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Evaluating the Validity of Tilapia Fish Obtained from Qarun Fish Farms for Human Consumption

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ABSTRACT

In this study, the quality and safety were addressed for tilapia fish cultured in two fish farms around Lake Qaroun which is irrigated with untreated agricultural drainage water from El-Battas and El-Wadi drains. The chemical composition, quality parameters, heavy metals (HMs), organochlorine pesticides (OCPs) and bacteriological were assessed and compared with the permitted Egyptian and International borders. A high rate of lipid was administered for tilapia cultured in farm 1,while tilapia fish of farm 2 exhibited high levels of protein and energy. Compared to the species under study in farm 2, the values of TVB-N, TMA-N, TBA and pH were higher for tilapia raised in farm 1. In addition, values of HMs (lead, cadmium, zinc and manganese) and OCPs were higher in tilapia fish of farm1 compared to those of farm 2. Total bacterial count and total coliforms were 3.85 and 1.60 (cell×10^3cfu/g) for tilapia farm 1, respectively; whereas, values of 3.22 and 1.10 (cell ×10^3cfu/g) were recorded for tilapia fish of farm 2. For the two farms under investigation, no staphylococcus or salmonella bacteria were detected in tilapia. Generally, values of freshness and quality, HMs, OCPs and bacteriological aspects in tilapia from the two farms were below the Egyptian and International maximum permissible limits (MPLs). Therefore, these fish are suitable and safe for human consumption. Accordingly, the quality and safety of fish in aquaculture is in the interest of public health.

INTRODUCTION

Fish meat is an important source of protein, polyunsaturated fatty acids, minerals, vitamins, omega-3, as well as low cholesterol source that provide a human health and reduce the incidence of heart disease **(FAO/WHO, 2011 & KhaliliTilami & Samples, 2018)**.

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Aquaculture is considered as one of the most important sources of animal protein production in Egypt for meeting the increasing demand for protein **(Konswa, 2007)**. Egypt is the largest aquaculture producer in Africa, producing 63.2% of all fish produced on the continent, and it is ranked the seventh in the world in terms of production volume **(Feidi, 2018)**. The aquatic environment and water quality are considered the main factors controlling the state of health and disease in both cultured and wild fishes. The agricultural drainage water containing heavy metals, pesticides, fertilizers and effluents of industrial activities and runoffs in addition to sewage effluents supply the water bodies and sediment with huge quantities of inorganic anions and heavy metals **(ECDG, 2002)**. Although fish are often at the top of the aquatic food chain, the metals are accumulated in their tissues to concentrations much higher than that present in water and sediment. Fish can absorb heavy metals through epithelial or mucosal surface of the skin, gills and gastrointestinal **(Jovanovic *et al*., 2011)**. Additionaly, organochlorine pesticides (OCPs) are of immense concern as environmental contaminants owing to their bioaccumulation, potential for magnification in food chain and adverse effects on human and the wild life **(Kunisue *et al.*, 2003).** Furthermore, they have been widely used in controlling pests and diseases since 1940s since, and subsequently causing widespread contamination of the environment **(Muzyed, 2011**). In the developed countries, the production and use of most compounds was banned since 1970s. However, they are still used in the developing countries and represent an environmental issue of concern. Fish is exposed to pesticides in four main dermal ways: direct absorption, respiration, orally, and feeding **(Louis *et al.*, 2009)**.

Egypt now ranks as the top aquaculture producer in Africa; it accounts for 71% of the continent's output (**FAO, 2016; Shaalan *et al.*, 2018**). Importantly, Egypt is the third largest tilapia producer globally (after China and Indonesia), with tilapia aquaculture playing a significant role in the national economy and food security (**FAO, 2020a, 2020b)** The Nile tilapia, *Oreochromis niloticus*, for instance, accounts for 65.15% of the freshwater fish farmed in Egypt, and it is the most popular and consumed fish among the Egyptian population compared to other species **(GAFRD, 2020).** *O. niloticus* can survive in bad environmental conditions since their resistance to disease is physically powerful, and their respiratory demands are slight so that they can accept low oxygen and high ammonia levels **(Zhou *et al.*, 1998)**. Therefore, tilapia is one of the most important farmed species all over the world. Given that farming of fast growing monosex populations of tilapia produced by hormonal sex reversal of male tilapia, *Oreochromis niloticus* is getting popularized as male tilapia grow nearly twice as fast as females and its commercial production is increasing worldwide. The most important producers of tilapia today are China, Egypt, Indonesia, and the Philippines **(Laly *et al*., 2017)**.

The Egyptian government has motivated the development of aquaculture and intensification of culture methods along the parts of Lake Qarun, especially for *Oreochromis niloticus* and *Mugil cephalus*. This is due to the regulation rules for use of water resources, upon which the fish farms are allowed to use water from the agricultural drainage network of El-Batts and El-Wad drains and other subsidiary drains that finally discharge into the Lake **(Konsowa, 2007)**.

The accumulation of chemical contaminants (heavy metals, pesticides and other contaminants) is expected to increase annually in all its components (e.g. water, sediment and fish) in addition to changing their quality and affecting their aquatic life **(Mansour & Sidky, 2002)**. Thus, it is necessary to periodically determine these contaminants in fish meat to ensure their safety and control the quality of fish avoiding microbial and chemical contamination. In addition, the evaluation of proximate composition and microbial aspects is necessary to determine whether fish tissues have healthy safe qualities, meeting the national and international standard specifications **(WHO/FAO, 2011)**.

Generally, fish consumption information is essential for assessing human health implications associated with the consumption of chemically contaminated fish **(Copat *et al.*, 2012)**. Therefore, this study was conducted to assess the chemical composition, quality criteria and contaminants concentrations in addition to some heavy metals (HMs), organochlorine pesticide (OCPs) and microbial aspects in the edible muscle samples of cultured tilapia fish that were collected from two fish farms around Lake Qarun in Faiyum Governorate, where they were irrigated with the drainage water from the agricultural drainage network of the El-Batts and El-Wadi and other subsidiary drains that finally discharge into the Lake Qarun. In addition, the results were compared to the Egyptian and International permissible limits to maintain the safety and quality of these fish to safeguard the safety of fish consumers.

MATERIALS AND METHODS

1. Materials

1.1. Fish samples

The Nile monosex tilapia fish (*Oreochromis niloticus*) samples were obtained from two fish farms in earthen ponds established around Lake Qarun, El- Faiyum Province (Qarun fish farms). Qarun fish farms extend along the eastern part of Lake Qarun; the first farm (farm1) is located at the eastern region, while the second farm (farm 2) lies in the western region, where two main drains (El-Batts and El-Wadi) were respectively used as a water feeder. In an ice boox, about 15kg of every kind of fresh tilapia fish were transferred to the Fish Processing Technology Laboratory, Fish Research Station in Shakshouk belonging to the National Institute of Oceanography and Fisheries (NIOF), El-Fayoum, Egypt. The average of weight and length were 400±50g and 29.00±1.5cm for the samples from farm (1) while, other samples of farm (2) recorded 500± 60g and 31±2cm, respectively.

2. Methods

2.1. Analytical methods

2.1.1. Chemical composition.

The proximate composition (moisture, crude protein, lipid and ash contents) of fresh fish meat was determined according to **AOAC (2012**). The carbohydrate content was calculated by computing the difference using the standard equation as follows:

Carbohydrate content = 100% - (% protein + % fat + % ash + % moisture).

2.1.2. Physicochemical properties.

Total volatile basic nitrogen (TVB-N) was determined by the Macro distillation method proposed by **Pearson (1991)**. Thiobarbituric acid reactive substances (TBARS) were spectrophotometrically determined according to the procedure described by **Siu and Draper (1978)**. Trimethylamine (TMA-N) and pH values were determined according to **AOAC (2012)**.

2.2. Contaminants

2.2.1. Heavy metals (HMs).

Lead (Pb), cadmium (Cd), zinc (Zn) and manganese (Mn) were estimated using Atomic Absorption Spectrophotometer in the Central Laboratory of Residue Analysis of Pesticides and Heavy Metals in Food (QCAP), Agricultural Research Centre, Giza Governorate, Egypt, as described by **Nisbet *et al.* (2010)**.

2.2.2. Organochlorine pesticides residues (OCPs).

OC pesticides residues were determined in Central Laboratory of Residue Analysis of Pesticides and Heavy Metals in Food (QCAP), Agricultural Research Centre, Giza Governorate, Egypt according to TSQ 8000 GC/MS (**Koc & Karakus, 2011**). Results of HMs and OCPs were expressed as mg/kg (ppm), wet weight basis.

2.3. Bacteriological examination

2.3.1. Total bacterial count (TBC).

Total bacterial count was determined as described by the standard procedures of **AOAC (2012)** via using nutrient agar medium (incubated at 30°C, 3 days).

2.3.2. Salmonella bacteria count (SBC).

Salmonella count was determined using S-S agar medium, as reported by **FAO (1979**).

2.3.3. Total coliform bacteria count (TCBC).

The total coliform count was performed, as described by **AOAC (2012)**, using the most probable number (MPN) method. Three tubes of Lauryl Sulphate Tryptose broth were used for each dilution (1:10, $1:10^2$, $1:10^3$, $1:10^4$ and $1:10^5$), and the tubes were incubated at 35ºC for 48±2hr for gas formation. After primary incubation, one loopful of the positive tubes (gas formation tubes) was transferred to Brilliant Green Lactose Bile media for total coliforms (incubated at 35 ºC for 48 hr.).

2.3.4. *Staphylococci* spp. bacteria *count* (Stap BC).

Staphylococci spp. was determined on Baird Parker Agar enriched by egg yolk tellurite at 37°C for 24-48h according the manual on Laboratory Testing of Fishery Products **(Froese, 2016)**. All results of bacteriological analyses were expressed as cell $\times 10^3$cfu/g of sample.

3. Statistical analysis

The obtained results were statistically analyzed to determine the means and standard deviation (Mean ± SD), as reported by **Gomez and Gomez (1984)**, and the least significant difference test (LSD) was assessed at $P \leq 0.05$ and calculated using SPSS 10.0 for windows **(SPSS, 1998)**.

RESULTS AND DISCUSSION

1. Proximate chemical composition of the fresh Nile tilapia

Proximate composition of fish is often necessary to meet the requirements of food regulations and standard specifications **(Waterman, 2000)**. The chemical composition; moisture, crude protein, crude lipid, ash and carbohydrates, in addition to energy values of tilapia fish obtained from two fish farms are shown in Table (1).The obtained data showed that tilapia flesh from farm 1 contained 79.11% moisture, 16.50% crude protein, 2.87% crude lipid, 1.46% ash, 0.06% carbohydrates content and 92.07 kcal/100g energy values. While, the corresponding values of farm 2 contained 78.24%, 18.20%, 2.12%, 1.25%, 0.19% and 92.64 kcal/100g, respectively. Consequently, the results in this work were within the normal ranges of proximate composition (water 66-84%, protein 15-25%, fat 0.1-24%), as determined by **Huss (1995)**. **FAO (1992)** illustrated that fish flesh contains water (66-81%), protein (16-21%), carbohydrates (<0.5%), lipids (0.2-25%) and ash (1.2 to 1.5%).

The proximate compositions of the fish are considered healthy due to a high protein (15 to 20%), as mentioned by **Stansby (1982)**. Concerning crude lipid content, the investigated tilapia fish individual was classified as low fat fish, where fish species are generally grouped into four categories based on their fat contents: lean fish (<2%), low fat (2- 4%), medium fat (4- 8%) and high fat (>8%) (**Ackman, 1989**). From these results, significant differences ($P < 0.05$) were found in proximate composition between tilapia fish from farm 1 and that from farm 2, where tilapia fish from farm1 showed high values of moisture, crude lipid and ash, while tilapia fish from farm 2 recorded a high content of crude protein and energy value.

These results agree with those of **Olagunju *et al.* (2012**) who found that the protein and ash contents of tilapia fish were determined at 18.80 and 1.17%, respectively. **Ibrahim and El Sherif (2016)** found that the moisture, protein and ash contents of the

Nile tilapia were 78.3, 18.15 and 1.35%. Additionally, **Talab *et al.* (2016)** found that the ranges of moisture, protein, fat, ash, carbohydrates and calorific were (78.55-80.77%), (16.10-17.88%), (1.10-1.95%), (0.55-1.50%), (0.10-0.94%) and (78.37-89.73%), respectively, for *Oreochromis niloticus* muscles collected from the Nile Rayahs. while, **Mohamed (2018)** reported that the values of moisture, protein, fat, ash and carbohydrates contents recorded values of 79.41%, 18.05%, 1.12%, 1.14% and 0.28% for tilapia fish from Fayoum fish farms.

Table 1. Chemical composition (%, wet weight) of fresh tilapia from Qarun fish farms

Constituent	Farm 1	Farm 2	L.S.D at 5%
Moisture	79.11 ± 0.29[a]	78.24 ± 0.36	0.510
Crude protein	16.50 ± 0.30	18.20 ± 0.26	0. 308
Crude lipid	2.87 ± 0.21	2.12 ± 0.09	0.011
Ash	1.46 ± 0.08	1.25 ± 0.10	0.280
Carbohydrates	0.06 ± 0.07	0.19 ± 0.02	0.004
Energy value(kcal/100g)	92.07	92.64	0.080

Data (n=3) are expressed as mean ± (SD) standard deviation; Farm 1: Irrigated from El-Batts drain; Farm 2: Irrigated from El-Wadi drain; LSD: Least significant difference ($P \leq 0.05$).

2. Physicochemical properties of the fresh Nile tilapia fish

2.1. pH value

pH value is the only measurement which has been commonly used as a physical method for quality assessment of fish meat. The pH is an important determinant of microbial growth and seafood, with a high pH having a high spoilage potential and a short shelf life **(Newton & Gell, 1981).** Data in Table (2) show the pH values recording values of 6.28 and 6.10 for raw tilapia fish samples obtained from farms 1 and 2, respectively. These values of pH indicated that the tested fresh fish samples were highly fresh, in a result that coincides with that of **Buchtová (2011)** who assessed that fresh fish muscle is associated with pH value most frequently in the range of 6.0 to 6.5. The pH value in this study was in accordance with that obtained by **Mohamed (2018)** who recorded that the pH value was 6.40 for tilapia fish from Fayoum fish farms**.**

2.2. Total volatile basic-nitrogen (TVB-N) content

TVBN is considered a marker of the quality and freshness of fish flesh, and it is a group of nitrogen-containing compounds, including NH_3 and amines, originated from protein degraded by bacteria and enzymes' activities **(Rathod & Pagarkar, 2013)**.

Results in Table (2) exhibits that the TVB-N value of fresh tilapia meat from farm 1 was 12.04mg N/100g (w w), while it was 10.72 mg N/100g for fish from farm 2.The value of TVB-N was higher for samples obtained from farm 1 than those from farm 2.

Based on the aforementioned data, it could be noticed that, the TVB-N content in tilapia samples of two fish farms is less than the acceptability limit (35-40 mg/100g) mentioned by **Connell (1990)**. In addition, our data confirmed that the fish samples used in this study in a good freshness status according to **Shen (1996)** who reported that fresh fish TVB-N<15mgN/100g; subfresh fish TVB-N=15-25mgN/100g and deteriorated fish TVB-N>25mgN/100g. In the same trend, the quality classification of fish and fish products regarding TVB-N values would be at a high quality up to 25mgN/100g, good quality up to 30 mg N/100g, limit of acceptability up to 35mgN/100g, and spoilt above 35mgN/100g (**Gulsun *et al.*, 2009**).

Therefore, these TVB-N values of investigated fish samples were much lower than the maximum permissible levels (MPLs); 30 mg TVB-N/100g sample (**EOS, 2006**) and have a high freshness level and did not reach hazardous levels for the final consumer. This finding concurs with that of **Talab *et al.*,(2016)** who reported that the ranges of TVB-N of the Nile tilapia fish were 16.04– 19.24mgN/ 100g. In the same context, **Mohamed (2018)** found that TVB-N value of tilapia fish from Fayoum fish farms was 8.68mg N/ 100g.

2.3. Trimethylamine nitrogen (TMA-N) content

From Table (2), the results of the present study indicate that TMA-N value was 0.68 mg N/100g (w w) for fresh tilapia meat from farm 1 and higher than 0.43mg N/100g for fish meat from farm 2**.** TMA-N values of the investigated fresh tilapia fish meat were extermely lower than the acceptable limits reported by **Connell (1976**); TMA value less than 1.5 mg N/100g is considered as a good quality and 10-15mg TMA-N/100g is regarded within the acceptable limits. On the other hand, **Dalgaard *et al.* (1993**) elucidated that, when TMA value increases to more than 10mg N/100g flesh, the fish meat is considered stale. Therefore, the tilapia fish samples in this work are considered highly fresh based on the rule of TMA-N value.

2.4. Thiobarbituric acid reactive substances (TBARS) values

The obtained results in Table (2) indicate that the TBARS values of fresh tilapia samples from farms 1 & 2 recorded 0.57 and 0.31mg Malondialdehyde (MDA)/kg sample, respectively. This low value of TBA in the investigated tilapia fish is much lower than MPLs (4.5 MDA/kg) as reported by **Bonnell (1994)** and the Egyptian Standard Specifications **(EOS, 2006)**, indicating that these samples have high freshness. However, the current results are lower than those of **El-Sherif *et al*. (2016)** who postulated that TBA value of the Nile tilapia from Wadi El-Rayan Lake was 0.75 MDA/kg. Whereas, the present findings are higher than those determined in the study of **Mohamed (2018)**, with TBA value of 0.17 MDA/kg for tilapia fish from the Fayoum fish farms.

Table 2. Physicochemical properties (w w) of fresh tilapia muscles from Qarun fish farms

The criterion	MPLs*(EOS, 2006)	Farm 1	Farm 2	L.S.D at 5%
pH value		6.28 ± 0.09	6.10 ± 0.18	0.077
TVB-N (mg\100g)	30	12.04 ± 0.20	10.72 ± 0.41	.215
TMA-N (mg\100g)	5	0.68 ± 0.10	0.43 ± 0.07	0.009
TBARS (mg MAD\kg)	4.5	0.57 ± 0.22	0.31 ± 0.11	0.076

Data (n=3) are expressed as mean ± (SD) standard deviation; Farm 1: Irrigated from El-Batts drain; Farm 2: Irrigated from El-Wadi drain; TVB-N: Total volatile basic nitrogen. TMA-N: Trimethyl amine nitrogen. TBARS: Thiobarbituric acid reactive substances. w w: On wet weight basis. LSD: Least significant difference ($P \leq 0.05$).* Egyptian Standard Specifications **(EOS, 2006)**.

3. Contaminants

3.1. Heavy metals

Data in Table (4) reveal that the concentrations of determined heavy metals; Lead (Pb), cadmium (Cd), zinc (Zn) and manganese (Mn) in tilapia fish muscle obtained from Qarun fish farms in the eastern part (farm 1) surrounding the Qarun Lake were 0.120, 0.082, 4.115 and 0.851, respectively (mg⁄ kg, wet weight). While, the corresponding concentrations were 0.068, 0.015, 1.882 and 0.253(mg⁄kg) in tilapia fish muscle obtained from the western side (farm 2). These results were below the MPLs according to the standards of **WHO/FAO (2011)** for Pb, Cd, Zn and Mn (0.3, 0.2, 99.4 and 500mg ⁄ kg). Therefore, tilapia fish (farm 1) showed more accumulation of all determined trace metals; Pb, Cd, Zn and Mn than fish (farm 2); these observations are mainly due to the different fish habitats and the influence of the surrounding ecosystem status.

The accumulation of metals in fish tissues may be traced back to the Qarun fish farms and Lake Qarun receiving heavy load of organic and non-organic pollutants through agricultural, domestic and waste water in addition to the industrial effluent. Similarly, **Sabae and Mohamed (2015)** revealed that the highest concentrations of Ni, Zn, Mn and Fe were recorded in fish collected from the eastern part of Qarun Lake, which may be attributed to the impact of pollution sources in this area coming from El-Batts Drain in the east part. It was noticed that, the metal concentrations in *Tilapia* spp. from the east of the Lake Qarun were as follows: Cd (ND), Pb (1.65µg/ g dry weight), Mn (8.45µg/ g dry weight) and Zn (68.97µg/g dry weight). On the other hand, metal concentrations in *Tilapia* spp. from the middle and west of the Lake were evaluated as follows: Cd (ND), Pb (2.0 & 3.35µg/ g dry weight), Mn (0.43 & 0.78µg/ g dry weight) and Zn (27.48 & 30.91µg/g dry weight), respectively. In this respect, **Abumourad *et al.* (2013)** determined the heavy metal pollution in tilapia fish (*Oreochromis niloticus*) collected from three different fish farms in Egypt; Al-Abbasa, Kafr El-Sheikh and El-Fayoum. They found that cadmium (Cd), zinc (Zn) and lead (Pb) concentrations in Fayoum farm were 0.004, 0.022 and 0.009 (mg⁄kg dry wt), respectively, and these levels were lower than those recorded in the current study.

In the present study, the concentrations of heavy metals were lower than those reported by **Omar *et al.* (2013)** who found that Pb and Zn concentrations in *O. niloticus* and *M. cephalus* from Qarun fish farms were 2.38 and 1.77mg ⁄ kg for Pb, & 40.56 and 22.36 mg ⁄kg for Zn (dry weight). These findings concur with those of **Salaah *et al.*, (2022)** who found that the highest residuals of all analyzed heavy metals (Cd, Zn, Cu, MN and Ni) were detected in the eastern part of Lake Qarun in both *T. zillii* and *M. cephalus* species, followed by the middle part, while in the western part of the Lake, fishes showed the lowest concentrations of heavy metals. **Ahmed *et al.* (2023)** evaluated the heavy metal (HMs) levels in aquaculture tilapia fish collected from two highly producing districts in Egypt (Kafr El-Sheikh and El-Faiyum Governorates) farms, and reported that Kafr El-Sheikh farms were highly contaminated with HMs, compared to those of El-Faiyum Governorate. Regarding El-Faiyum governorate farms (Farm on Qarun Lake Touristic Road, Ibsheway), the levels of Cd (0.02), pb (0.10), Mn (0.48), Zn (5.85) mg/kg dry weight) were determined.

Table 4. Heavy metals (mg ⁄kg, wet weight) of fresh tilapia fish from Qarun fish farms

Heavy metal	Farm 1	Farm 2	L.S.D at 5%	MPLs WHO ⁄ FAO (2011)
Lead (Pb)	0.120 ± 0.08	0.068 ± 0.10	0.090	0.3
Cadmium (Cd)	0.082 ± 0.15	0.015 ± 0.09	0.093	0.2
Zinc (Zn)	4.115 ±0.44	1.882 ± 0.51	0.220	99.4
Manganese (Mn)	0.851± 0.18	0.253 ± 0.11	0.065	500

Data (n=3) are expressed as mean ± (SD) standard deviation; (n=3); Farm 1: Irrigated from El-Batts drain. Farm 2: Irrigated from El-Wadi drain. MPLs: Maximum Permissible limits (WHO/FAO, 2011). LSD: Least significant difference ($P \leq 0.05$).

3.2. Organochlorine pesticides residues (OCPs)

OCPs have witnessed a large scale concern owing to their chronic toxicity, tendency to accumulate and persistance in biota and potential ruinous impacts on humans and wildlife **(Zhou *et al.*, 2006)**. The residue levels of organochlorine pesticides in the muscles of the studied Nile tilapia (*O. niloticus)* obtained from Qarun fish farms are presented in Table (5). Fifteen components of OCPs were determined in tilapia muscles from two farms. Regarding the tilapia from the eastern farms (farm 1), eleven components were detected; p, p'-DDD, p, p'-DDE,p, p'-DDT, Endosulfan-I, Endosulfan-II, Heptachlore, Endrin aldehyde, dieldrin, Alpha(α)-HCH, Gamma (γ)-HCH, Delta (δ)-HCH, and their concentrations were 0.086, 0.017, 0.005, 0.058,0.080, 0.025, 0.050, 0.040, 0.009, 0.050 and 0.022mg⁄ kg, w w, respectively, while four compounds of OCPs were not detected; endosulfan-sulfate, endrin, aldrinandbeta (β)-HCH. However, for tilapia from western farms (farm2), nine components were detected; DDD, p,p'-DDE, Endosulfan-I, Endosulfan-II, Heptachlore, Endrin aldehyde, dieldrin, Gamma (γ)-HCH, Delta (δ)-HCH, and their concentrations were 0.031, .010, 0.035, 0.031, 0.10, 0.008, 0.015, 0.082 and 0.011mg⁄ kg. While, six compound were not detected; endosulfan-sulfate,endrin, aldrinandbeta (β)-HCH, p, p'-DDT and Alpha(α) –HCH. These traces of OCPs in fish flesh are ascribed to agricultural and municipal discharges. In this context, **Mahmoud *et al.* (2018**) reported that Lake Qarun receives agricultural and domestic untreated drainage waters, which are also used for aquaculture in Qarun area.

Based on the present results, it was noticed that the levels of pesticides detected in muscles of two fish samples were low, and they did not exceed the maximum permitted levels set by **FAO/WHO (1998)** and **EPA (2007)**. The present study revealed that the highest levels of organochlorine pesticides were recorded in tilapia obtained from eastern fish farms (farm 1) irrigated from El-Batts drain, while the lowest levels were recorded for tilapia from the western farms (Farm 2) that are irrigated from El-Wadi drain. These results agree with those of **Sabae and Mohamed (2015)** who decided that the eastern region of Qarun Lake is more polluted with heavy metals and pesticides residues compared to the western region. The concentration of OCPs in fish depends on environment conditions, level of exposure, nature of the pesticide and its solubility, as well as the fish species since fish may differ in metabolism and their ability to excrete the compounds.

It is worthy to mention that, Egypt is the largest market for pesticides in the Arab countries and the fourth largest importer of pesticides among the developing countries **(Yamashita *et al*., 2000)**. Some studies and surveys (**Zidan *et al*., 2002*;* El Nemr & Abdallah, 2004*;* Saad *et al*., 2008**) decided that the use of organochlorine pesticides in agriculture and pest control has been recorded in the Egyptian aquatic environment. However, there are no regular monitoring programs in Egypt to identify and punish the misuse of pesticides in the environment.

~~4.~~ Bacteriological examination

Fish represent one of the highly perishable foods mainly due to the action of high moisture content and microbial load on the surface of the newly caught fish. From recorded results in Table (3), total bacterial count (TBC) and total coliforms bacteria count (TCBC) are 3.85 and 1.60 (cell×10^3cfu/g) for tilapia fish samples from farm 1, respectively. While, values of 3.22 and 1.10 (cell ×10^3cfu/g) were, respectively, recorded for tilapia samples from farm 2. Besides, the obtained results performed that TBC and TCBC were higher IN tilapia samples from Farm 1 than that from Farm 2. On the other hand, it could be found that neither *Staphylococci* spp. (Staph BC) nor Salmonella bacteria (SBC) were found in the investigated fresh tilapia meat in both farms. Thus, the low number of TBC and TCBC, as well as the no detection of (Staph BC) and (SBC) indicate the safety of the tested tilapia fish meat collected from the two fish farms.

Additionally, the numbers of TBC and TCBC are within the permissible limits since they do not exceed the 10^6 cell/ g fresh flesh as reported by **EOS (2005)**. These values coincide with those of **Shen (1996)** who found that the total plate count of fresh fish < 10^4 cells/g, sub fresh 10^4-10^6 and deteriorated fish >10^6 cells/g sample. Whereas, the obtained results are lower than those of **Sabae and Mohamed (2015)** who demonstrated the bacterial load values in *Tilapia* spp. at 1.82 x 10^5cfu/g, 1.46 x10^5cfu/g and 1.52 x 10^5cfu/g in the eastern, middle and western parts of the Lake Qarun, respectively. Remarkably, the present values are higher than those recorded by **El Sherif *et al.* (2016)** who found that TBC was 2.50×10^3 cfu/g for the raw Nile tilapia fish obtained from Wadi El-Rayan Lake.

Table 5. Organochlorine pesticides residues (ppm, wet weight) in tilapia fish from Qarun fish farms

Organochlorine pesticide	Farm 1	Farm 2	MPLs
p,p'-DDD	0.086	0.031	0.5
p,p'-DDE	0.017	.010	0.5
p,p'-DDT	0.005	ND	0.5
Endosulfan-I	0.058	0.035	0.3
Endosulfan-II	0.080	0.031	0.3
Endosulfan-sulfate	ND	ND	
Heptachlore	0.025	0.10	0.3
Endrin	ND	ND	
Endrin aldehyde	0.050	0.008	0.3
Aldrin	ND	ND	
dieldrin	0.040	0.015	0.3
Alpha(α) -HCH	0.009	ND	0.3
Beta (β)-HCH	ND	ND	
Gamma (γ)-HCH	0.050	0.082	0.3
Delta (δ)-HCH	0.025	0.011	0.3

ND: Not detected/below limit of detection. Farm 1: Irrigated from El-Batts drain. Farm 2: Irrigated from El-Wadi drain. MPLs: Maximum permissible limits as reported by FAO/WHO (2011) and EPA (2007). LSD: Least significant difference ($P \leq 0.05$).

Table 3. Bacteriological properties (cell $\times 10^3$cfu/g) of fresh tilapia muscles obtained from Qarun fish farms

Bacteriological properties	Farm 1	Farm 2	L.S.D at 5%
Total bacterial count (TBC)	3.85± 0.21	3.22 ± 0.15	0.021
Total coliform count (TCBC)	1.60 ± 0.08	1.10 ± 0.20	0.008
Staphylococci spp. count (Staph BC)	ND	ND	
Salmonella count (SBC)	ND	ND	

Data (n=3) are expressed as mean ± (SD) standard deviation; Farm 1: Irrigated from El-Batts drain; Farm 2: Irrigated from El-Wadi drain; ND: not detected; LSD: Least significant difference ($P \leq 0.05$).

CONCLUSION

Based on these results, it could be summarized that the investigated tilapia fish obtained from Qarun fish farms were of a high quality and safety due to the high nutritional value and the lower values recorded for parameters of TVB-N, TMA-N, TBA, HMs, OCPs, TBC and TCBC compared to the safety permissible levels. All determined parameters were higher in fish samples taken from the eastern farms (farm 1) than those from the western farms (farm 2). Therefore, it can be concluded that filapia fish obtained from two fish farms around Lake Qarun are suitable for human consumption.

RECOMMENDATIONS

Given the upper mentioned data, it is recommended to protect Lake Qarun and the surrounded fish farms from contaminants of different kinds of wastewaters, sewage and agricultural wastes through establishing purification networks in the El-Wadi and El-Buts to reduce environmental risks. In addition, enforcement of laws and legislations regarding the protection of aquatic environments must be taken into consideration.

CONFLICT OF INTEREST STATEMENT

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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