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Review Article

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Potential Hazards Associated with the Consumption of Crustaceans: The Egyptian Scenario

Abd-Elsalam E. Hafez, Rasha M. Elbayomi, Sara M. El Nahal, Ahmed E. Tharwat, Wageh Sobhy Darwish*

Food Control Department, Faculty of Veterinary Medicine, Zagazig University, Zagazig 44511, Egypt.

***Correspondence**
Wageh Sobhy Darwish
Food Control Department, Faculty of Veterinary Medicine, Zagazig University, Zagazig 44511, Egypt.
E-mail address: wagehdarwish@gmail.com

Abstract

Crustaceans such as shrimp and crab are considered as a rich source of protein, omega 3 fatty acids and trace elements. However, they are exposed to a vast array of xenobiotics during their lifetime such as heavy metals, pesticides, and dioxins. Moreover, crustaceans are also implicated in the transmission of many foodborne pathogens such as *Aeromonas hydrophila*, *Staphylococcus aureus*, *Vibrio* parahemolyticus, and others. They are also rich in biogenic amines such as histamine and cadaverine, and they might cause severe allergic reactions in highly susceptible people. This review summarized the current scenario of potential hazards associated with the consumption of crustaceans in Egypt.

KEYWORDS
Crustaceans, Chemical hazards, Microbial hazards, Egypt

INTRODUCTION

Crustaceans, including crab, lobster, and shrimp, are regarded as new sources of high biological value protein (16.0-19.2%), rich in omega-3 polyunsaturated fatty acids, moisture (75.3-79.5%), carbohydrate (1.3-3.6%), minerals including calcium and phosphorus, and vitamins, particularly vitamin D. The amino acids alanine (3.9-8.1%), arginine (4.7-7.1%), aspartic acid (7.7-10.7%), glutamic acid (10.7-16.2%), glycine (4.5-8.7%), and lysine (5.5-9.4%) are abundant in crustaceans (Sidwell, 1981). The consumption of fish and shellfish is increasing worldwide, particularly in Egypt to compensate the shortage of red meat.

At the same time, crustaceans are exposed to a vast array of xenobiotics (Fig. 1) during their lifetime such as heavy metals including lead (Pb), cadmium (Cd), arsenic (As), and copper (Cu); pesticides such as organochlorine pesticides (OCPs) like dichlorodiphenyltrichloroethanes (DDTs), and hexachlorocyclohexanes (HCHs); polychlorinated biphenyls' (PCBs), and dioxins that find their way to human body via consumption of the contaminated crustaceans causing serious adverse health effects (Thompson and Darwish, 2019). Moreover, the transmission of foodborne pathogens such as *Staphylococcus aureus* (*S. aureus*), *Salmonella* spp., *Vibrio* spp., and *Aeromonas* spp. (Fig. 2) is thought to be possible with crustaceans (Hatha and Lakshmanaperumalsamy, 1997; Traore *et al*., 2012; Rajkovic, 2016).

Chemical contaminants of crustaceans include heavy metals that have serious health effects on humans. For instances, Pb is associated with several cases of intoxications among children

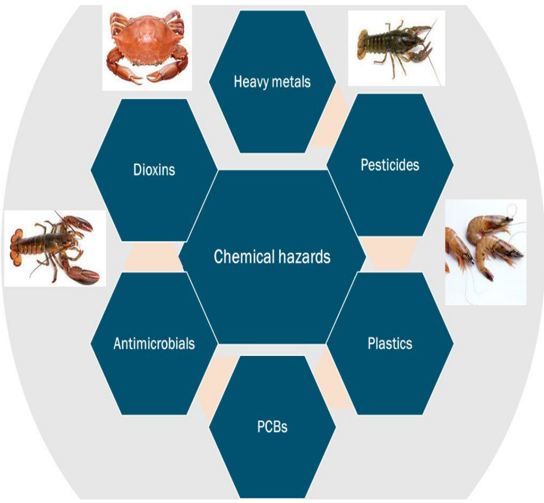

Fig. 1. Chemical hazards associated with the consumption of crustaceans.

causing several cases of deaths as reported in Zambia (Yabe *et al*., 2015), Nigeria, and China. Lead is also reported to impair intellectual functions, interferes with hemoglobin synthesis leading to anemia (Darwish *et al*., 2016). Cadmium is another toxic metal which is associated with kidney dysfunction, and bone softening causing what is called itai-itai disease. Moreover, Cd is also classified as a carcinogen by the International Agency for Research on Cancer (IARC, 2016). Arsenic (As) is also related to several public health hazards such as skin keratosis, cancer, and multiple organ damage (Morshdy *et al*., 2013; 2019). Mercury (Hg) is a highly toxic element causing different adverse health effects that in-

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clude neurological, immune, renal, and developmental disorders (Clarkson and Magos 2006). Copper (Cu) is classified as one of the essential trace elements needed for the normal function of many enzymes, however, excess exposure to Cu is also associated with toxicities and oxidative damage (Darwish *et al.*, 2014). Organochlorine pesticides are also another group of environmental chemicals that can be transferred to humans via consumption of contaminated crustaceans leading to several health implications including endocrine disrupting effects, toxicities, and teratogenesis (Thompson *et al.*, 2017).

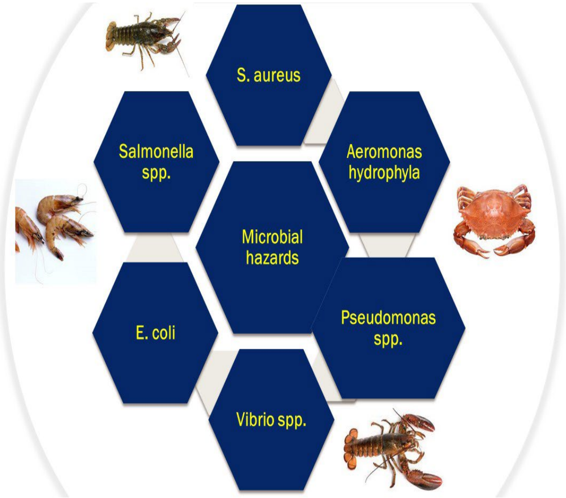

Fig. 2. Microbial hazards associated with the consumption of crustaceans.

Microbial contaminants of crustaceans include several bacterial species that are associated with foodborne intoxications such as *S. aureus* which can produce different types of *Staphylococcus* enterotoxins (SE) A, B, C, D, and E), and foodborne infections such as *Salmonella* spp., *E. coli*, *Aeromonas* spp. (Darwish *et al.*, 2018; Shaker *et al.*, 2022).

Consumption of crustaceans are also associated with the human exposure to allergens. For instances, WHO/IUIS registered seafood allergens include currently 21 fish, 31 crustacean, and 6 mollusc allergens. The allergens associated with the consumption of crustaceans include troponin, tropomyosin, arginine kinase, paramyosin, and others. Such allergens are of significant importance on human health causing anaphylaxis and sever allergy (Motoyama *et al.*, 2007; Ruethers *et al.*, 2018).

This review will summarize the occurrence of chemical, and microbiological hazards associated with the consumption of fish in Egypt.

Chemical contaminants of crustaceans

Crustaceans are regarded as an ideal bioindicator organisms to reflect the water pollution with various chemical contaminants such as heavy metals, OCPs, PCBs, and others (Thompson and Darwish, 2019). Consumption of such contaminated crustaceans might lead to severe toxicological implications. In this regards, the levels of OCPs were estimated in shellfish from several stations along the Egyptian Mediterranean coast, where, OCPs detected in shellfish include, α, β, γ, -HCH, DDTs (p,p-DDE, p,p-DDD and p,p-DDT), cyclodienes (aldrin, dieldrin, endrin, endrin aldehyde, endrinketone, heptachlor, methoxychlor, heptachlor epoxide, γ-chlordane, α-endosulfan, β-endosulfan, and endosulfan sulfate) and polychlorinated biphenyls (PCBs). The total OCPs' concentrations ranged from 47.07 ng/g to 113.9 ng/g with an average of 85.77 ng/g. Concentrations of OCPs in shellfish followed the order: Total cyclodienes < PCBs < DDTs < HCHs. The total PCB concentration in the shellfish samples that were taken ranges from 15.13 ng g1 to 37.49 ng/g, with an average of 25.72 ng/g. The samples taken from the areas of Eastern Harbor and Abo-Qir had the highest values of PCB (37.49 and 33.42 ng/g), respectively. Due to their extended half-lives and ease of bioaccumulation across the trophic chain, the higher chlorinated congeners are of considerable environmental significance. The concentration of POPs in the investigated area's shellfish can generally be regarded as not being at levels causing a health danger, according to international health authorities (Salem *et al.*, 2014). In another study by El Nemr *et al.* (2016), metal contents showed a descending order of Zn > Cu > Ni > Al > V > Pb > Cd > Hg in the soft tissues of crustaceans collected from the red sea coast in Egypt. Mercury did not provide any risk to human health, according to calculations made for the hazard quotient (HQ) of heavy metals found in the soft tissue of shellfish, but other heavy metals found in the samples had HQ values between 1 and 10, indicating a potential concern over the long term. In mussels, the levels of Cu are higher than desired. Cu was the sole heavy metal that had a negative impact on the health of toddlers, according to the RQ estimations of both toddlers and adults. Besides, the amounts of OCPs and heavy metal residues in shellfish (shrimp, oyster, and crab) collected from three Egyptian governorates (Ismailia, Damietta, and Alexandria) were examined. The levels of 12 OCPs, including DDTs, aldrin, endrin, and HCHs were measured. ß-HCH, p,p-DDE, and endrin were the three most prevalent OCPs found. OCPs were detected in the following order: HCHs > DDTs > Other OCPs (HCB, heptachlor, heptachlor-epoxide, aldrin, endrin, and chlordane). Heavy metals and trace elements were also estimated. The results of the study showed a range for pb concentrations in shellfish (0.84 to 1.63μg/g ww) with a mean value of 1.19 μg/g ww. The Cd residual concentrations in shellfish ranged from 0.21-0.55 μg/g ww with a mean value of 0.38 μg/g ww. The range of As levels in shellfish was 0.81 to 1.45μg/g ww with an average concentration of 1.13 μg/g ww. The concentrations of Hg in shellfish were varied from 0.53 to 1.16 μg/g ww with a mean value of 0.83 μg/g ww. The highest Pb, Cd, As, and Hg levels were observed in oysters from Damietta, while the lowest concentration was found in crabs from Ismailia (Saber *et al.*, 2018). Lead, Cd, Hg, and As residues were estimated in six shellfish species, including shrimp, crab, crayfish, clam, oyster, and mussels, which were procured from fish markets in Ismailia governorate, Egypt. The obtained data showed a distinct and considerable variance in the rate at which each metal accumulated in the investigated shellfish. Positive connections in the pattern of metal buildup were also found. Authors concluded that consumers who regularly consume large amounts of shellfish may be putting their health at risk. Shellfish that has been grilled or barbecued has higher levels of the tested metals (Atia *et al.*, 2018). Antimicrobials such as tetracyclines were also detected in the aquatic organisms in Egypt (Morshdy *et al.*, 2022).

Microbial contaminants of crustaceans

Crustaceans play a major role in the transmission of foodborne pathogens to human leading to several cases of human hospitalizations worldwide (Campos *et al.*, 2020). In Egypt, few studies investigated the microbiological quality and safety of crustaceans. For instances, crayfish (Procambarus clarkia) from fresh water collected from the river Nile and its resources throughout Egypt, was examined microbiologically and chemically to establish its safety and suitability as food for humans. The average aerobic plate and Enterobacteriaceae counts/g were $1.6x10^8$ and $3.5x10^5$, respectively, and 100% and 40% of the samples under examination had coliforms and *E. coli* isolated. However, none of the analyzed samples allowed for the isolation of *Salmonella*e. For human ingestion, 20% of the samples were safe, 33.33% were moderately acceptable, and 46.67% were unacceptable (Elmossalami and Emara, 1999). However, *Salmonella* spp. was isolated from shrimp, mussels (om-elkhloul), and gandofli collected from Alexandria at 9.8% (Bakr *et al*., 2013). Mesophilic, psychrophilic, *S. aureus*, and most probable number (MPN) of coliforms, faecal coliforms, and *E. coli* are all examined in crab and shrimp samples collected from Beni-Suef governorate, Egypt. The obtained results showed that pathogenic *E. coli* and *S. aureus* were isolated at a high percentage of the examined crustaceans, but the total mesophilic, psychrophilic, and *S. aureus* counts in the majority of the samples of the examined crustaceans were below the acceptable limits advised by national and international organizations (Ali *et al*., 2018). Moreover, Ahmed *et al*. (2018) examined 225 samples of crustaceans and human stool samples tested as well. A prevalence rate of 15.1% of *Vibrio parahaemolyticus* isolates were found in the bacterial and molecular analyses of crustaceans, together with 0.9% *Vibrio* cholerae isolates, while isolates of *V. parahaemolyticus* were found in 3% of the human stool samples. In comparison to the two *V. cholerae* isolates, the virulence-associated genes tdh and/or trh were found in 5.9% of crustacean samples and 100% of human samples, respectively. Antibiotic sensitivity testing found that the *Vibrio* isolates had a significant level of antibiotic resistance and had an average MAR score of 0.77. Besides, in a recent international collaborative study by our group investigated the presence of *Aeromonas* spp., opportunistic microorganisms that often live in aquatic habitats including freshwater and marine water bodies, in crustaceans like crab, lobster, and shrimp. It notes worthy to confirm that, food-borne gastroenteritis from *Aeromonas* spp. may progress into septicemia, meningitis, endocarditis, and osteomyelitis, all of which have substantial mortality rates in those with impaired immune systems. Samples from three crustaceans (crab, lobster, and shrimp) sold at retail in Zagazig, Egypt, and Al-Ahsa, Saudi Arabia, were collected and examined bacteriologically for isolation of *Aeromonas* spp., particularly, *A. hydrophila*. PCR was also used to screen for the presence of virulence-related genes in the recovered *A. hydrophila* isolates. The recovered *A. hydrophila* isolates were also tested for antibiotic resistance profiles. The studied crustacean samples were acquired from Egypt and Saudi Arabia, respectively, and the obtained results of the current study showed that overall isolation rates of *Aeromonas* spp. were 48.33% and 21.66%, respectively. In samples taken from Egypt and Saudi Arabia, crab samples had the highest incidence rates, followed by lobster, and shrimp. *Aeromonas hydrophila*, A. sobria, A. caviae, and A. veronii are the four *Aeromonas* species that were identified. Aerolysin (*aer*A) and haemolysin (*ahl*), two hemolytic toxins with multidrug resistance profiles, were present in the recovered isolates of *A. hydrophila* (Shaker *et al*., 2022). It is of importance to mention that the bacterial quality of crustaceans also affect their potential to produce biogenic amines, which are nitrogenous substances that produced by amino acid decarboxylase processes (Tang *et al*., 2020). Autolysis or proteolysis by proteolytic bacteria can produce several species of biogenic amines (Ruiz-Capillas and Jimenez-Colmenero, 2005). In various dietary matrices, including meat, fish, cheese, and vegetables, biogenic amines are generated (Ma *et al*., 2020). Foods containing biogenic amines may have toxicological effects such as anaphylaxis, nervous system diseases, and muscle disorders (Stadnik and Dolatowski, 2010). The levels of biogenic amines in food provide information on the food's microbiological quality and the sanitary practices adopted during preparation and processing. But there is a glaring dearth of information regarding the biogenic amines' levels in crustaceans in Egypt.

CONCLUSION

The current review highlights the current knowledge about the potential hazards associated with the consumption of crustaceans in Egypt. Despite being less investigated, the available information demonstrated that crustaceans play important roles in the human exposure to several chemical pollutants particularly, heavy metals in Egypt. Crustaceans also contribute to the human exposure to several foodborne pathogens such as *S. aureus*, *Salmonella* spp., *E. coli*, *Vibrio parahaemolyticus*, and *Aeromonas hydrophila*. Therefore, it is of importance to expose crustaceans to efficient heat treatment before serving to humans. Moreover, continuous monitoring studies are still necessary for proper understanding of the current scenarios of the potential health risks associated with the human consumption of crustaceans in Egypt.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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