%
PM+RL	77. 5%	56%	35.7%	17%

Table 5 Actual amount of ingredients mixed

Ingredient in Kg	T1	T2	T3	T4	Total
Cattle Blood	0.56	0.625	0.7125	0.775	2.673
Poultry Manure	0.87	0.625	0.3925	0.187	2.0743
Rumen Liqueur	1.075	0.775	0.5	0.238	2. 59
Banana	0	0.1375	0.25	0.375	0.77
Papaya	0	0.1375	0.25	0.375	0.77
Cabbage	0	0.15	0.3	0.4125	0.86
potato	0	0.05	0.0925	0.1375	0.28
Total	2.5 Kg	2.5 Kg	2.5 Kg	2.5 Kg	10 Kg

Table 6 the crude protein (CP) of Fruit-vegetable leftover

Fruit-vegetables leftover	CP in %	Information sources
Banana	5.5-7.87	Emaga *et al*., 2007
Papaya	9.67	Pathak *et al*., 2019
Cabbage	14	Mustafa & Baurhoo, 2017
Potato	18	Sepelev & Galoburda, (2015)

3.5 Experimental fish proximate composition Analysis

The cultured Nile tilapia fingerling in fish hapa was analyzed at the Jimma University, College of Agricultural and Veterinary Medicine, Animal nutrition Laboratory. The analyzed parameters were; Crude protein, crude fat, moisture and ash were analyzed according to the standard AOAC methods (Ayuba & Iorkohol, 2010). Crude protein was determined by estimating the nitrogen content (% protein = N x 6.25) of the fish samples using the micro-Kjeldahl procedure. The total fat was determined by Soxhlet extraction used diethyl- ethyl chemical. Moisture content was determined using oven drying method at 105 ^{0}C until to constant weight (48 hours) and the ash content was determined by burning of the dried fish sample in a muffle furnace at 550^{0}C for 3 hours.

3.6. Nile Tilapia Fingerling Selection and Stocking

Nile tilapia fingerlings selection was from cultured in earthen pond which found in the Jimma University main compass aquaculture site. The selected Nile tilapia fingerlings were measured their boy size (total weight and length) and counted number before stocked in eight fish hapa which each has $3m^2$ area. Nile tilapia fingerlings of uniform size about 8-11g were stocked in all four treatments with the same stocking densities (12 fish per hap) as study design.

Figure 7 Selecting and stocking fish in Hap in pond

3.7 Feeding Nile tilapia

The stocked fingerlings were fed a basal diet (T1) and treatment feed (T1,T2 and T3) that was formulated at 35% crude protein with 0% FVLO as control, 25% FVLO as $T_{1,}$ 50 FVLO % as T_2 and 75 FVLO % as T_3 of fruit-vegetable leftover which use as supplementary feed, about 10% body weight of fingerling fed for three months. The fingerlings were fed two times daily (at 9am and 4pm) (Alal *et. al.*2018).

3.8 Measuring water quality parameter

Water quality parameters (temperature, DO, EC, TDS, and Salinity) were measured and recorded by weekly interval to evaluate the impact of Fruit-vegetable leftover on water quality of the fish pond. The dissolved oxygen (DO; $g \cdot L^{-1}$), water temperature (T; °C), electric conductivity (EC; m cm^{-1}), total dissolved solids (TDS; g L^{-1}), and salinity (S; ppt) of the water in the fish ponds was measured weekly as per the need using *multi physic parameters (Palin test MICRO 800 model)* before feeding the fish two time per a day. The remaining chemical-parameters like ion

Ammonia (NH3+), Nitrate (NO3-), Amonium (NH4+) , Nitrite (NO2-) and PH were measured three times (at the beginning, middle, and end) of the experiment by multi-parameter of Palin test (Photometer 7500 model).

Figure 8 measuring water quality parameters

3.9 Measuring growth performance of Nile tilapia fingerling

Data was collected by randomly selecting 50% of fish from each fish pond. Fish was catched using hand net. The total weight and length of fish was recorded at the fourteen days of after treatment was started by using electronics balance and measuring board, respectively, every two weeks. At end of experiment the final weight and total length of all caught fish from each pond were recorded.

Figure 9 Sampling the weight and length of fish

3.10 Data Analysis

The Statistical Package for Social Sciences (SPSS) computer software version 26 was used to analyze the data. One-way analysis of variance (ANOVA), with the Tukey HSD Multiple Range Test, was used to determine the significant differences among and between the means of all growth performance parameters. Growth performance and water quality parameters were expressed as mean plus or minus standard deviation (SD). Statistical significance was considered at $P < 0.05$. At the end of the experiment, the final weight and total length of randomly caught Nile tilapia from all fish ponds will record as row data. WG, DGR, FCF, FCR, RGR and SGR were quantified by the method described by Lugert *et al.* (2016) as the following formula: Growth performance, Fulton condition factors and feed conversion ratio was calculated as follows:

Weight gain (g) = Final total weight (g) - Initial total weight (g)

$$\text{Daily growth rate (g/day)} = \frac{\text{Final Weight} - \text{Initial Weight (g)}}{\text{Culture period (days)}}$$

$$\text{(Fulton condition factors (K)} = \frac{\text{Mean final weight (g)}}{\text{Mean final total length (cm) 3}} * 100$$

$$\text{(Feed conversion Ratio} = \frac{\text{Total feed consumed by fish (g)}}{\text{Weight gain of fish (g)}}$$

$$\text{Specific growth rate (\%)} = \frac{\text{(Ln Final weight} - \text{Ln Initial weight)}}{\text{Culture period (days)}} * 100$$

$$\text{Survival rate} = \frac{\text{Total number of survived fish}}{\text{Total Numbers stocked}} * 100$$

4. Results

4.1. Growth performance

The result of growth performance of juveniles during this study was significant ($P < 0.05$) difference between all treatment groups.

4.2 Growth performance and feed utilization parameters of Nile tilapia

Growth performance and feed utilization parameters of Nile tilapia was presented in table 7.Weight gain specific growth rate and feed conversion ratio was statistically significantly difference ($P<0.05$) across the diet treatments. With T2 had the highest weight gain, specific growth rate and lower feed conversion ratio. However T4 had the lowest weight gain, specific growth rate and highest feed conversion ratio. Survival rate was not statistically significantly difference ($p>0.05$) across the diet treatments.

Table 7 growth performance Parameters and survival rate of Nile tilapia fingerlings in Fish Hapa

Parameters	No	T_1	T_2	T_3	T_4	P-Value
IL(g)	1	7.30 ± 0.28^{a}	7.34 ± 0.23^{b}	7.92 ± 0.24^{d}	7.71 ± 0.05^{c}	0.121
FL(g)	1	20 ± 1.17^{c}	22 ± 0.94^{d}	17.75 ± 0.11^{b}	15.6 ± 0.12	0.004
IW(g)	1	9.65 ± 0.49^{a}	9.67 ± 0.0^{a}	9.87 ± 0.06^{a}	9.7 ± 0.05^{a}	0.8
FW(g)	1	$57.\ 5\pm0.95^{c}$	63.6 ± 0.07^{d}	51.8 ± 1.5^{b}	46.7 ± 0.95^{a}	0.00
WG (g)	1	47.85 ± 0.47^{c}	$53\ .9\pm0.47^{d}$	42.93 ± 0.57^{b}	37.00 ± 0.142^{a}	0.00
DGR (g/day)	1	0.54 ± 0.00^{c}	$0.\ 6\pm 0.31^{d}$	0.46 ± 0.007^{b}	0.41 ± 0.007^{a}	0.00
K (%)	1	0.4 ± 0.14^{ab}	0.3 ± 0.14^{a}	0.48 ± 0.14^{ab}	0.64 ± 0.14^{b}	0.00
FCR (%	1	2.15 ± 0.035^{b}	1.95 ± 0.014^{a}	2.47 ± 0.00^{c}	2.41 ± 0.14c	0.01
SGR g/day)	1	2 ± 0.007^{a}	$1.\ 6 \pm 0.00^{d}$	$1.\ 62\pm 0.14^{c}$	$1.\ 52 \pm 0.00^{b}$	0.00
SR (%)	1	95.8 ± 0.14^{c}	100 ± 0.00^{d}	91.7 ± 0.14^{b}	87.5 ± 0.07^{a}	0.00

Note: values represent mean ± standard deviation of duplicate tests. Different alphabets (a<b<c<d) in the same rows symbolize non-homogenous means ($p<.05$).

4.3 Weight Gain per Week

Figure 10 displays the weight gain of Nile tilapia cultured in various FVLO inclusions. Noticeable differences in weight gain were observed across all treatments. Specifically, the (T2) exhibited the highest weight gain. Each treatment group displayed a distinct exponential growth curve, with none of the curves overlapping throughout the 90 days of experimental period.

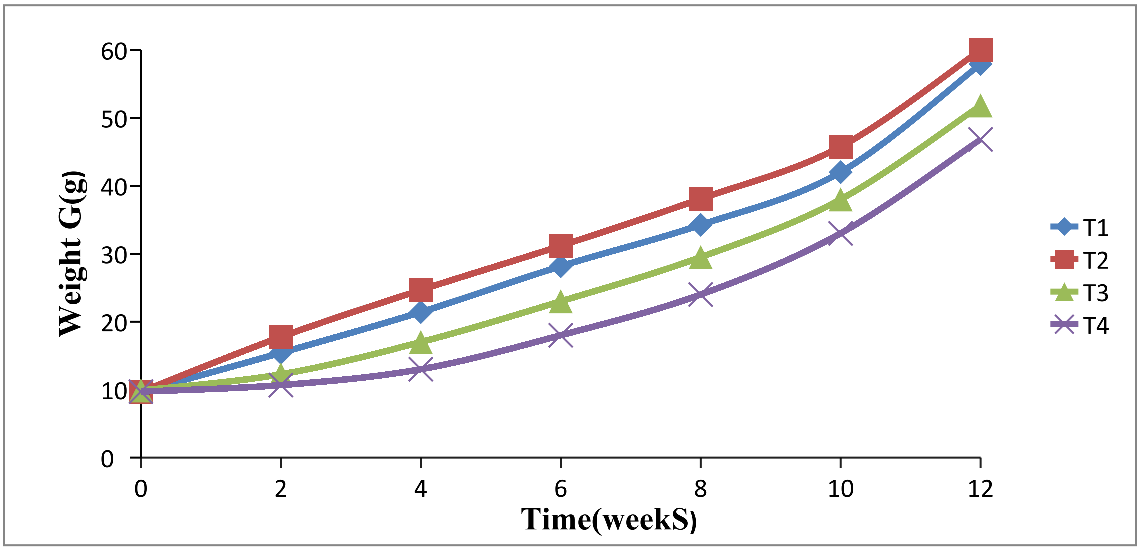


Figure 10 weight gains per week

4.4. Water Quality Parameters in ponds during fruit- vegetable leftover Supplementation

In this experiment, the water quality parameters measured (temperature, DO, salinity, TDS EC, NH4+, NO3 $NO2^-$, $NH3^+$ and PH) were not statistically significantly differences ($p > 0.05$) among all groups of treatment as showed in Table 8.

Table 8 **The results of water quality parameters in the ponds during different ratios fruit-vegetable leftover supplemented with basal diet**

Parameters	**No**	**T_1**	**T_2**	**T_3**	**T_4**	P-Value
Temperature(°c)	25	21.1 ±0.09	21.18 ± 0.02	21.18 ±0.01	21.16 ± 0.01	0.65
DO (mg/L)	25	7.05 ±0.03	6 86± 0.06	7.03± 0.06	7.04± 0.05	0.60
TDS (mg/L)	25	52.31± 1.80	51.52±0.02	51.83 ±4.6	52.80± 2.65	0.97
Salinity (ppt)	25	0.026 ± 0.00	0.016± 0.19	0.02 ±0.07	0.03 ± 0.00	0.47
EC (µs/cm)	25	83.30. ±3.48	81.12 ± 0.07	82.12 ±7.13	81.55 ± 4.55	0.96
$NO3^-$(mg/L)	3	1.85±0.00	1.79±0.01	1.85±0.00	1.91±0.01	0.16
$NH4^+$ (mg/L)	3	0.61±0.14	0.60±0.01	0.59±0.00	0.58±0.03	0.28
$NO2^-$(mg/L)	3	0.545±0.07	0.540±0.01	0.535±0.00	0.545±0.00	0.69
$NH3^+$ mg/L	3	0.045±0.00	0.048±0.00	0.049±0.00	0.045±0.00	0.68
PH	3	7.01±0.01	7.05±0.07	7.06±0.05	6.92±0.03	0.15

Note: Values represent mean ± standard deviation of duplicate tests.

4.5 proximate composition

The proximate composition of whole Nile tilapia reared by feed FVLO during this experiment are showed in Table 9. The dietary inclusion 25% of fruit-vegetable leftover increases the whole fish body crude protein and the lowest moisture than control and other ratio of fruit-vegetable leftover. However, T2 had lower contents of ash, and CHO.

Table 9 Proximate composition analysis result of whole tilapia (Except gut)

parameters	**T1**	**T2**	**T3**	**T4**
Protein	15.2±0.3	16.5±0.3	14.8±0.6	14.6±0.0
Ash%	1.2±0.0	0.9±0.1	1.3±0.14	0.78±0.1
Moisture%	80.23±0.16	79.78±0.3	80.91±0.07	81.04±0.0
Fat %	1.2±0.1	1.1±0.07	1.4±0.01	1.7±0.01
CHO	1.77±0.01	1.72±0.07	1.59±0.l0	1.88±0.01

5. Discussion

5. 1.Growth Performance of Nile Tilapia

In this study, the growth performance of Nile tilapia juveniles showed highly significant ($p < 0.05$) variations between the different ratios of fruit- vegetable leftover (FVLO) supplementation with basal diet. In terms of weight gain and other growth parameters, fish fed with 25% FVLO demonstrated significantly higher ($p < 0.05$) growth than those fed with other fruit waste ratio and the control diet. This may be due to some fruit wastes having adequate flavor and palatability, containing phenolic chemicals such as gallic acid and ferulic acid, which can promote fish and livestock growth (Cai, et. *al.,* 2020).

These results agree with findings from Dawood *et al*., (2020) & Sulaiman *et al*., (2022), who reported that dietary supplementation with fruit wastes could promote growth performance and stimulate the immune response against disease-causing agents. However, the weight gain and growth performance of fish in this study disagree with Kamali-Sanzighi *et al*. (2019), who reported no significant differences in all of growth and feeding parameters between fingerlings fed a basal diet and those fed a waste meal supplementation diet ($P>0.05$). In this study, as the supplementation ratio increased beyond 25%, the growth performance of fish decreased. This may be due to some fruit vegtable wastes having ant nutritional factor. The study results indicate that up to 25% of FVLO can be profitably used to replace the basal diet.

The value of survival rate of fish was not affected by the different ratios of fruit- vegetable leftover (FVLO) supplementation with basal diet. This study agreed with Yogesh (2016) who reported survival was good in all treatments; being 100% in T_2 (fish fed 10% of fruit waste was supplemented). The lowest survival was recorded in the control. In general, survival rate of fish during this study was good. This may be feeding Nile tilapia both of basal diet and FVLO was not affected on water quality and free from toxic.

Specific growth rate in the present study is lower than (*Rahman et. al.2022)* who reported 4.90 study of the specific growth rate (sgr) at different stages of tilapia (*Oreochromis niloticus*) production cycle in tank based aquaculture system. This may be due to feed substrate we used is different in protein content.

Feed conversion ratio in the present study is lower than Gutema &Haile Michael, (2021) who reported 2.48 Growth Response of Nile Tilapia Fries Fed on Silage-based Diets. This may be due to FCR is the ratio of given feed weight over fish weight gain in a certain period of time. Lower FCR value indicates that a feed is efficiently converted into fish weight gain while over feeding increase the ratio.

5.2 Water quality

In this experiment, the water quality parameters such as temperature, DO, and salinity were not significant varied ($p > 0.05$) between all groups of treatment. This is may be due to conducted at the same weather, water changing, stocking density and water sources for all treatments. But, feeding is different the feed does not any effect on water quality.

This study results agreed with Berzi-Nagy *et al*. (2021) those reported that the hypothesis that plant-based feeds can eventually completely replace fish oil feeds without having a negative impact on water quality in the semi-intensive fish production.

Ammonium ion depends on the pH of the water. If the water is acidic the ammonium ion will pick up a hydrogen ion and become the less toxic (to animals) ammonium molecule. In alkaline water it stays as ammonia. Ammonia is another water quality parameter that determines the condition of cultured fish in the culture system. According to El-Sherif and El-Feky (2008), ammonia is toxic to tilapia at concentrations of 2.5 mg/l and unionized ammonia becomes toxic to fish at 7.1 mg/l. However, the concentration of ammonium ion ($NH4+$) recorded in the present study was 0.61±0.14 (T1) 0.6±0.01 (T2), 0.6±0.007 (T3) and0.58±0.03 (T4) table 8.

This indicates that ammonia concentration recorded in the present study was in the optimum range of Nile tilapia production. Nitrite recorded during the study period was not significant among the treatment and controls (Table 8). According to (El-Sayed, 2006) the tolerance range of Nile tilapia to Nitrite is (0.1-0.2 mg/l. the present result is also on the side of this range.

5.3 proximate composition of tilapia

The proximate composition of whole Nile tilapia cultured with fruit-vegetable leftover (FVLO) feed showed 79.78-81.04% moisture, 14.6- l6.5% crude protein, 0.78-1.2% ash and 1.1±0.5-1.7±0.2% crude fat in wet base. This study demonstrated that the dietary inclusion 25% of fruit-vegetable leftover increased the whole fish body crude protein and moisture compared to the control and other ratio of fruit-vegetable leftover. , However, the ash and crude fat contents decreased. This result agrees with Suwannatrai *et al*., (2023), who reported a crude protein value of 14.2725 ± 0.0601% in sun-dried Nile tilapia. However, it does not align Olaniyi *et al*. (2016), who reported proximate composition results of *O. niloticus* from fresh water and brackish water, showing moisture content was of 73.92% in brackish water species and 72.07% in fresh water, and crude protein content of 17.90 % in brackish samples and 22.23% in the fresh water ones. The Carbohydrate content in the present study is approximately equal to the to 2.16% reported Sulaiman et al., (2022), who found that fruit wastes improved the growth and health of hybrid red tilapia. The fat content in the present study is greater than reported by Olopade *et.al.* (2016) who found a fat content of 0.54% in the proximate composition of Nile tilapia and hybrid red tilapia.

6. Conclusion and Recommendations

6.1 Conclusion

In general the FVLO supplement at 25% to basal diet induces higher growth performance, specific growth rate, survival rate, proximate composition and lower feed conversion ratio of the Nile tilapia. The result of this study showed that as FVLO supplementation ratio increase the value of growth performance, specific growth rate, survival rate, proximate composition decrease and increase feed conversion ratio of the Nile tilapia.

6.2 Recommendations

This study recommended that,

- ✓ To accelerate growth of fish FVLO should not be given alone, but combined with animals based feed ingredients make the feed complete.
- ✓ 25%FVLO is the for best growth performance and survival rate of Nile tilapia in hapa culture system however,
- ✓ Community awareness is required using such ingredient for fish feed and other animals beside to reduce environmental pollution.

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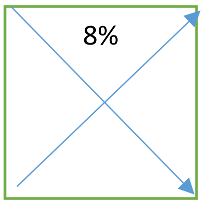
8. Appendix

Steps of feed Formulation

Step1 Feed formulation in fruit waste on 8%Cp=0.5%papaya&banana

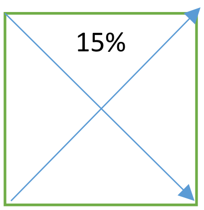
9 1=0.5



7 1 0.5

Step 2 Feed formulation in vegetable waste on 15%Cp=0.25% potato &0.75% cabbage

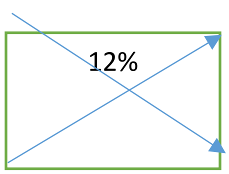
18 1=25%potato



14 3 =75% cabbages

Step 3 Feed formulation in combination of fruit & vegetable waste on 12% Cp=

15 4=57% vegetables



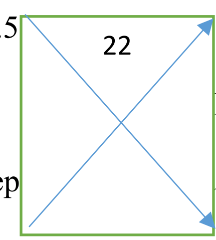
8 3= 43% Fruit

57% vegetables waste &43% fruit waste

Step 4 Formulation of feed from poultry manure& rumen liqueur on 22% Cp =

44% = poultry manure &56% rumen liqueur

24.5 2 =44% pm



20 L

Step l diet formulation ingredient=

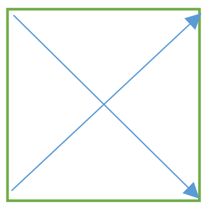
Cattle blood =80%Cp poultry manure& rumen liqueur=22%Cp

FV =12% cp

Step 5.1 T1 containing 0% FV & Formulate cattle blood 80% with poultry manure& rumen liqueur on 22% Cp =34% cattle blood &66% poultry manure& rumen liqueur

80 %CB

13 =22.41% cattle blood



22 %PM+RL

45 =77.59% the mixed of PM+RL

Treatment 1

Ingredient	%100
FV	0
CB	22.41
PM+RL	77.59

Step 5.2 T2 containing 25%FV &75% poultry manure& rumen liqueur

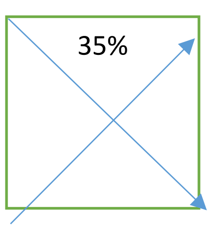
FV=25% *12 cp=3%

CB=100%*80 cp =80%

PM+RL=75*22cp =16.5%

80

15.5/60.5



19.5

45/60.5

CB=100%*15.5=15.5

FV=25%*45=11.25

PM+RL=33.75

15.4/60.5=25% CB

11.25/60.5=19% Fv

33.75/60.5=56%PM+RL

Treatment 2 (T2)

Ingredient	Out of 100%
CB	25
FV	19
PM+RL	56

Cattle blood =25% FV =19 % poultry manure& rumen liqueur=56%

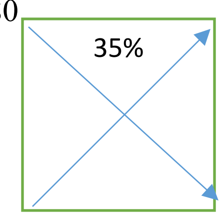
Step 5.3 feed containing equal amount 50% 50% Fv & poultry manure& rumen liqueur

CB=100*80Cp% =80CP

50%*12%CP=6 FV

50%*22CP=11

80 18 parts



17 45 parts

63

18 parts*100%=18

45parts*50%=22.5

45*50%=22.5

CB=18/63*100%=28.5%

FV=22.5/63*100=35.7%

PM+RL=22.5/63*100=35.7%

Cattle blood, 28.5% Fv 35.71% &35.71% poultry manure& rumen liqueur

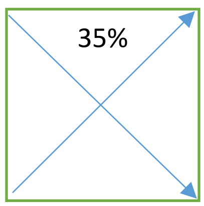
Step 6 T4 poultry manure& rumen liqueur is replaced by 75%Fv

CB=80*100% =80

FV=12*75%=9

PM+RL= 22*25%=5.5

80 20.5



14.5 45/65.5

CB=20.5*100=20.5parts

FV=45*75% =33.75Parts

PM+RL=45*25%=11.25parts

CB=20.5/65.5*100=31%

FV=33.75/65.5*100=52%

PM+RL=11.25/65.5*100=17%

In general Feed formulation looks like as follow

Ingredient	T1(0%FVW	T2(25%FVW)	T3(50%FVW	T4(75%FVW)
CB	22.41%	25%	28.5%	31%
FVLO	0%	19%	35.7%	52%
PM+RL	77. 59%	56%	35.7%	17%

Table 5 Actual amount of ingredients mixed

Ingredient in Kg	T1	T2	T3	T4	Total

Cattle Blood	0.56	0.625	0.7125	0.775	2.673
Poultry Manure	0.87	0.625	0.3925	0.187	2.0743
Rumen Liqueur	1.075	0.775	0.5	0.238	2. 59
Banana	0	0.1375	0.25	0.375	0.77
Papaya	0	0.1375	0.25	0.375	0.77
Cabbage	0	0.15	0.3	0.4125	0.86
potato	0	0.05	0.0925	0.1375	0.28
Total	2.5 Kg	2.5 Kg	2.5 Kg	2.5 Kg	10 Kg

Initial Weight Length Raw Data of Week 0

Treat	W & L	1	2	3	4	5	6	7	8	9	10	11	12
T1.1	W	9	9	10	10	8	10	11	11	10	11	11	10
	L	7	7	8	7	7	7	8	8	8	8	7	8
T1.2	W	9	10	9	11	8	8	11	9	10	9	10	8
	L	6	7	7	8	7	6	7	6	8	8	8	7
T2.1	W	11	8	10	9	10	10	9	11	10	10	9	9
	L	8	6	8	7	8	7	6	9	9	9	6	7
T2.2	W	10	11	11	10	9	9	10	9	10	9	9	9
	L	7	8	8	7	7	6	8	7	7	6	8	7
T3.1	W	9	10	11	11	9	8	11	10	9	10	11	10
	L	6	7	9	8	7	7	8	8	7	9	9	8
T3.2	W	11	9	8	10	10	9	10	11	10	11	9	10
	L	10	8	7	8	8	7	8	9	8	9	7	8
T4.1	W	11	11	9	10	10	9	11	9	9	8	9	10
	L	9	9	7	9	8	7	9	7	6	6	7	9

T4.2	W	9	10	9	11	9	10	9	9	9	11	10	11
	L	6	8	7	9	7	9	7	6	8	8	7	10

50% of Fish Weight –length Gain Per Weeks

Treat	WL	1	2	3	4	5	6	
T1.1	W	16	15	16	15	14	15	
	L	10	8	9	9	8	7	
T1.2	W	14	16	15	16	17	16	
	L	9	9	8	9	8	9	
T2.1	W	16	19	18	16	17	18	
	L	10	10	10	11	9	9	
T2.2	W	17	19	18	17	18	19	
	L	10	8	11	10	11	11	
T3.1	W	12	12	13	12	13	12	
	L	8	8	8	8	8	9	
T3.2	W	12	13	12	12	12	12	
	L	8	8	9	8	8	8	
T4.1	W	10	11	10	11	10	11	
	L	8	8	7	9	8	7	
T4.2	W	10	10	12	11	11	11	
	L	8	7	7	9	7	8	week 2
T1.1	W	22	21	22	23	21	20	
	L	11	11	12	12	12	11	
T1.2	W	21	22	19	22	21	23	
	L	10	11	10	10	11	11	
T2.1	W	25	23	24	25	23	25	
	L	12	12	13	14	12	14	
T2.2	W	25	24	26	24	25	27	
	L	14	14	14	13	11	13	
T3.1	W	20	17	13	15	17	16	
	L	11	11	9	9	10	10	

T3.2	W	22	20	16	16	17	15	
	L	10	9	9	9	9	9	
T4.1	W	12	12	12	13	14	12	
	L	8	8	8	9	9	8	
T4.2	W	10	12	14	11	13	12	
	L	8	8	8	9	10	10	week 4
T1.1	W	30	28	28	27	30	29	
	L	15	13	12	12	13	12	
T1.2	W	25	27	29	25	29	27	
	L	12	13	13	13	14	14	
T2.1	W	30	31	32	30	31	30	
	L	15	15	15	16	16	16	
T2.2	W	31	30	31	32	34	32	
	L	16	14	15	13	14	15	
T3.1	W	25	23	23	23	24	25	
	L	11	11	11	11	11	12	
T3.2	W	22	23	24	24	22	18	
	L	11	12	12	12	11	12	
T4.1	W	20	22	17	18	18	17	
	L	10	11	10	10	10	11	
T4.2	W	19	17	17	16	17	18	
	L	10	10	9	10	9	10	week 6
T1.1	W	37	34	32	33	33	32	
	L	16	15	16	15	16	17	
T1.2	W	33	37	37	36	32	35	
	L	15	1 5	16	15	14	16	
T2.1	W	40	37	35	39	37	35	
	L	18	18	17	17	17	18	
T2.2	W	40	42	39	36	37	41	
	L	18	18	17	16	19	17	
T3.1	W	33	28	30	30	31	29	

	L	14	14	13	14	14	12	
T3.2	W	30	31	28	27	29	28	
	L	14	14	14	13	13	14	
T4.1	W	23	23	27	27	23	25	
	L	12	12	13	13	12	12	
T4.2	W	23	22	23	24	23	25	
	L	11	11	11	11	12	11	week 8
T1.1	W	41	40	46	46	42	39	
	L	19	17	17	19	16	17	
T1.2	W	41	42	42	40	40	45	
	L	18	18	18	17	16	18	
T2.1	W	44	45	42	48	47	45	
	L	22	20	19	21	17	21	
T2.2	W	46	46	45	47	45	49	
	L	18	18	18	20	22	20	
T3.1	W	40	41	37	37	38	38	
	L	15	17	17	15	17	16	
T3.2	W	40	37	38	37	36	37	
	L	18	16	15	17	16	17	
T4.1	W	30	31	34	33	35	33	
	L	12	13	14	14	14	14	
T4.2	W	34	34	34	32	33	33	
	L	14	14	14	13	15	15	week 10
T1.1	W	59	60	60	57	56	60	
	L	25	23	24	18	17	18	
T1.2	W	57	59	60	55	55	57	
	L	19	19	23	20	17	17	
T2.1	W	71	63	63	64	61	58	
	L	27	25	27	19	19	19	
T2.2	W	70	65	59	64	64	60	
	L	23	22	23	23	19	18	

T3.1	W	55	52	52	53	48	50	
	L	20	17	17	18	18	17	
T3.2	W	52	55	49	54	53	49	
	L	21	17	17	18	17	16	
T4.1	W	45	46	47	46	48	46	
	L	15	15	15	16	17	15	
T4.2	W	47	45	44	50	51	47	
	L	16	13	14	17	17	17	week 12

Mortality Rate Data During 90 days

Treat	*T1.1*	*T1.2*	*T2.1*	*T2.2*	*T3.1*	*T3.2*	*T4.1*	*T4.2*	*Total*
No.	*1*	*-*	*-*	*-*	*1*	*1*	*2*	*1*	*6*

Temperature Raw Data from week 0-12

Treat	wek0	wk 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	week 10	week 11	week 12
T1.1M	18	17.7	18.6	18	19	20	20.4	19	19	19.2	20	19	20
T1.1E	23	23.4	22.4	23	23.4	22	22	25	21	23	24	24	22
T1 AV	20.5	20.55	20.5	20.5	21.2	21	21.2	22	20	21.1	22	21.5	21
T1.2M	18	18	18.8	18.3	19.2	20	20	19.3	19.4	19.6	20.2	19.4	20
T1.2E	23	23	23	23.1	23	22.3	22	25.1	21.3	22.8	24	24.1	22.1
T1.2 AV	20.5	20.5	20.9	20.7	21.1	21.15	21	22.2	20.35	21.2	22.1	21.75	21.05
T2.1M	18.2	18.5	18.9	18.1	19.6	20.3	19.9	18.9	19	19.8	19.9	19	19.9
T2.1E	22.7	23.2	23.4	22.9	25.5	22	23	23.5	21.5	22	24	24.3	21
T2.1 AV	20.45	20.85	21.15	20.5	22.55	21.15	21.45	21.2	20.25	20.9	21.95	21.65	20.45
T2.2M	18.4	18.7	19.2	18	19	20.1	19.8	19	19.3	20	19.7	19	20
T2.2E	22.9	23.2	23.3	22.9	25.6	22.5	23.2	23	21.8	22.5	23.8	23.8	21.5
T2.2 AV	20.65	20.95	21.25	20.45	22.3	21.3	21.5	21	20.55	21.25	21.75	21.4	20.75
T3.1M	18.5	18.6	19.4	18.5	19.9	20	18	19.8	19.5	19	19.6	19.6	18
T3.1E	23.1	23.5	23.5	24	23	22.3	23	23	22	23	24	23	24
T3.1 AV	20.8	21.05	21.45	21.25	21.45	21.15	20.5	21.4	20.75	21	21.8	21.3	21
T3.2M	19	18.6	19.4	18.5	19	20	18.3	19.5	19.6	19.4	19.5	18.9	18.9
T3.2E	23	23.5	24	23.9	23.3	22	22.8	23.4	22.5	22.5	24	23	24.1
T3.2 AV	21	21.05	21.7	21.2	21.15	21	20.55	21.45	21.05	20.95	21.75	20.95	21.5
T4.1M	18.7	18.8	19.4	17.9	18	20	20	20	19.3	19.5	20	18.9	17.7

T4.1E	22.9	23.7	24	23	25.4	21	23	23.5	21.9	23	23.8	23.3	21
T4.1 AV	20.8	21.25	21.7	20.45	21.7	20.5	21.5	21.75	20.6	21.25	21.9	21.1	19.35
T4.2M	18.8	18	19.3	18.1	18.9	20	20	20.4	19.5	20	20	19.1	18.4
T4.2E	23	24	23.7	23.7	26	21	23.4	23	22	22.8	23.7	23	21.6
T4.2 AV	20.9	21	21.5	20.9	22.45	20.5	21.7	21.7	20.75	21.4	21.85	21.05	20

Dissolved Oxygen Raw Data from week 0-12

TREAT	Wek0	week1	week2	week3	week4	week5	week 6	week 7	week 8	week 9	wek 10	wek 11	wek 12
T1.1M	6.12	4	4.35	5	6	5.75	7	5	5	5	5	5	5
T1.1E	7.24	7.87	7.53	8.9	7.87	8	7	10	9	8	7	8	9
T1.AV	6.68	5.935	5.94	6.95	13.87	6.875	7	7.5	7	6.5	6	6.5	7
T1.2M	5.44	5.44	4.9	5.2	6.3	4.3	6.5	5.7	5.3	4.8	6	4	5.5
T1.2E	7.53	8.33	7.53	8.7	8.33	9	6.9	9.5	8	7.7	8	9	9
T1.2 AV	6.485	6.885	6.215	6.95	7.315	6.65		7.6	6.65	6.25	7	6.5	7.25
T2.1M	5.56	5.54	5.88	6	3.78	5	6	5.9	5.1	6	5	5.6	5
T2.1E	8.31	8.72	8.31	8.4	10	9	7	8.8	7	8	7	7.5	8.9
T2.1 AV	6.935	7.13	7.095	7.2	6.89	7	6.5	7.35	6.05	7	6	6.55	6.95
T2.2 M	5.46	5.46	6.1	5.96	5.16	6	5.8	6.3	4.7	5.3	5	5.6	6.55
T2.2 E	8.75	8.77	8.75	9	9.7	9	8	7.4	8	7	7.3	7.8	7
T2.2 AV	7.105	7.115	7.425	7.48	7.43	7.5	6.9	6.85	6.35	6.15	6.15	6.7	6.775
T3.1M	7	7	6.29	5.3	7	6	5.5	6	6	5	4.8	5.2	6
T3.1E	9.28	8.77	9.28	9.7	9.7	7	7.9	7	8	9	6.7	7	9.5
T3.1 AV	8.14	7.885	7.785	7.5	8.35	6.5	6.7	6.5	7	7	5.75	6.1	7.75
T3.2M	7	7	6.17	5.3	7.35	5	4	6.3	5.8	5.2	6	5	7.6
T3.2E	9.69	9.68	9.69	8	9.66	6.8	8	7.5	6.8	7	8	7.8	8

T3.2AV	8.345	8.34	7.93	6.65	8.505	5.9	6	6.9	6.3	6.1	7	6.4	7.8
T4.1M	7.32	7.32	6.21	5.2	6	5.9	6	5	6	6	5	4	7
T4.1E	8.5	9.67	8.5	7	9	7	10	9	9	9	6	8	7.9
T4.1AV	7.91	8.495	7.355	6.1	7.5	6.45	8	7	7.5	7.5	5.5	6	7.45
T4.2 M	7.35	7.35	6.25	5.6	6.2	6.2	6	5.5	5.8	6	5.67	4.5	6
T4.2E	8.76	9.62	8.76	8	8.66	6.6	8.9	8.5	8	8	7	7.1	7.7
T4.2 AV	8.055	8.485	7.505	6.8	7.43	6.4	7.45	7	6.9	7	6.335	5.8	6.85

Electric conductivity raw data from week 0-12

TREAT	Wek0	week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	wek 10	wek 11	wek 12
T1.1M	72	80	89	72	88	96	71	84	78	81	83	83	90
T1.1E	76	75	83	86	76	82	73	99	60	61	84	84	83
T1.AV	74	77.5	86	79	82	89	72	91.5	69	71	83.5	83.5	86.5
T1.2M	72	88	89	72	88	94	78	83	90	92	87	87	96
T1.2E	78	75	84	84	75	82	81	99	93	86	87	87	82
T1.2 AV	75	81.5	86.5	78	81.5	88	79.5	91	91	89	87	87	89
T2.1M	90	86	73	90	92	87	68	95	90	94	68	68	94
T2.1E	77	76	68	84	92	93	76	78	69	60	87	87	60
T2.1 AV	83.5	81	70.5	87	92	90	72	86.5	79.5	77	77.5	77.5	77
T2.2 M	88	88	73	88	84	96	82	99	78	66	75	75	66
T2.2 E	67	76	70	83	78	90	78	95	60	92	87	87	93
T2.2 AV	77.5	82	71.5	85.5	81	93	80	97	69	79	81	81	79.5
T3.1M	86	75	76	86	75	87	71	71	74	82	84	84	78
T3.1E	70	78	73	86	77	90	74	66	69	60	84	84	66
T3.1 AV	78	76.5	74.5	86	76	88.5	72.5	68.5	71.5	71	84	84	72
T3.2M	76	77	75	76	77	90	88	85	95	99	93	93	95
T3.2E	68	77	75	76	88	96	85	87	93	98	93	93	88
T3.2 AV	72	77	75	76	82.5	93	86.5	86	94	98.5	93	93	91.5

T4.1M	75	73	72	75	88	81	71	87	71	93	84	84	68
T4.1E	74	87	79	72	88	90	66	85	60	60	84	84	78
T4.1AV	74.5	80	75.5	73.5	88	85.5	68.5	86	65.5	76.5	84	84	73
T4.2 M	76	74	72	76	92	82	86	88	91	65	93	93	95
T4.2E	73	85	69	76	88	96	88	87	93	92	87	87	88
T4.2 AV	74.5	79.5	71.5	76		89	87	87.5	92	78.5	90	90	91.5

Total dissolved solution from week 0-12

TREAT	Wek0	week 1	week 2	week 3	week 4	wek 5	week 6	week 7	week 8	week 9	week 10	week 11	week 12
T1.1M	72	80	89	72	88	96	71	84	78	81	83	83	90
T1.1E	76	75	83	86	76	82	73	99	60	61	84	84	83
T1.AV	74	77.5	86	79	82	89	72	91.5	69	71	83.5	83.5	86.5
T1.2M	72	88	89	72	88	94	78	83	90	92	87	87	96
T1.2E	78	75	84	84	75	82	81	99	93	86	87	87	82
T1.2 AV	75	81.5	86.5	78	81.5	88	79.5	91	91	89	87	87	89
T2.1M	90	86	73	90	92	87	68	95	90	94	68	68	94
T2.1E	77	76	68	84	92	93	76	78	69	60	87	87	60
T2.1 AV	83.5	81	70.5	87	92	90	72	86.5	79.5	77	77.5	77.5	77
T2.2 M	88	88	73	88	84	96	82	99	78	66	75	75	66
T2.2 E	67	76	70	83	78	90	78	95	60	92	87	87	93
T2.2 AV	77.5	82	71.5	85.5	81	93	80	97	69	79	81	81	79.5
T3.1M	86	75	76	86	75	87	71	71	74	82	84	84	78

T3.1E	70	78	73	86	77	90	74	66	69	60	84	84	66
T3.1 AV	78	76.5	74.5	86	76	88.5	72.5	68.5	71.5	71	84	84	72
T3.2M	76	77	75	76	77	90	88	85	95	99	93	93	95
T3.2E	68	77	75	76	88	96	85	87	93	98	93	93	88
T3.2 AV	72	77	75	76	82.5	93	86.5	86	94	98.5	93	93	91.5
T4.1M	75	73	72	75	88	81	71	87	71	93	84	84	68
T4.1E	74	87	79	72	88	90	66	85	60	60	84	84	78
T4.1AV	74.5	80	75.5	73.5	88	85.5	68.5	86	65.5	76.5	84	84	73
T4.2 M	76	74	72	76	92	82	86	88	91	65	93	93	95
T4.2E	73	85	69	76	88	96	88	87	93	92	87	87	88
T4.2 AV	74.5	79.5	71.5	76		89	87	87.5	92	78.5	90	90	91.5

Salinity Raw Data from week 0-12

TREAT	Wek0	week 1	week 2	week 3	week 4	wek 5	week 6	week 7	week 8	week 9	wek 11	wek 12
T1.1M	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.03	0.02	0.03
T1.1E	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.03	0.03
T1.AV	0.025	0.025	0.03	0.03	0.03	0.02	0.03	0.02	0.025	0.025	0.025	0.03
T1.2M	0.02	0.03	0.03	0.03	0.03	0.025	0.02	0.02	0.02	0.03	0.03	0.03
T1.2E	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03
T1.2A	0.02	0.025	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.025	0.03	0.03
T2.1M	0.03	0.03	0.02	0.02	0.03	0.02	0.03	0.02	0.03	0.03	0.02	0.03
T2.1E	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.02
T2.1av	0.025	0.025	0.02	0.02	0.03	0.02	0.025	0.02	0.025	0.025	0.025	0.025

T2.2 M	0.03	0.02	0.02	0.02	0.03	0.025	0.02	0.02	0.03	0.03	0.02	0.02
T2.2 E	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.03
T2.2av	0.025	0.025	0.02	0.02	0.03	0.02	0.02	0.025	0.025	0.025	0.025	0.025
T3.1M	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.03	0.03	0.03
T3.1E	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02
T3.1av	0.025	0.02	0.02	0.02	0.025	0.02	0.02	0.02	0.025	0.025	0.03	0.025
T3.2M	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03
T3.2E	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03
T3.2av	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03
T4.1M	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.02
T4.1E	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.03	0.03	0.03
T4.1AV	0.02	0.025	0.02	0.02	0.03	0.02	0.02	0.025	0.02	0.03	0.03	0.025
T4.2 M	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.03
T4.2E	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.02
T4.2av	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.025