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Castro-Mejía J
Universidad Autónoma Metropolitana Xochimilco. División de CBS. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calzada del Hueso No.1100, Colonia Villa Quietud. Alcaldía de Coyoacán. CP. 04960. Ciudad de México

Castro-Mejía G
Universidad Autónoma Metropolitana Xochimilco. División de CBS. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calzada del Hueso No.1100, Colonia Villa Quietud. Alcaldía de Coyoacán. CP. 04960. Ciudad de México

Castro-Castellón AE
Universidad Autónoma Metropolitana Xochimilco. División de CBS. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calzada del Hueso No.1100, Colonia Villa Quietud. Alcaldía de Coyoacán. CP. 04960. Ciudad de México

Martínez-Meingüer AM
Universidad Autónoma Metropolitana Xochimilco. División de CBS. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calzada del Hueso No.1100, Colonia Villa Quietud. Alcaldía de Coyoacán. CP. 04960. Ciudad de México

Reséndiz-Corona A
Universidad Autónoma Metropolitana Xochimilco. División de CBS. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calzada del Hueso No.1100, Colonia Villa Quietud. Alcaldía de Coyoacán. CP. 04960. Ciudad de México

Corresponding Author:
Castro-Mejía J
Universidad Autónoma Metropolitana Xochimilco. División de CBS. Depto. El Hombre y su Ambiente. Laboratorio de Producción de Alimento Vivo y Biofloc. Calzada del Hueso No.1100, Colonia Villa Quietud. Alcaldía de Coyoacán. CP. 04960. Ciudad de México

Preliminary study of *Oreochromis nilóticus, Coriandrum sativum, Anethum graveolens*, and *Petroselinum crispum* growth cultured in Biofloc/aquaponic system

Castro-Mejía J, Castro-Mejía G, Castro-Castellón AE, Martínez-Meingüer AM and Reséndiz-Corona A

Abstract
The culture of aromatic plants using this system is not a new activity but using flocs from Biofloc system is relatively new. That is why it was stablished a vertical aquaponic system to produce aromatic plants combined with tilapia production in a Biofloc system. It was planted dill, parsley and coriander. Tilapia organisms were fed with a dry diet with 35% of protein and Moringa as carbon source to produce Biofloc. At the end of experiment, tilapia organisms had a survival of 95% and weight of 436.24 ±0.52 g mean value org^{-1}. The aromatic plant which obtain the highest length was the coriander with 20.94±0.49 cm, with a mean gain of 12.85 cm, an AGR of 0.080 cm day^{-1} and IGR of 0.59% day^{-1}. The parsley has the lowest value with 8.64±0.46 cm total length, a gain of 2.37 cm, an AGR of 0.014 cm day^{-1}, an IGR of 0.20% day^{-1}. Dill obtained 11.55±0.15 cm of total length, a gain of 3.17 cm, an AGR of 0.019 cm day^{-1}, an IGR of 0.20% day^{-1}. The positive obtained results in this study suggested than Biofloc/aquaponics system is adequate to produce these three aromatic plants used in many food plates of Mexican cuisine.

Keywords: *Oreochromis nilóticus, Coriandrum sativum, Anethum graveolens, Petroselinum crispum*

1. Introduction
Tilapia fish has become in Mexico in an economic important specie, because since 2016 it has been reported a production of more than 150,000 tons with an economic value of $106,453.33 million USD. México is the nineth worldwide producer of tilapia. This represent to Mexico the 94.3% of their national fishery production. The principal country producers' entities are Jalisco, Chiapas, Sinaloa, Nayarit, Michoacán, Veracruz, Tabasco, Guerrero, Hidalgo and México [1].
The tilapia or mojarra is a freshwater fish, with a length from 10 to 30 cm, with different skin coloration according to specie. Their native origin is Africa and was introduced in water bodies of Mexico since 1964. Their geographical distribution includes Central America, South Caribbean, South North America, Southeast Asia, Middle East and Africa. Tilapia have long and narrow body, small mouth which does not reach eye margin, dorsal fin in crest type with thorns and ratio in his final portion, and a caudal fin round and truncated. Worldwide level, tilapia fish has the second place in aquaculture activity and some few species in Mexico are cultured for human consumption. In Mexico, it exists 4,623 fish farming which produce tilapia and some varieties [1-3].
Tilapia has great qualities for their culture in ponds like fast growing, great physical endurance, high reproduction capacity, great adaptations to live in captivity, and cultured in high densities concentration, also, accept a great variety of live and dry foods that allows highly profits. Another important characteristic in tilapia culture, is that it can be cultured in low oxygen concentrations and can be cultured in fresh and salty waters too. This characteristic allows tilapia to be cultured in mixed culture system with other organisms like shrimps and prawns, among others; also, vegetables, fruits, ornamental and aromatic plants were cultured in aquaponic systems. Since 2001, in Mexico, the Universidad Autónoma Guadalajara, started bioassays with tilapia and Australian lobster cultured with cucumbers, lettuce, and tomato [4].

In 2005, The Centro de Estudios Superiores del Estado de Sonora developed a little scale aquaponic system to produce tilapia, tomato, European cucumber, lettuce, and hydroponic green grass [4]. At Instituto de Boca del Río, Veracruz, in 2012 they began to make studies with hydroponic/aquaponic productions of basil and Malay shrimp (*Macrobrachium rosenbergii*) [5].

However, the combination of fish and plant cultures demands high quantities of water, generating a overexploitation of water sources reservoirs, causing environmental pollution caused by water discharges with high organic matter concentration, nutrients, and antibiotics which affect water quality of fishes and plants culture medium [6]. For that, it was necessary the development of an alternative culture system with low environmental impact for the use and contamination of water, also low food expense and the organic nutrient source to plants [7, 8]. This condition in culture medium can be achieved by applying an external carbohydrates source to culture medium and a better management of quality and quantity of food supplied. This allows to produce a heterotrophic bacterial community beneficial to fish as biomass source and for their capacity to eliminate nitrogen compounds and transformed into useful compounds to plants (nitrites and nitrates) [9, 10]. Therefore, a high fish and plant survival and better growth rate and weight gains are achieved [11, 12].

For all above, this is a preliminary study of culture Tilapia (*O. niloticus)* and aromatic plants *Coriandrum sativum, Anethum graveolens* and *Petroselinum crispum* in laboratory conditions.

2. Materials and methods

2.1 Fishes

Fifty juveniles' stage of *O. niloticus* with a mean initial length of 1.18±0.28 cm, mean height of 1.37±0.46 cm, mean width of 0.51±0.05 cm and mean weight of 0.26±006 g, were introduced in a 200 L plastic beaker with 160 L of water (0.80 x 1.0 m). With constant strong aeration to maintain the water column in movement (Fig.1). Temperature was maintained at 23±2°C and every 10 days was measured the chemical parameters of nitrates, nitrites, ammonium, phosphate, pH and chloride.

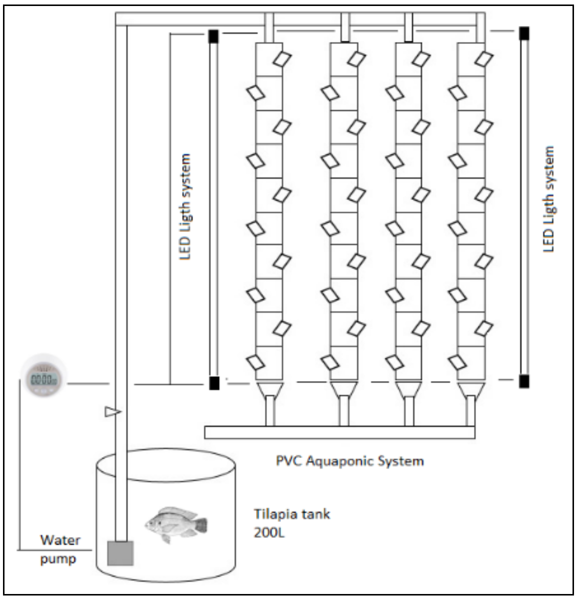

Fig 1: PVC vertical aquaponic system with *O. niloticus* and aromatic plants

Every 10 days, organisms were measured with a Digital Vernier Truper® ±0.001mm precision and weighted with a Digital balance Nimbus® ±0.01 g precision. Organisms total weight was used to obtain the 10% of food ratio of dry Tilapia pellet 35% of protein, 10% lipid, and 30% fiber content and the 0.01% of total weight of carbohydrate source (moringa flour) to produce Biofloc.

2.2 Plants

Coriandrum sativum (Coriander), *Anethum graveolens* (Dill), and *Petroselinum crispum* (Parsley) seed were sown in 250 mL plastic beakers, filled with 200 mL of peat moss. From each aromatic plants were sown 20 plastic beakers with three seed each one. Plastic containers were drilled down with four holes to allow water absorption. All plastic containers were placed in a plastic dish (60x40x2 cm), under a solar light tube of 60 watts with a photoperiod of 12/12 hours light/dark, until plant hatch and reach 5 cm tall with a well branched root. Peat moss was retired, and plant root was wrapped with a sponge cylinder (4 cm wide and 5 cm tall) and introduced to 250 mL plastic beaker again and introduced in each PVC aquaponic holes (Fig.1).

2.3 Aquaponic tower

An aquaponic PVC tower was made with a 10 cm diameter PVC tube. Thirty holes were made in each tower to put the 250 mL plastic beakers with the aromatic plants. In each hole was introduced and glued a segmented PVC elbow of 45°. Each aquaponic tower had a LED light tube 1.0 m length of 18 watts, connected to a temporize clock (Timer Digital LG®), turned on for three hours and turned off 2 hours each day.

2.4 Water flow

A water circulation system was made with two fountain water pumps (Simple Deluxe 400 GPH UL®). One pump was placed in a water reservoir cylinder (used to eliminated big debris), and another pump in 200 L fish plastic beaker. The pumps were connected to temporized clock (Timer Digital GE®), turned on for three hours and turned off for two hours each day.

2.4 Information processing

Every ten days, biometric values of total length, tall, width and weight of fishes, and total length and number of leaves of aromatic plants were introduced into a data base in Excel 2010 to obtain their descriptive statistic and their growth tendency curves. Also, their gain values, Absolute Growth Rate (AGR) and Instantaneous Growth Rate (IGR).

To obtain the gain values (G) of biometric values the following formula was used:

G = Final value - Initial value

To obtain AGR the following formula was used:

$$AGR = \frac{\text{Final value} - \text{Initial value}}{\text{Total culture days}}$$

To obtain IGR the following formula was used:

$$IGR = \frac{\text{Ln (Final value)} - \text{Ln (Initial value)}}{\text{Total culture days}} \times 100$$

3. Results

3.1 Chemical parameters of water

The pH variable was maintained between 6.7-7.3; chloride between 0.13-0.21 mg L^{-1}; ammonium (NH_4) between 0.69 a 1.06 mg L^{-1}; nitrates (NO_3) between 16-102 mg L^{-1}; nitrites (NO_2) between 11-27 mg L^{-1}; and phosphates between 0.42-11.97 mg L^{-1}.

3.2 Survival

At the end of the experiment it was obtained a survival of 95% in tilapias and plants between 90-95% at final culture experimental day.

3.3 Biometric values of fishes

Mean values (±SD) are shown in Table 1. The organisms reached at 160 culture days a total length of 19.56±0.54 cm, height of 5.96±0.56 cm, width of 6.89±0.25 cm, and weight of 436.24±0.52 g.

Table 1: Mean values (±SD) of biometric variables of fishes fed with dry pellets (35% protein content) and Moringa as carbohydrates source

Sampling days	Biometric values considered			
	Total length (cm)	Height (cm)	Width (cm)	Weight (g)
0	1.18 ±0.28	1.37 ±0.46	0.51 ±0.05	0.26 ±0.06
10	3.23 ±0.11	3.45 ±0.09	3.41 ±0.46	1.51 ±0.37
20	3.44 ±0.73	4.08 ±0.55	4.28 ±0.39	6.23 ±0.16
30	3.68 ±0.62	4.45 ±0.42	4.79 ±0.63	14.42 ±0.30
40	4.89 ±0.33	4.71 ±0.70	5.15 ±0.25	26.07 ±0.26
50	6.11 ±0.63	4.91 ±0.39	5.43 ±0.42	41.19 ±0.18
60	7.34 ±0.12	5.07 ±0.58	5.66 ±0.68	59.77 ±0.27
70	8.56 ±0.39	5.21 ±0.61	5.85 ±0.49	81.82 ±0.35
80	9.78 ±0.33	5.33 ±0.39	6.02 ±0.29	107.34 ±0.72
90	11.00 ±0.64	5.44 ±0.17	6.17 ±0.51	136.32 ±0.58
100	12.23 ±0.11	5.53 ±0.11	6.30 ±0.56	168.77 ±0.46
110	13.45 ±0.52	5.62 ±0.29	6.42 ±0.64	204.68 ±0.09
120	14.67 ±0.57	5.70 ±0.47	6.53 ±0.28	244.06 ±0.58
130	15.90 ±0.27	5.77 ±0.44	6.63 ±0.50	286.91 ±0.09
140	17.12 ±0.58	5.84 ±0.50	6.72 ±0.31	333.22 ±0.17
150	18.34 ±0.13	5.90 ±0.31	6.81 ±0.37	383.00 ±0.22
160	19.56 ±0.54	5.96 ±0.56	6.89 ±0.25	436.24 ±0.52

Growth tendency curve of fish's biometric values are shown in Fig. 2.

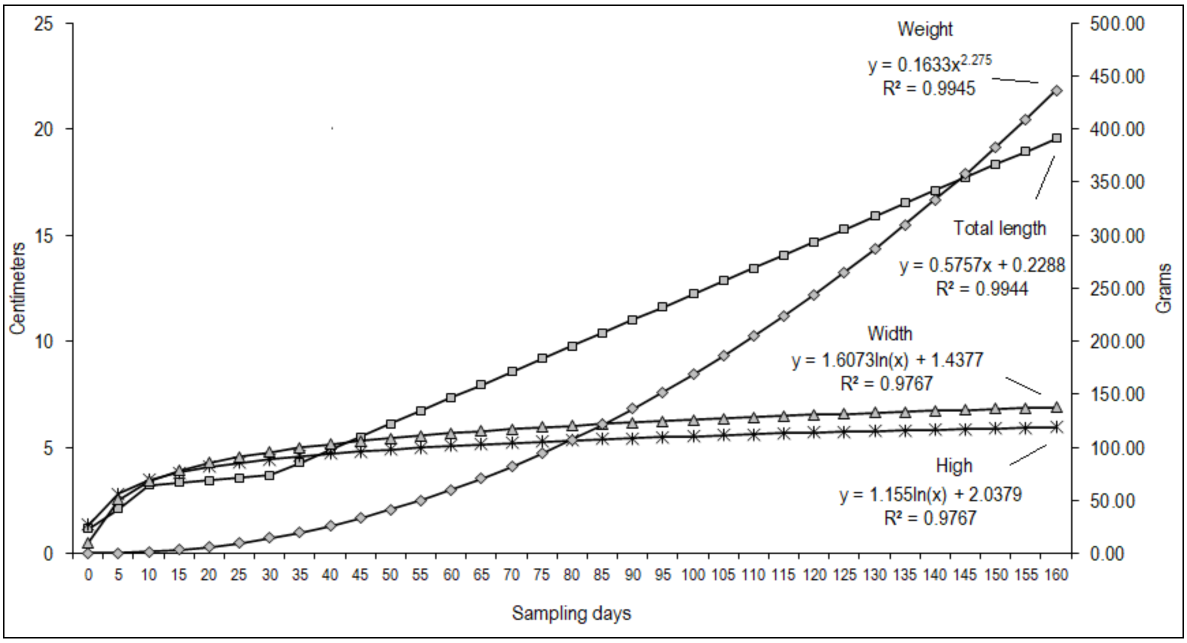

Fig 2: Growth tendency curves of biometric variables of *O. niloticus* fishes in aquaponic/Biofloc system

3.4 Gain, AGR and IGR biometric values of fishes

Table 2 shows the gain, AGR and IGR values of Tilapia culture in Biofloc system.

Table 2: Gain, AGR and IGR (%) values of *O. niloticus* in aquaponic/Biofloc culture system

Biometric variable	Gain	Absolute Growth Rate (TCA)	Instantaneous Growth Rate (TIC) (%)
Total length (cm)	18.38	0.115	1.75
Height (cm)	4.59	0.029	0.92
Width (cm)	6.38	0.040	1.63
Weight (g)	435.98	2.725	4.64

3.5 Aromatic plants
3.5.1 Total length of plants stem
Total length of coriander, parsley and dill and their tendency growth curves are shown in Fig. 3. Coriander plant reached a total length of 20.94±0.49 cm, with a mean gain value of 12.85 cm, an AGR of 0.080 cm day^{-1}, and IGR of 0.59% day^{-1}. Parsley had a total length of 8.64±0.46 cm, with a mean gain value of 2.37 cm, an AGR of 0.014 cm day^{-1}, and IGR of 0.20% day^{-1}. Dill plants had a total length of 11.55±0.15 cm, a gain value of 3.17 cm day^{-1}, an AGR of 0.019 cm day^{-1}, and IGR of 0.20% day^{-1}.

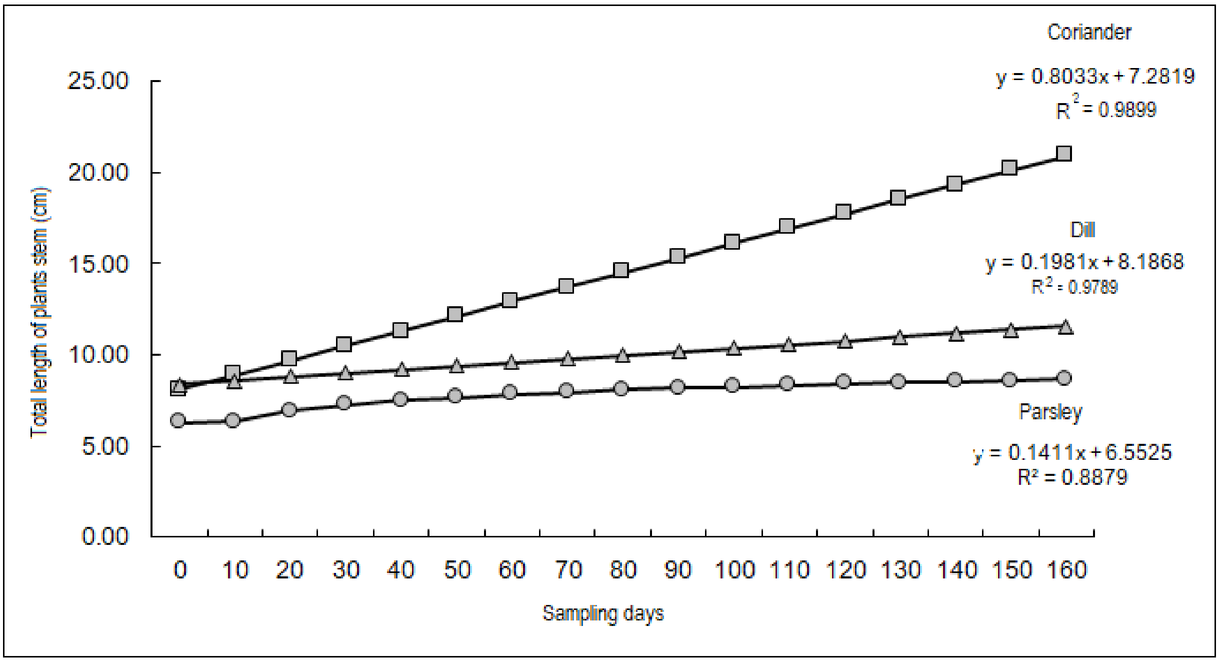

Fig 3: Total lengths of plants stem of coriander, parsley and dill in aquaponic/Biofloc system with *O. niloticus*

3.5.2. Total number of plants leaves
At Fig.4 are shown the total number of aromatic plants leaves and tendency curves of this variable in aquaponic/Biofloc culture system. At the end of experiment, the coriander stem had 26 leaves, parsley stem 23 leaves, and dill stem 113 leaves.

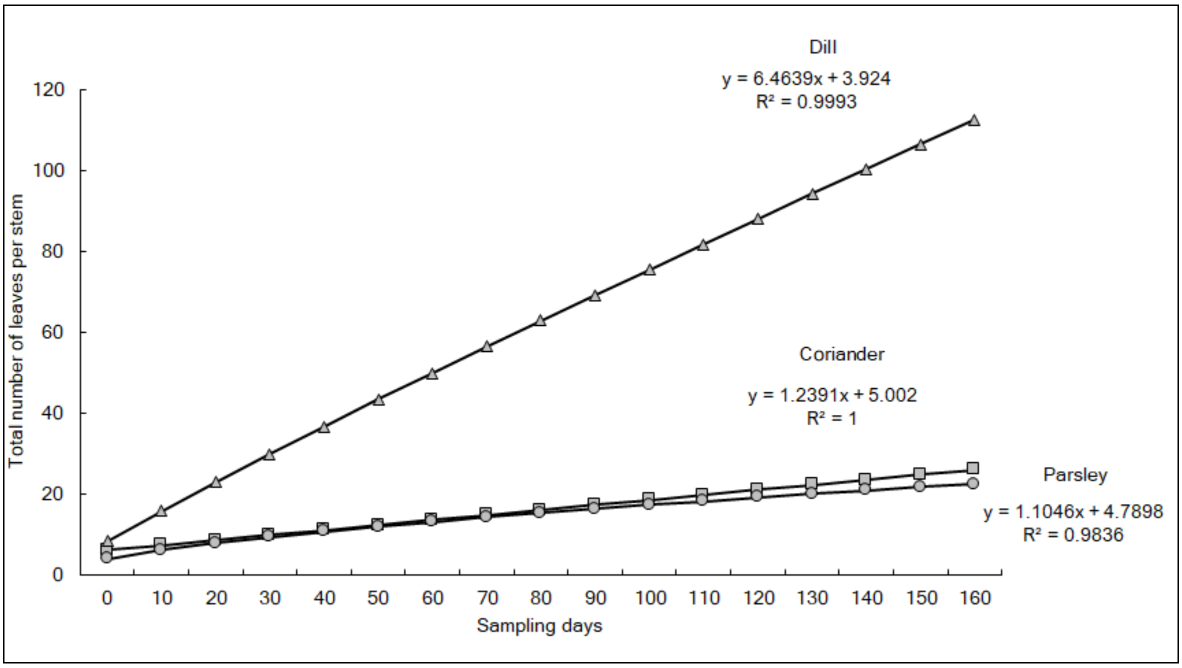

Fig 4: Total leaves per plant stem and tendency curve of coriander, parsley and dill cultured in aquaponic/Biofloc culture system with *O. niloticus*.

4. Discussion
Aromatic plants have a culinary use that is more important every day because consumers want more healthier food, principally in selection of organic and ethnic products [13]. Among the most demanded aromatic plants in market, are find the dill (*Ocimum basilicum* L.) [5], the peppermint (*Mentha spicata* L.), and mint (*Mentha piperita* L.) [14, 15]. Although there are other important aromatic plants to be cultured like sage, thyme, mint, rosemary, and oregano [16]. However, information scarcity is notable about plant

production in aquaponic systems, particularly peppermint and mint, plants with a high productive potential in those type of systems [17-19].

Ronzón-Ortega *et al*. [20], obtained good results with coriander production in an aquaponic systems in a culture period of 60 days, they obtained plants with a stem growth of 20 cm and nine branches with nine leaves each one. Different values to the ones obtained in this study because at 60 culture days the stem had less than 15 cm. Only at final culture day, the stem of coriander reached 20 cm (160 days). Nitrates, nitrites, phosphates and pH values were maintained stable during all experimental culture days (160), thanks to the Biofloc system establishment with the bacterial community in tilapia culture medium. Also, the light lamps used for this experiment was insufficient to growth plants.

For many herbaceous plants, the optimal pH range is 7.80-8.30 [21]. For the culture period of plants in this study, dill showed the lowest growth rate, because their optimal pH range need to be acid (<6.5). Caló [22], mentioned that for aromatic plants pH culture medium need to be around 5.5-6.5, that allow better efficiency nutrient absorption. The pH value is one of the principal factors to get a better plant grow, because it affects the absorption of nutrients from water to obtain better growth [23, 24]. In other way, Rakocy [25], suggest that higher pH value with temperature variable outstand optimal parameters can cause growth problems in aromatic plants.

Physical and chemical factors showed no toxicity in Tilapia culture. The organisms showed good weight and total length at the end of the 160 culture days. Similar studies were made by Espinosa *et al*. [21] when they cultured tilapias with aromatic plants like mint, peppermint and dill. The fishes showed good health and high survival (95%); also, they did not presented injuries in skin, eyes and gills.

5. Conclusion

The preliminary results obtained in this experiment, allows to establish new ideas to make better management and culture of aromatic plants in aquaponic systems and try to stablish them into small scale urban conditions, but is necessary to make changes to improve the combination of the aquaponic/Biofloc system.

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