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Assessing the chemical and microbiological quality of farmed tilapia in Egyptian fresh fish markets

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ABSTRACT

Fish make important contributions to food and nutrition security in low and middle income countries; however, they are also prone to contamination with a range of chemical and biological hazards. The presence of people's perception and health hazards has implications for consumer acceptability and hence the potential contribution of fish to nutrition and health. The aim of this study was to assess the chemical and microbiological quality of farmed tilapia in Egypt. We conducted a systematic literature review resulting in 38 papers meeting inclusion criteria. We also conducted a survey of seven hazardous chemicals in fish sampled from farms (300 samples from 100 farms) and of 5 biological hazards as well as total bacterial counts in fish sampled from retailers (300 samples from 100 retailers). The results showed that the level of contamination with heavy metals and pesticides was lower than the national and international permissible limits. On the other hand, level of contamination of a considerable proportion of samples with microbial pollutants was higher than the permissible limits. Results from the literature indicated that, the level of contamination of wild tilapia was higher than farmed tilapia, again in contradiction to common perceptions. Our results indicate that the risk of human exposure to heavy metals and pesticides via consumption of farmed tilapia is negligible compared to microbial hazards. These findings suggest that post-harvest contamination is the major health risk in the tilapia fish value chain and we make recommendations for addressing this.

1. Introduction

Globally, aquaculture accounts for about 50% of fish consumed and is one of the fastest growing food sectors (Subasinghe et al., 2009) with a growth rate of approximately 6.2% in 2011 (FAO, 2013). In low and middle income countries, most farmed fish (> 80%) is produced in fresh water by small scale producers (Hastein et al., 2006). While fish is an important source of low fat, protein rich food, omega-three/omega-six fatty acids that protect against adverse health effects, such as coronary heart disease and stroke (Domingo, 2007), there are also increasing concerns about foodborne hazards, chemical and microbial, that might be present in fish. These concerns can also result in decreasing demand for farmed fish (Smallwood and Blaylock, 1991). This could negatively affect fish farmers and retailers and decrease consumption and use of animal source food.

Egypt is the largest aquaculture producer in Africa and among the top 10 producer countries worldwide; in 2015 the aquaculture production was 1.5 million tonnes.[1] Published data on public health hazards associated with farmed tilapia in the Egyptian fresh fish value chains are scarce. Given the unprecedented production and consumption of tilapia in Egypt of over half a million tonnes in 2011 (Macfadyen et al., 2012), it is critical to get an understanding of potential contamination of this important food. A characterisation of farmed tilapia production, marketing and consumption patterns in the Nile Delta identified various potential points of potential contamination (Eltholth et al., 2015). Agriculture drainage canals, which contain water that has been used for agricultural activities and constitute the main water supply for most fish farms in this area were identified as sources of pesticide residues, runoff derived fertilizers and metals that may contaminate farmed fish (Authman et al., 2013, 2012; Authman, 2011; Authman and Abbas, 2007).

The aim of this study was to assess the chemical and microbiological

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[1] https://dailynewsegypt.com/2017/02/20.

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quality of farmed tilapia in the Nile Delta, Egypt. The objectives were 1) to measure chemical and biological contamination levels at farm and retail levels, respectively, and 2) to compare detected contamination with values published in the scientific literature. Outcomes of this study are important inputs for risk assessment and appraisal of strategies for management of human exposure to chemical and/or microbiological health hazards via consumption of farmed tilapia.

2. Materials and methods

2.1. Study site and sampling

For the assessment of chemical pollutants, 300 whole tilapia of at least 100 g were collected from 100 fish farms (three each) in Kafrelsheikh governorate, the main fish producing area in Egypt, in which about 55% of the farmed fish is produced (Macfadyen et al., 2011). Farms were selected randomly (Eltholth et al., 2015). Visits were scheduled with the owner, manager, or a worker who was authorised to talk to the enumerators. Upon visiting the farm, three fish from one pond, given that all ponds within the farm were connected, were collected in sterile plastic bags. When ponds were not connected, one pond was randomly selected and fish samples were collected. Samples were transported to Kafrelsheikh University Central Laboratory of Environmental Studies (KUCLES) on ice in an ice box as soon as possible.

For the assessment of microbiological pollutants, tilapia samples were collected from 100 fresh fish retailers (20 wholesalers, 56 retailers and 24 street vendors) from Kafrelsheikh, Gharbia and Menoufia governorates in the Nile Delta. The target fish retailers were those serving the consumers in the study area; they were traced from consumers interviewed as described elsewhere (Eltholth et al., 2015). From each retailer three whole tilapia of at least 100 g were taken from tilapia boxes offered for sale to customers. To make sure that tilapia were locally produced, retailers were asked about the source of tilapia. All samples were collected in sterile plastic bags and transported to the Central Diagnostic and Research Laboratory, Faculty of Veterinary Medicine Kafrelsheikh University on ice in an ice box.

2.2. Laboratory analysis

Samples were prepared and analyzed for chemical and microbial contaminants according to the standard methods. Detailed description of the analysis for chemical and microbial contaminants is available in appendix 1.

2.3. Literature review

A systematic litrature review aimed to compare detected contamination with values published in the scientific literature. The following databases were searched: PubMed and Google Scholar. For the initial identification of primary studies the search terms “heavy metals”, “arsenic”, “lead”, “cadmium”, “mercury”, “muscles”, “pesticides”, “residues”, “organophosphorus” or “organochlorines” were applied in combination with “Egypt” AND “tilapia” using AND. The searches of Google Scholar were restricted to articles published since 2000 to December 2013. Titles and abstracts were screened for primary identification of relevant studies according to the following criteria: (i) published in a scientific journal, (ii) in English language and (iii) addressed at least one of the chemical pollutants under the scope of this study. The following studies were excluded: review articles, experimental studies or trials for assessing the impact of pollution on tilapia, and studies investigating the contamination of fish species other than *Tilapia niloticus*. Additionally, studies investigating the contamination of tilapia organs other than muscles were excluded, as only muscle tissue is commonly consumed. Relevant articles were imported to the Endnote database, duplicates were removed and the full text was obtained. Next, the articles were read in full and the concentration of pollutants under the scope of this study was recorded. Simple descriptive statistics using excel was used to summarize the findings of relevant studies.

2.4. Ethical approval

The present study received approval from the Ethics and Welfare Committee of the Royal Veterinary College, London, UK (reference number URN 2012 1191) and Kafrelsheikh University, Egypt. Oral informed consent was obtained from each study participant after reading written consent form. The interviewers confirmed the participants' oral consent by ticking the relevant boxes on the hardcopies. The consent form mainly explained about the purpose of the study, the risks and benefits of participation in the study, conditions of confidentiality and the right to refusal or withdrawal from the study.

3. Results

3.1. Chemical analysis of tilapia samples from fish farms

Six pesticides and one heavy metal were detected namely, aldrin, dieldrin, endrin, heptachlor, heptachlor-epoxide (beta) and lindane pesticides and mercury, respectively. All detected pesticides were well within the maximum permissible limits (MPL) defined by Codex Alimentarius Commission (CAC, 2009). The concentration of mercury in all contaminated samples was lower than the MPL (0.50 ppm) stated by Egyptian Organization for Standardization and Quality (EOS, 2010). Arsenic, lead and cadmium were not detected in any of the samples. Results for the chemical hazards in farmed tilapia are in Table 1.

3.2. Bacteriological analysis of fish samples from retail sale

The mean total counts of aerobic plate count (APC), *E. coli, S. aureus* and *V. parahaemolyticus* in positive samples are listed in Table 2. The proportions of samples with count higher than the MPL stated by EOS (EOS, 2005) were 13.7%, 8.0%, 7.7%, 3.3%, 13% and 12.3% for APC, *E. coli, L. monocytogenes, Salmonella, S. aureus* and *V. parahaemolyticus*, respectively. Out of the tested samples, only 64.3% complied with all bacteriological standards: the level of APC and tested pathogens were under the MPL stated by the EOS. The mean APC ($6.2 * 10^5$ Colony Forming Unit (cfu)/g) for samples collected from the whole sale market was lower than that from the retail markets and the latter was lower than that from street vendors.

3.3. Literature review for chemical pollutants in tilapia

The initial search revealed 6,108 publications. After exclusion of duplications and applying the inclusion criteria, 38 papers were retained. From these articles data were extracted and summarised in appendix 2 and 3 for pesticide residues and heavy metals, respectively.

Table 1
The concentrations of pesticide residues in tilapia from fish farms in Kafrelsheikh governorate, Egypt.

Concentration (ppb[a])	Pesticides					
	Aldrin	Dieldrin	Endrin	Heptachlor	Heptachlor-Epoxide	Lindane
Minimum	7.48	9.2	0.34	0.8	0.34	1.2
Maximum	35.42	33.6	12.4	6.96	2.91	5.9
Mean	19.18	16.78	2.37	2.68	1.29	3.04
Standard deviation	7.64	6.18	2.69	1.48	0.56	1.33
MPL[b]	300	300	300	200	200	200

[a] ppb = part per billion.
[b] MPL = Maximum permissible limits (Yahia and Elsharkawy, 2014).