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Research Article
Lipid Classes, Fatty Acid Profile and Histology of Ovaries of Parent and Progeny of *Oreochromis niloticus* Reared in Aquaponic System

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Abstract

Background and Objective: Aquaponic is a type of recirculating aquaculture system where plant and fish provide suitable media for the development of each. The lipid classes, fatty acids profile and ovary structure of Nile tilapia *Oreochromis niloticus* reared in this type of system aquaponic parents (AP) and also their first generation aquaponic progeny (AG) allowed to develop in this system till ripening and were evaluated and compared with control parent (CP) and control progeny (CG) reared in normal aquaria. **Methodology:** *Oreochromis niloticus* larvae were introduced to aquaponic (AP) and control (CP) rearing tanks (40 fish for each). When females in aquaponic and control groups (AP and CP) about to spawn, they were removed with spermiating males of their groups to continue fertilization process. After hatching (15 day old fries) were transported to their corresponding tanks. When fishes reach maturity, females from each aquaponic group as well as from the control parent and progeny were sacrificed then ovaries were used for determination of lipid content, lipid fatty acids profile as well as ratio of deformed oocytes. Data were analyzed using one-way analysis of variance (ANOVA) at significance of ($p < 0.05$). **Results:** This study showed insignificant differences in lipid class, fatty acid profile among AP and CP groups and an alteration in ovaries lipid content and class-composition of AG group relative to CG, recording significantly ($p < 0.05$) higher triglycerides (TG) level, lowered total lipid (TL), cholesterol (COL) and phospholipid (PL) levels. Fatty acids profile alterations occurred in ovary of AG fish relative to CG fish. Saturated fatty acids significantly decrease ($p < 0.05$) and MUFA increased ($p < 0.05$). Levels of Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA) and Arachidonic acid (ARA) fatty acids showed insignificant variation in ovaries of aquaponic groups. Histological examination of ovaries indicated significant increase in percentage of deformed oocytes in AG group. Deformation was restricted to mature and maturing oocytes. **Conclusion:** Aquaponic rearing conditions affect Nile tilapia progeny reared to maturity in this type of system, causing significant decrease in total lipid content, altered fatty acid classes and fatty acids profile and increase percentage of deformed oocytes.

Key words: Aquaponic, lipid contents, fatty acids, oocyte deformity, Nile tilapia

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Nile tilapia fish is one of the most common freshwater fishes in Egyptian hatcheries and characterized by cheapness, easy of dispersion and rapid growth. The adult stages can be obtained within 6-7 months of fertilization.

Aquaponic is the combined culture of fish and plants in a symbiotic environment. It is a good culture technique for the fish as it insures better control of water quality, reduced water usage, improve waste management and nutrient recycling[1]. In aquaponic recirculating system, the biological nutrient wastes excreted by fish (e.g., ammonia) and those generated from the microbial breakdown of fish feed (nitrite, nitrate) are absorbed by plants as nutrients for growth and thus this method allows the removal of undesirable nutrient wastes from the water by plants and the water can then be reused for fish culture. These could potentially lead to higher production of both the fish and plants[2].

Lipids are important components as energy and essential fatty acids source, including growth, reproductive and maintenance of healthy tissues[3]. The composition of fish gonads, in terms of fatty acid profile, is another important aspect for successful reproduction of fish in captivity. As opposed to saturated and monounsaturated fatty acids, which are a preferred source of catabolic energy, long-chain, polyunsaturated and highly unsaturated fatty acids (PUFA and HUFA, respectively) are usually transferred to fish oocytes[4]. The HUFA Docosahexaenoic acid (22:6n-3; DHA), Eicosapentaenoic acid (20:5n-3; EPA) and Arachidonic acid (20:4n-6; ARA) play roles as constituents of neural tissues, are precursors of hormone-like molecules and are involved in the development of the embryo's immune system and hatching[5,6]. Therefore, these fatty acids are usually present in relatively high amount in gonads of fish[7]. Lipids and in particular n-3 HUFA affect broodstock reproductive performance in a variety of farmed fish species[8,9]. A reduction in n-3 HUFA, principally Eicosapentaenoic acid (EPA, 20:5 n-3) and Docosahexaenoic acid (DHA, 22:6 n-3) in fish could potentially affect directly or through their metabolites, fish reproductive performance, influencing patterns of gonad development, plasma levels of lipids and sex steroids, oocyte quality, fecundity, hatching and survival rate[10,11]. Arachidonic acid (ARA, 20:4 n-6) also possesses vital functions as a main precursor of eicosanoids such as prostaglandins (PGs) which stimulate steroidogenesis and oocyte maturation in fish[12-14].

An additional biochemical components relevant to reproduction is the lipid class cholesterol, that serves as a precursor to all steroid hormones, which regulate reproduction physiology[15]. Cholesterol is the precursor of all the steroid hormones (estradiol, progesterone and testosterone) that promote fish gonadogenesis and maturation[16]. Therefore, it is increasingly important to evaluate the possible impacts of aquaponic systems on fat content, fatty acid composition as well as on gonad structure of reared tilapia fish. Studies performed on Nile tilapia, Gunasekera *et al*.[17] has demonstrated that incorporation of essential nutrients into the developing eggs depends on the availability of these nutrients in the female broodstock gonads. No available studies have been reported on impact of recirculating aquaponic system on reproduction efficiency of fish.

This experiment aimed to determine, whether aquaponic would provide optimal conditions that allow fish to reproduce through its impact on structure and lipid content of ovaries, as well as to accumulate a set of base information, which could be used for further studies.

MATERIALS AND METHODS

The study was carried out at Aquaculture laboratory of the Arab Academy for Sciences and Technology, Alexandria, Egypt at the period from 15/12/2015-15/1/2017.

Design of recirculating aquaponic system: Aquaponic unit consisted of 3 tanks: A fiber glass fish rearing tank (500 L), sump tank (400 L) and hydroponic tank (2000 L). The rearing tank supplied with air stones connected to an air blower to maintain sufficient oxygen supply to the fish, a mechanical filter to retain solid particles and removing them regularly. The loss of water from evaporation, transpiration and sludge removal was replenished with aerated water from reservoir. The waste from the rearing tank allowed to trickle down to a well-sealed sump incubated with denitrifying bacteria for denitrification treatment. The hydroponic tank grown with leaf vegetable planted on polystyrene sheets that floated along the hydroponic tank; the polystyrene sheet supported the plants at the water surface with roots suspended in the culture water, providing good exposure of the roots to the culture water while preventing undesired clogging. Water flow as maintained from fish tank to sump tank and then to hydroponics tank. A submersible water pump (capacity 50 L min^{-1}) was fitted into the sump tank which lifted water from sump to hydroponics tank with timer set to switch on for 10 min and off for 50 min every hour to ensure the whole volume of water in a fish tank to be changed every hour. In hydroponics tank a bell siphon was assembled to maintain the flood and drain system which was connected to fish tank.

Two independent aquaponic units were maintained in this experiment for the different generations and 2 separate fish tanks (same size of raring tanks) without the hydroponic system maintained with same feeding and water exchange used as control. The water temperature was maintained at 20.0±2.1°C, dissolved oxygen at 6.12±0.6 mg L^{-1}, ammonium at 0-0.2 mg L^{-1}, nitrate at 50±9.6 mg L^{-1}, alkalinity at 110±3.2 mg $CaCO_3$ L^{-1} and pH at 7.2±0.56 throughout whole experiments. During winter, the water temperature was maintained using heaters. The system was housed in a climate-controlled laboratory with controlled photoperiod (12 h light and 12 h dark). Water quality parameters temperature, pH, dissolved oxygen, alkalinity, ammonia, nitrite, nitrate, were analyzed during the experimental by weekly interval using color-coded freshwater test kits to make sure all the parameters are within the optimum levels (Aquarium testing kits, PL precision Laboratories). Each test involves adding 5-10 drops of a reagent into 5 mL of aquaponic water; values are determined by comparing the test water color with that of the reference card.

Fish rearing and breeding: The experiment was conducted for a period of 12 months using newly hatched fries of Nile tilapia, *Oreochromis niloticus*, which were obtained from same parental breeding pair held at private fish farm, alive to the Aquaculture laboratory of the Arab Academy for Sciences and Technology, Alexandria, Egypt and left acclimated for 2 weeks prior to the experiment in fiber glass holding tanks supplied with a continuous flow of well-aerated fresh water (water temperature: 22°C, pH: 7.5; DO>6 mg L^{-1}). Eighty larvae *Oreochromis niloticus* initial wet body weight (0.53±0.05 g) and standard length (0.8±0.1 cm) were introduced to aquaponic (AP) and control (CP) rearing tanks (40 fish for each). The fish were provided with artificial pelleted feed containing 30% protein and 2.98 kcal kg^{-1} diet, twice a day (equivalent to a feeding rate of about 6% b.wt./day) at 8 am and 3 pm. Sampling of fishes was carried out at 15 days interval and the daily feed ration was adjusted accordingly to weight.

When females in aquaponic and control groups (AP and CP) about to spawn, they were removed with spermiating males of their groups to another tanks containing dechlorinated and aerated water to continue fertilization process. When eggs were seen in the mouth of the brooder, eggs were removed from the brooder's buccal cavity and left to hatch. After hatching and yolk sac absorption and beginning of exogenous feeding the fries of both control and aquaponic groups (15 days old) were transported to their corresponding tanks.

Sample collection

Histological studies: Fish were examined from time to time to determined stage of maturity. When reared fish reach maturity 10 mature females from each aquaponic groups as well as from the control parents and progenies were immediately sacrificed then ovaries were carefully removed and weighed and used for further analyses. Each ovary was partitioned into two portions. One stored frozen for determination of the fatty acid, total lipid and lipid classes. The other portion stored in formal saline fixative (10%) for 3 days proceeded in ethanol progressive higher concentrations for dehydration, then in xylene for clearing, embedded in paraffin, sectioned at 4 μm thick, stained with Iron hematoxylin and Eosin and microscopically examined for any abnormality in structure. Also tissues of ovary of (~2×2×2 mm) thickness of same fish were fixed in 4% gluteraldehyde solution in 0.1 M cacodylate buffer pH 7.4 at 4°C, dehydrated in alcohol grades, embedded, sectioned and stained with uranyl acetate and lead citrate and examined with a JEDL, transmission electron microscope (TEM) (100 CX JEOL. ltd, Tokyo, Japan). Moreover, counts of deformed ovarian cells were conducted, on sections, to detect the precise effect of aquaponic rearing media on ovary structure. Four different areas within each section, from the central portion of ovary, were selected at random for cell-counting. The number of deformed oocytes per unit area (4.2 m m^2), for each maturity stage, was recorded on the photomicrographs and count was repeated for 3 fish from each treatment. The occurrence (incidence) ratio of deformed oocyte, for each maturity stage, to total number of oocytes was then calculated[18] and the mean for each treatment was finally obtained.

Determination of total lipid and lipid classes: Total lipids (TL) in ovary samples were extracted and determined gravimetrically according to method described by Folch *et al.*[19]. Lipid-classes, triglycerides (TG), phospholipids (PL) and cholesterol (COL) in ovary lipid-extracts were separated and identified by thin-layer chromatography (TLC, Silica gel G 60, 20x20 cm glass plates; FID (TH-10) Latron Lab, Tokyo, Japan) according to Juaneda and Rocquelin[20] technique, using hexane/diethyl ether/acetic acid (85:15:1/v:v) as the system-solvent. Lipid bands were quantified, by a Dual-wavelength TLC-Scanner, CS-930; Shimadzu, Tokyo, Japan).

Fatty acid analysis: Fatty acid determination was carried out on total lipid extracts of ovary at end of trial. Fatty acid methyl esters (FAME) were prepared from aliquots of total lipids

(50 mg) by acid-catalyzed transmethylation with 5 mL methanolic sulphuric acid (1 mL sulphuric acid and 100 mL methanol) overnight at 50°C. The FAMEs were purified by TLC using hexane/diethyl ether/acetic acid (85:15:15, v/v/v) as solvent[21]. Separation of FAMEs was conducted in a HP (Hewlett-Packard, CA, USA) 8690 Gas Liquid Chromatography system (GLC), equipped with a flame ionization detector (FID), column HP-5 (30 m, 0.32 mm ID, 0.25 μm film thickness), using nitrogen as carrier gas, gas flow 1 mL min^{-1}. Initial temperature programming was 150°C, held for 2 min, rising to 200°C at 5°C min^{-1} and then to 250°C and held for 9 min. Individual FAME were identified by reference to FO standards (Sigma Chemicals, St. Louis, USA) and the relative amount of each fatty acid was expressed as a percentage of the total amount of fatty acids in the analyzed sample.

Statistical analysis: Each factor analyzed as triplicated sample, using one-way ANOVA test to detect the effect induced by aquaponic systems on total lipid, lipid-classes and fatty acid composition of ovaries of both control and aquaponic groups. Results are presented as means±standard deviation (SD). Tukey-Kramer's multiple-range test was applied to compare means differences between means were considered to be significant at $p \leq 0.05$ level for all results. All analysis were made using the SPSS package, version 1.11 (SPSS Inc., Chicago, IL, USA).

RESULTS

No difference was detected in timing of reaching maturity between control and aquaponic fish groups, parent groups reach maturity after 165-170 days, while progeny groups reach maturity after 170-180 days. Fish weight showed decreased values in AG group (average weight 235.25 g) compared with CG group (average weight 250 g). Water quality was maintained within optimum levels throughout the experiment, by increasing oxygen supply, partial replacement of water, stop feeding or increasing surface area of nitrification media.

Gonads total lipids and lipid-classes: Results of total lipids (TL), cholesterol COL, triglycerides (TG) and phospholipids (PL) content of fish ovary of the control and aquaponic reared fish are listed in Table 1. Rearing fish in aquaponic system affect gonad lipid content and class-composition of progeny (AG). Ovary of fish of aquaponic progeny group (AG) recorded significantly ($p<0.05$) higher TG, concurrent with a significantly decrease ($p<0.05$) in TL, COL and PL levels relative to fish of (CG) group (Table 1). In the meantime, no significant alteration in lipid content and lipid classes of (AP) group compared to same compartment in (CP) group. However, TL, COL and PL content of ovary of parents were relatively higher, than that of progeny group.

Fatty acids composition of ovaries: As a general trend, result showed insignificant variation in fatty acid content of AP compared to CP group, while the fatty acid content of AG showed alteration compared to CG group. A significant decrease in the total SFA, 16:0. 18:0 fatty acids and a significant increase ($p<0.05$) in MUFA, 18:1 n-7 and 20:1 n-7 fatty acids were recorded. The total fatty acid content (TFA) was higher in the ovary of control fish (97-94%) than in their aquaponic counter parts (96-92%) (Table 2), in ovary of control parent fatty acids, 16:0, 18:0,20:1n-9, 20:3n-3, 20:5n-3 and 22:6n-3 were more abundant and 18:1n-9 also was more abundant in ovaries of control progeny. Saturated fatty acids constituted nearly 40% of the total fatty acids in fish ovary of all groups tested The most abundant SFA was C16:0 Palmitic acid that is the most abundant fatty acid in ovary of tilapia ranging from 23-25% of total fatty acid in ovaries of control compared to 21-23% of total fatty acid in ovaries of aquaponic reared fish. Data showed that the primary source of total PUFA found in ovary samples of all tested groups was the highly unsaturated fatty acids (HUFA), namely n-3 fatty acids EPA and DHA. The sum of n-3 HUFA in fatty acids of ovary of control, being 19.44 and 18.33% of total fatty acids of CP and CG groups respectively compared to16.54 and 16.80% in aquaponic parents (AP) and progeny (AG). Highly unsaturated fatty acids like DHA, ARA and EPA were the major fatty acids in

Table 1: Total lipids and lipid classes of ovaries of control and aquaponic reared *Oreochromis niloticus*

	Parents		Progeny	
Tissue	CP	AP	CG	AG
Gonads				
TL (g kg/wet weight)	132.57±9.01[a]	120.43±16.36[a]	123.67±13.50[a]	99.37±13.26[b]
COL (g kg^{-1} TL)	203.21±8.72[a]	187.55±9.53[a]	199.22±7.52[a]	175.15±5.40[b]
TG (g kg^{-1} TL)	193.80±11.22[a]	180.31±9.37[a]	185.10±8.25[a]	206.13±6.59[b]
PL (g kg^{-1} TL)	578.20±56.40[a]	555.52±44.24[a]	560.50±29.61[a]	538.10±31.37[b]

Values are Means±Standard Deviation (SD), different letters denote significant differences between groups in same row, TL: Total lipids, COL: Cholesterol, TG: Triglycerides, PL: Phospholipids

Table 2: Fatty acid profile (% of total) of ovaries of *Oreochromis niloticus* reared in control and aquaponic systems

	Parents		Progeny	
Fatty acids	CP	AP	CG	AG
14:0	2.52±0.03[a]	2.30±0.04[a]	2.43±0.04[a]	2.00±1.00[a]
16:0	24.98±0.48[a]	23.29±1.00[a]	23.70±0.23[a]	21.07±1.00[b]
16:1 n-7	1.74±0.11[a]	1.80±0.64[a]	1.69±0.18[a]	1.55±0.54[a]
18:0	12.68±0.04[a]	11.70±0.12[a]	12.47±0.78[a]	10.80±0.86[b]
18:1 n-7	3.35±0.38[a]	3.40±0.04[a]	2.95±0.95[a]	4.67±1.10[b]
18:1 n-9	10.00±0.18[a]	11.80±0.21[a]	9.40±1.10[a]	10.58±1.00[a]
18:2 n-6 (LA)	4.99±1.04[a]	4.69±0.08[a]	3.91±0.89[a]	4.39±0.68[a]
18:3 n-3 (LNA)	3.81±0. 24[a]	3.63±1.12[a]	2.62±0.11[a]	2.63±0.28[a]
18:3 n-6	3.90±1.20[a]	2.50±0. 53[a]	3.71±0.15[a]	3.87±0.19[a]
18:4 n-3	3.75±0.22[a]	3.62±0.35[a]	2.80±0.14[a]	2.97±0.32[a]
20:1 n-7	0.91±0.02[a]	1.03±0.30[a]	0.80±0.28[a]	1.57±0.30[b]
20:1 n-9	2.78±0..12[a]	1.95±0..01[a]	2.53±0.06[a]	2.00±0.25[a]
20:2 n-6	2.90±0.22[a]	2.70±0.05[a]	2.86±0.01[a]	1.90±0.03[a]
20:3 n-3	1.10±0.22[a]	0.65±0.17[a]	0.96±0.06[a]	1.14±0.42[a]
20:4 n-6 (ARA)	6. 90±0.03[a]	6.40±0.11[a]	5.29±0.08[a]	5.66±0.08[a]
20:4 n-3	1.10±0.04[a]	1.00±0.03[a]	1.11±0.04[a]	0.90±0.03[a]
20:5 n-3 (EPA)	5. 03±0.45[a]	3.97±0.85[a]	5.83±0.75[a]	4.57±1.55[a]
22:2 n-6	0.45±0.03[a]	0.50±0.03[a]	0.34±0.01[a]	0.70±0.03[a]
22:5 n-3	0.50±0.01[a]	0.70±0.23[a]	0.90±0.02[a]	1.26±0.20[a]
22:6 n-3 (DHA)	11.92±0.46[a]	10.42±0.91[a]	9.53±0.52[a]	8.93±0.46[a]
24:0	0.29±0.06[a]	0.38±0.04[a]	0.19±0.01[a]	0.23±0.02[a]
Σ SFA	40.11±1.22[a]	37.45±2.33[a]	38.75±2.51[a]	34.03±1.92[b]
ΣMUFA	18.60±2.14[a]	19.38±1.07[a]	17.18±2.88[a]	20.10±2.95[b]
Σ n-3	21.11±5.98[a]	23.49±2.33[a]	23.10±4.98[a]	22.32±5.29[a]
Σ n-6	17.25±2.59[a]	16.70±1.85[a]	16.11±0.92[a]	16.20±0.95[a]
ΣPUFA	38.30±4.11[a]	40.19±2.00[a]	39.21±1.90[a]	38.52±1.43[a]
ΣTFA	97.07±1.67[a]	96.12±2.15[a]	94.64±2.77[a]	92.65±3.11[a]
Σn-3 HUFA	19.44±0.18[a]	16.54±1.76[a]	18.33±1.20[a]	16.80±0.31[a]
Σn-6 HUFA	10.11±0.11[a]	9.40±0.21[a]	8.36±0.52[a]	8.26±1.20[a]

Values are Means±Standard Deviation (SD), different letters denote significant differences ($p<0.01$) between groups in the same row

ovaries tissues of control and aquaponic reared females that emphasized the importance of these fatty acids in the reproduction processes. The ARA was the most abundant n-6 PUFA, ranged from 6.90-5.29% of total fatty acids in control groups and from 6.40-5.66% of total fatty acids in aquaponic reared groups, respectively.

Ovary histology: Ovaries of fish of aquaponic rearing groups showed increase ($p<0.05$) in percentage of deformed oocytes that are common in yolk vesicles oocytes and mature ones in AG group and in mature oocytes in AP group (Table 3). While most of ova in ovaries of control fish groups (CP and CG) look normal, deformed mature oocytes have theca cells with necrotic fossi and syncytial granulosa layer cells (Fig. 1a, b). Hyperplasia of follicular theca cells with picnotic nuclei (Fig. 1c), more over edema of granulosa layer separating it completely from underlying ooplasm occurred. Granulosa cells with crescent shaped nuclei and dark apoptotic bodies were distinguished in yolk vesicles oocytes of aquaponic reared fish (Fig. 1d).

DISCUSSION

In present study water quality was maintained within optimum levels throughout the experiment, to minimize nutrient and fish wastes. A component ratio of $\geq$3 m^3 of hydroponic tank volume to 1 m^3 of fish rearing tank volume showed advantages in improving the production of the fish and removing the nutrient wastes, 60% removal of total phosphorus, 88% removal of total suspended solid, 63% removal of 5-day biochemical oxygen demand were observed at high component ratio (3 m^3 m^{-3}) in recirculating aquaculture system[22]. In present work a ratio of >3 m^3 of hydroponic tank volume to 1 m^3 of fish rearing tank volume was used. Also fish weight showed decreased values in AG group compared with CG group. High accumulation of substances originating from fish and feed in recirculating aquaculture system (RAS) induced a reduction in growth (83%) of Nile tilapia[23]. Similarly Martins *et al.*[24] suggested that in the high-accumulation water, the concentration of phosphate, nitrate is likely to have impaired the embryonic

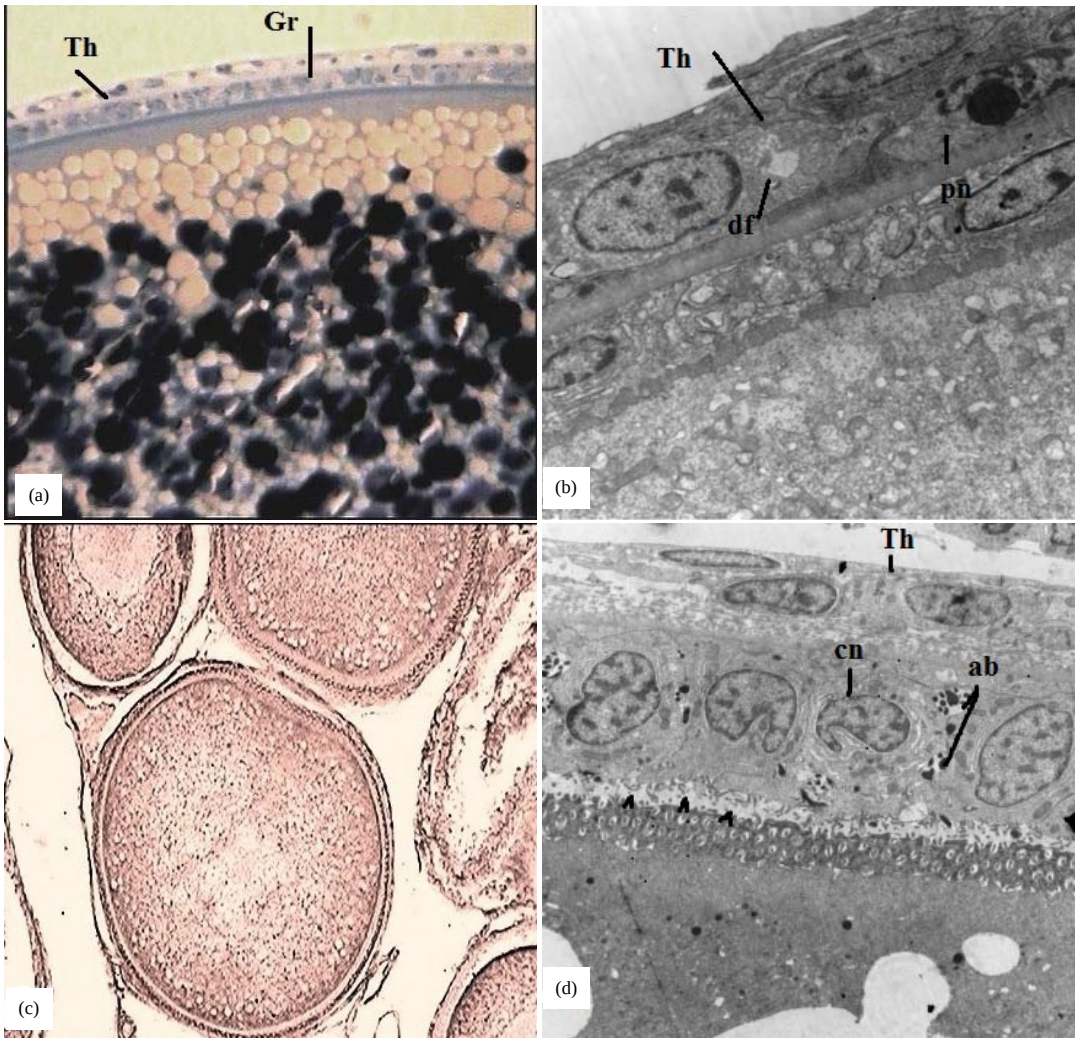

Fig. 1(a-d): Deformed oocytes from aquaponic reared parents (AP) and progeny (AG), (a) Ova of (AP) fish showing synctial granulosa and necrotic theca cells (400X), (b) Higher magnification of previous section, showing theca cells, with picnotic nuclei and degenerating fossi (1500X), (c) Yolk vesicle oocytes of (AG) fish (100X) and (d) Higher magnification of previous section, showing multilayer theca cells, granulosa layer edema (arrows), with crescent shaped nuclei and apoptotic bodies (2000X)

Gr: Granulosa, Th: theca cells (Th), df: degenerating fossi, pn: Picnotic nuclei, cn: Crescent nuclei, ab: Apoptotic bodies

Table 3: Ratio of deformed oocytes to normal oocytes per unit area (4.2 m m^2) in ovaries of control and aquaponic reared *Oreochromis niloticus*

	Treatments			
Oocyte stage	Control parents	Aquaponic parents	Control progenies	Aquaponic progenies
Maturing	0.03±0.01 (3)^a	0.04±0.01 (3)^a	0.04±0.02(6)^a	0.09±0.02(5)^b
Mature	0.04±0.01(4)^a	0.06±0.01 (3)^b	0.04±0.00(6)^a	0.08±0.03(4)^b

Values are Means±Standard Deviation (SD), values of different superscript are significantly differences ($p<0.05$) with respect to control, number of cases is indicated in parentheses

and larval development of carp. However, health status, as mortality and total hemoglobin content was not significantly affected by RAS water in turbot indicate that metal accumulation is not a main factor limiting turbot grow-out in RAS[25].

With respect to the gonads fatty acid composition, the overall FA content was numerically higher in control fish, which is likely a reflection of their higher total lipid content. In present work levels of EPA, DHA and ARA fatty acid levels showed insignificant decreases in ovaries of aquaponic groups

compared to control ones. The important physiological role that these FAS play explains their presence in significant amounts in gonadal tissues. EPA and ARA are precursors of prostaglandins and leukotrines, that participate in ovarian steroidogenesis[5]. In addition, it has been suggested that ARA is involved in the process of hatching and early larval performance[6]. DHA, play a specific role in maintaining the structural integrity in cell membranes, especially in the neural cell, so its percentage is expected to increase during the gonad development stage[26,27]. The ARA has similar biologically importance as EPA and DHA are considered as the precursor of several eicosanoids which are produced by the ovarian tissues and play an important role in the ovulation process[27] and cholesterol accumulation in tissues[28]. Cholesterol serves as a precursor to all steroid hormones, which regulate reproductive physiology[29].

A significant decrease in levels of SFA, 16:0 and 18:0 fatty acids and an increase in MUFA, 18:1n-7 and 20:1n-7 fatty acids was detected in present work in aquaponic reared group (AG). Palmitic acid (C16:0) is noted for being a predominant source of potential metabolic energy in fish during growth and particularly during the egg formation stage in female fish[7]. Ostaszewska[30]reported that the C16:0, C18; 1n-7,C20:1n-9 and C22:1n-7 fatty acids are mainly catabolic for energetic purposes. High amounts of such acids are consumed during fish development and they are easily catabolized by mitochondrial, β-oxidation[31]. Therefore, the high value detected for both C20:1n-7, C18:1n-7 in AG samples reflects a requirement for energy metabolism during the course of gonad developments.

CONCLUSION AND RECOMMENDATION

Parents *Oreochromis niloticus* allowed to develop till ripening in aquaponic rearing conditions, possessed normal ovary lipid content, lipid classes and fatty acids profile as control parents reared in normal aquaria. Their progenies had deformed oocytes, decreased lipid content, decreased cholesterol and phospholipid levels. Saturated and highly unsaturated fatty acids level also showed alteration that may affect their reproduction.

Effect of aquaponic rearing conditions on other aspects of reproduction should be addressed in order to complete the image of possibility of breeding fish in this type of system. As well as aquaponic reared parents to maturity in this system, showed significant increase in percentage of deformed oocytes. The cause of this is unclear and should be discussed in further studies.

SIGNIFICANCE STATEMENT

This study discovers the possibility of breeding fish in aquaponic rearing system via studying the impact of aquaponic rearing conditions on structure, lipid content and lipid classes of fish ovaries whish beneficially effect fish reproduction. This study will help the researchers to uncover the critical areas of possibility of using fish reared in this type of system as a nutritional source of protein, also to accumulate a set of base information.

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