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Review Article

Microbial Quality of *Tilapia nilotica* in Egypt: A Review

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Abstract

Fish is considered as important source of animal derived protein, omega-3-fatthy acids, minerals such as calcium, phosphorus, iodine, and vitamins. Among the fish species, *Tilapia nilotica* is the most famous fish in Egypt due to its ease culturing, short production cycle, cheap price, and therefore play fundamental roles in food security, particularly in the human supply of the anumal-derived protein. Fish during its production till delivery to the consumer's table might be exposed to a vast array of microbial contaminants either originated from its surrounding eniveronment or via cross contamination from the angler's hands, during transportation, and storage. Therefore, tilapia might act as a potential source of spreading of foodborne pathogens to the consumers. However, few reports had investigated the microbal quality of tilapia, particularly in Egypt. Therefore, this review was undertaken to report literatures studying the prevalence of some foodborne pathogens in tilapia fish in Egypt, the factors that affect the microbial quality of the fish, and some recommendations in order to extend the shelflife and improve the microbial quality of *Tilapia nilotica*. This reviw concluded that tilapia is eligible for contamination with a vast array of microorganisms such as *Enterobacteriacae*, *Staphylococcus aureus*, *Shewanella putrefaciens*, *Corynebacterium urealyticum*, *Aeromonas hydrophila*, and *Flavobacterium* spp. Therefore, it is highly recommended to have efficient cooking of fish either via boiling, grilling, panfrying, dipping in liquid smokes, irradiation, ozonization, and addition of smone natural addirives such as lemon juice.

KEYWORDS
Tilapia, microbial quality, Shelf life, Egypt.

INTRODUCTION

One of the fastest-growing food industries, aquaculture provides roughly 50% of the fish consumed globally and has a growth rate of about 6.2% in 2011 (FAO, 2013). Small-scale farmers produce the majority of farmed fish (>70%) in fresh water in low- and middle-income countries (Hastein *et al*., 2006). While fish is a significant source of low-fat, protein-rich foods that contain omega-3 and omega-6 fatty acids that protect against harmful health effects like coronary heart disease and stroke (Morshdy *et al*., 2013, 2019). Egypt is one of the top 10 producers globally and the largest producer of aquaculture in Africa; 1.5 million tonnes of aquaculture were produced in Egypt in 2015 (Eltholth *et al*., 2015). There are also growing worries about possible chemical and microbial foodborne hazards that might be transferred to human through fish consumption. The demand for farmed fish may decline as a result of these worries (Smallwood and Blaylock, 1991). This can have a negative impact on fish farmers and there may be a decline in the consumption and use of foods derived from animals.

Tilapia nilotica (*Oreochromis niloticus*) is the most famous aquatic species in Egypt and several African countries. This species play a major role in filling the shortage in the animal protein in Egypt, particularly because of its short life cycle, cheap price, and their massive production. There are few published studies on the risks to public health posed by farmed tilapia in Egyptian fresh fish value chains. It is essential to comprehend any potential contamination of this significant delicacy, especially given the exceptional production and consumption of tilapia in Egypt in 2011 of over half a million tonnes (Macfadyen *et al*., 2012). In the Nile Delta, numerous potential locations of potential contamination were discovered by a characterization of farmed tilapia production, marketing, and consumption patterns (Eltholth *et al*., 2015). Tilapia contributes to the transfer of some chemical contaminants as confirmed in previous reports from our laboratory and others such as heavy metals (Morshdy *et al*., 2019, 2021), antibiotics (Morshdy *et al*., 2022b), and pesticides. Tilapaia also contributes largely to the spread of some foodborne pathogens to human such as *Salmonella* spp., *E. coli*, *Staphylococcus aureus*, and others (Morshdy *et al*., 2022a).

Tialpia at the same time is a highly pershaple food and can be easily contaminated and spoiled if not properly and adequately preserved. Several factors affect the microbial quality of the tilapia fish. For instances, the kind of the tilapia whether wild or farmed, the water quality at which the fish was reared, the method of fishing, the season of harvest, temperature, and relative humidity, the storage conditions. All of these factors affect the initial microbial load of the fish and subsecuentelly affect the shelflife and microbial quality of the fish (de Mendonça Silva and Gonçalves, 2017).

Therefore, in this review, we would like to highlight the prevalence of some foodborne pathogens in tilapia fish in Egypt, the factors that affect the microbial quality of the fish, and some recommendations inorder to extend the shelflife and improve the microbial quality of *Tilapia nilotica*.

Prevalence of some foodborne pathogens in *Tilapia nilotica*

Few studies were conducted to investigate the microbial quality of tilapia in Egypt. For instances, El-Shafai *et al*. (2004) investigated the microbial quality of tilapia reared in fecal contaminated fishponds. They indicated that faecal coliform was present in all tissue samples, with the exception of muscle tissues. Intestine was ranked on the top in terms of faecal coliform infection followed by the gills, skin, and liver. Besides, Al-Harbi *et al*. (2005) demonstrated that bacterial counts can be used as a measure of quality because bacterial activity is by far the main factor affecting fish quality. The aerobic heterotrophic microflora in the intestine of fresh and frozen tilapia was described in their work. There were 16 distinct bacterial taxa found in all, with gram-negative rods (67%) dominating. Four bacterial species, *Shewanella putrefaciens*, *Corynebacterium urealyticum*, *Aeromonas hydrophila*, and *Flavobacterium* spp., were consistently found in both fresh and frozen conditions, with a prevalence of 10% in most instances. Throughout the research period, *Shewanella putrefaciens* predominated as the main organism (15 percent of all isolates). Some bacteria were lost during frozen storage, however most bacteria survived after extended freezing. Salem and El-Newishy (2010) examined 35 tilapia fish collected from fish markets at Qaluobia, Egypt. They recorded a microbial contamination rate of 45.7%. *S. aureus* was the bacteria found in the highest percentage of the isolated bacteria (22.9%), followed by *E. coli* (14.3%), *Salmonella* spp. (5.7%), and *Shigella* spp. (2.9%). The skin surface of the fish under examination had the largest percentage of bacterial isolates, followed by the intestine, while the muscles had the lowest rate. Muscles of tilapia purchased from fish shops at Zagazig city Egypt were found contaminated with *Salmonella* spp., at 20%, where *S.* Typhimurium was the most prevalent at 13.3%, and *S. rubislam* at 6.7% (Bayomi *et al*., 2016). Moreover, Donia *et al*. (2017) mentioned that the fish that were sampled from El Salam Canal, Northern Sinai, Egypt. included a variety of bacterial species. Eight different bacterial species, including *Salmonella* spp., *Enterobacter cloacae*, *Rhizobium radiobacte*, *Fluorescens* spp., *Listeria monocytogenes*, *Streptococcus agalactiae*, *Streptococcus iniae*, and *Aeromonas hydrophila*, were isolated from fish. These bacteria were identified biochemically. Each sample had a different amount of bacteria, with the gills having $44.5x10^7$ cfug/g, the gut having $20x10^8$ cfug/g, and the skin having $38.75x10^8$ cfug/g. Authors recommended to follow restrictive measures to prevent the spread of pollution sources in El-Salam Canal as a result of the isolates being discovered to be of medical value. Besides, Shokr *et al*. (2018) reported that *E. coli* contamination in fresh fish suggests recent contamination and is typically due to contaminated handlers or ice storage. When handling fish or eating raw or undercooked fish, *E. coli* can be transferred to people. Human infections (foodborne illnesses) can range in severity from mild diarrhoea to hemorrhagic colitis and hemolytic uremic syndrome, both of which can be fatal. In this regard, 200 fish samples from the gills, muscles, surface, and gut, 100 water samples, and 100 hand swaps from vendors' hands were obtained for this investigation from the Kafrelzyate and Tanta retail markets in Gharbiya. The samples were analysed to see if *E. coli* was present. The presence of *E. coli* was detected in forty-four samples (8 gills, 3 muscles, 8 surface, 9 gut, 9 water, and 7 seller's hands). The identification was done using PCR and biochemical techniques. Ten antimicrobial discs were used to test the 44 isolates for antimicrobial resistance, and the findings showed multiple antimicrobial resistance. The isolates' serological identification revealed that O44 (15.9%), O125 (20.4%), O172 (13.6%), O103 (6.8%), and O119 (18.1%) were present. By using PCR, the isolates' virulence genes *stx1, stx2*, and *eaeA* were identified. In addition, tilapia samples collected from Benha city had 94% microbial contamination level with mean counts of 2.65x103, and $1.81x10^3$ cfu/g for *Enterobacteriaceae* and coliform bacteria. Additionally, bacteriological classification of *Enterobacteriaceae* isolates revealed detection of *Citerobacter diversus*, *Citrobacter freundii*, *E. coli*, *Enterobacter aerogenes*, *Enterobacter cloacae*, *Klebsiella oxytoca, Proteus mirabilis, Proteus vulgaris*, and *Yarsenia enterocolitica* at variable percentages. Since it is evident that raw fish might be contaminated with bacteria of serious health significance, it is strongly advised to prepare and treat fish in a hygienic manner (Rawash *et al*., 2019). Furthermore, Salem *et al*. (2020) reported isolation of Aeromonas spp., from diseased tilapia in three tilapia fish farms located in Kafr El-Sheikh, El- Manzala, and Gamsa fish farms at prevalence rates of 79.17, 70, and 58.33%, respectively. *Salmonella* spp. was isolated from 35 tilapia collected frol Lake Qarun protectorate in El-Fauoum governorate by 8.6% of external surfaces, 5.7% of internal surfaces, 2.85% of gut, and 0% of muscle (Khalefa *et al*., 2021).

Factors affecting microbial quality and sources of microbial contamination in tilapia

Several factors might contribute to the microbial contamination of the fish such as temperature, relative humidity, oxygen level, water activity, and nutrient supply. In addition, fish might be contaminated with vast array of microorganisms through their surrounding environment, water contamination, contaminated animal feed, polluted aquatic environment, cross-contamination from the fish handlers, during transportation, contaminated refrigerators and others (Alsayeqh *et al*., 2021; Darwish *et al*., 2022).

El-Shafai *et al*. (2004) reported that the poor water quality, rich in ammonia and nitrite, could enhance the microbial contamination in the fish tissues. The authors concluded that human consumption of the fish muscle is safe for tilapia raised in fishponds fed with water and/or duckweed pond system treating home sewage. The only issue could be cross-contamination during fish processing from severely polluted organs (general viscera, gills, and skin). Fish handlers can contribute largely to the cross contamination of the fish with vast array of microorganisms as documented by Salem and El-Newishy (2010) who mentioned that hand swabs of fish handlers demonstrated 20% and 10% positive results for *S. aureus* and *E. coli*, respectively. The degree of bacterial contamination of fish organs may be impacted by water quality factors like ammonia and nitrite in fishponds. Tilapia handling and pre- and post-harvest contamination were noted as potential causes of contamination (Eltholth *et al*., 2015, 2018; Shokr *et al*., 2018). Given the lack of a cold chain, the methods used to collect and handle tilapia from the farm to retail sale may increase its bacterial burden. This effect will be more noticeable in the summer when the average temperature will be above 30°C. Fish may get contaminated after being caught due to the use of infected fishing equipment, contaminated water, ice, filthy surfaces and crates, and unclean handling procedures (Mhango *et al*., 2010). Tilapia contamination may be influenced by environmental factors such as seasonal variations in contamination level and ambient temperature and relative humidity. *Staphylococcus* spp. were shown to be more prevalent in sea foods after storage at 2-4°C, according to studies (Rantsiou *et al*., 2005; Nimrat *et al*., 2006). While preserving the quality of fish by postponing the spoilage process, fish should be stored at 0°C as soon as possible after capture (Farag, 2012). Pollutants would shorten the shelf life of fish and speed up seafood rotting. Bacterial contaminants may cause concerns with food safety in addition to affecting the quality of tilapia.

Despite the fact that farmed tilapia is safer than wild fish, according to our research and statistics from the literature, customers still prefer wild fish and will pay more for it. This could be as a result of worries that farm-raised tilapia are fed on dead chicken and excrement. Additionally, some sellers assert that the fish they sell is of high quality and comes from sustainable sources. The value chain for farmed tilapia is negatively impacted by consumers' lack of information and traceability (Eltholth *et al*., 2015). In addition, Khalefa *et al*. (2021) highlighted the role of the migratory water fowls in the transmission of some bacterial species into the aquatic organisms as documents by the dissemination of *Salmonella* spp. Into the water body through the birds' feces. In genereaql, if the value chain is developed to manage risks, especially post-harvest contamination, increase trust, and better match risk perception with reality, farmed fish can be of high quality.

In general, it is highly recommended to have efficient cooking of fish either via boiling, grilling, panfrying. Some new technologies are also adopted to improve the microbial quality and extend the shelf life such as dipping in liquid smokes (Bayomi *et al*., 2016), irradiation, and ozonization (de Mendonça Silva and Gonçalves, 2017), addition of smone natural addirives such as lemon juice (Morshdy *et al*., 2022a).

CONCLUSION

The current review threw the light on the microbial quality of the tilapia fish, which plays an important role in food security in Egypt, particularly for the protein of animal origin. Tilapia can contribute to the spread of some foodborne pathogens such such as *Salmonella* spp., *Vibrio* spp., *Aeromonas* spp., and others. Therefore, it is necessary to adopt restrict food safety measures to ensure continuous monitoring and checking of the quality of the tilapia fish either cultured or wild.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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