Mycoflora of Fresh Shrimps (*Penaeus aztecus*) from Different Markets in Port Harcourt Nigeria

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ABSTRACT

Fungi were isolated from fresh brown shrimps (*Penaeus aztecus*) purchased from three different markets in Port Harcourt using standard mycological methods. The total counts of heterotrophic fungi range from 2.0 x 10^4 spore forming units per gram (sfu/g) to 7.1 x 10^4sfu/g, while the total counts for pathogenic fungi range from 1.7 x 10^4sfu/g to 7.1 x 10^4sfu/g. The heterotrophic fungi and their percentage occurrence in the H/E/T (head, exoskeleton and telson/uropod) before deterioration and about deterioration were: *Aspergillus clavatus* (20%), *Aspergillus flavus* (20%), *Penicillium* sp (20%), *Rhizopus* sp (20%), *Rhodotorula* sp (20%), and *Aspergillus flavus* (28.6%), *Mucor hiemalis* (14.3%), *Penicilllium* sp (14.3%), *Rhizopus* sp (14.3%), *Rhizopus stolonifer* (14.3%), Yeast sp (14.3%) respectively. While the pathogenic fungal occurrence before deterioration and about deterioration in the H/E/T were: *Aspergillus clavatus* (11.1%), *Aspergillus flavus* (22.2%), *Penicillium* sp (33.3%), *Rhizopus oryzae* (11.1%), *Rhodotorula* sp (11.1%), Yeast sp (11.1%), and *Aspergillus clavatus* (12.5%), *Aspergillus flavus* (12.5%), *Mucor hiemalis* (12.5%), *Penicillium* sp (12.5%), *Rhodotorula* sp (12.5%)and Yeast sp (37.5%) respectively. Heterotrophic fungi in the flesh before deterioration and about deterioration were, *Aspergillus flavus* (33.3%), *Penicillium* sp (33.3%), yeast sp (33.3%) and *Aspergillus flavus* (22.2%), *Aspergillus niger* (11.1%), *Mucor plumbeus* (11.1%), *Penicillium* sp (22.2%), *Phialophora fastigiata* (11.1%), *Rhizopus stolonifer* (11.1%) and *Rhodotorula* sp (11.1%) respectively. While the pathogenic fungal occurrence before deterioration and about deterioration in the flesh were *Aspergillius flavus* (28.6%), *Penicillium* sp (14.3%), *Rhizopus oligosporus* (28.6%), *Rhizopus stolonifer* (14.3%), Yeast sp (14.3%), and *Aspergillus niger* (10%), *Mucor hiemalis* (10%), *Mucor plumbeus* (20%), *Penicillium* sp (10%), *Rhizopus stolonifer* (10%), *Rhodotorula* sp (20%), and Yeast sp (20%) respectively. The presence of these fungi in the shrimps is attributed to contamination from the environment and from shrimp handlers (mongers). Also, some of these fungi are normal flora of the shrimp which unfortunately happens to be opportunistic pathogens or pathogens of humans. The maintenance of high personal and environmental hygiene as well as proper heating and cooking will improve fresh shrimp quality and prevent food-borne diseases

Key words: shrimps, contamination, pathogenic fungi, food-borne diseases.

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Introduction

Brown shrimp is a small free-swimming edible crustacean with ten legs. It is basically marine commonly found in estuaries and along coastal waters. However, its primary habitat is muddy bottom areas from inter tidal zone to approximately 110 meters with greatest density occurring at depth between 27-55 meters (Williams, 1984).

Brown shrimps are scavengers generally termed bottom-feeding opportunistic omnivores, which means they feed on most organic materials– dead plant or animal

matter that they encounter at the bottom. They consume some algal species (i.e. filamentous green algae, benthic diatoms, plant detritus), invertebrates such as copepods, mollusks, and annelids (Dall, 1968; Odum and Herald, 1972). Also shrimps between the sizes of 65 – 100mm in length became predatory, feeding on annelid worms, amphipods, zooplankton larvae, and nematodes (Jones, 1973).

These edible crustaceans are composed of 41% (w/w) high value protein and omega–3 fatty acids which have anti-inflammatory effects and are able to prevent the formation of blood clots). They provide excellent sources of cancer protection from selenium as 64.2% of the daily value for this trace mineral can be gotten from just a 4–ounce serving of shrimps. They are also important sources of vitamin D and B12 needed to keep low levels of homocysteine – a molecule that can directly damage blood vessel walls and is considered a significant risk factor for cardiovascular diseases.

Shrimps, apart from being of great nutritional value to the consumer; also serves as an ideal culture medium for microbial growth, which connotes spoilage. Despite all the benefits associated with shrimps, one thing still remains clear and yet unsolved; shrimps are highly prone or susceptible to rapid deterioration immediately after harvest.

Microorganisms are undoubtedly responsible for spoilage of shrimps and these microorganisms include bacteria and fungi, both the heterotrophic and pathogenic forms. One important characteristic of microbes is that, they grow rapidly and increases in number (Harrigan and McCance, 1990). Molds which belongs to fungi, grows rapidly on food (shrimp) when held under moist conditions. These organisms take advantage of the moist condition available and through the aid of enzymes which they possess, they weaken and penetrate the protective outer layer of the shrimp and cause spoilage (Donald et al., 1999).

It is almost always possible to detect a range of human pathogens on any shrimp that has not received any microbiocidal treatment. Some of these pathogens may constitute part of the normal flora on the shrimp or be present as a result of unavoidable contamination (1CMSF, 1996). Also, a normal microflora of humans can cause spoilage of shrimp by way of contamination from handlers, as they touch the shrimp with bare hands in the bid of harvesting and selling the shrimps. Also shrimp spoilage based on microbial origin, originates mainly from the shrimp's environment (which is aquatic) and in this environment, contamination may occur as a result of the presence or introduction of microorganisms through faecal means into the water bodies.

Shrimp deterioration or spoilage is characterized by a change in colour (from grayish to pinkish), texture, taste and odour. At this point, it is believed that the microorganisms switch from the diminishing levels of glucose in the shrimp to amino acids which the microbes now use as a substrate for their growth and survival.

The progress and degree of deterioration of fresh shrimp depends mainly on the temperature at which they are kept soon after harvest. It has been revealed that the longer the shrimps are left unwashed and not iced, the faster they will deteriorate as at these conditions (temperature) microorganisms proliferate more. However, the microorganisms are not naturally present in the shrimp but later gain entrance into the shrimp through handlers and soon after their death; by way of the gills, kidney, skin, blood vessels and exoskeleton. Shrimp deterioration results in loss of a valuable product, and the creation of a repugnant odour both of major concerns to shrimp consumers and processors of shrimp.

Fresh brown shrimps sold in the common markets in Port Harcourt do not undergo

any form of microbiocidal treatment, and they are not iced before sale. The shrimp mongers also handle them with bare hands during transactions. Some shrimp consumers cook the shrimps whole (i.e. including the head, exoskeleton and telson/uropods); others remove the head, exoskeleton and telson/uropods of the shrimps before cooking (only flesh) while some consumers after removing the head, exoskeleton and telson/uropods, grind them and add the paste to the soup or sauce.
There is therefore the need to ascertain the microorganisms (fungi) associated with these various parts of shrimps and the health hazards associated with the types of microorganisms. The knowledge of the types of microorganisms involved in their spoilage will also help to control shrimp spoilage.

Materials and Methods

Sampling sites and Collection of Fresh Shrimp Samples

Fresh shrimp samples were purchased from shrimp mongers in Creek Road market, Town market, and Mile One market all in Port Harcourt Local Government Area of Rivers State. These markets were visited at about 7:30am on the days of collection of samples.
Disposable gloves were worn, before collection of the fresh shrimps from the tray into a sterile transparent plastic container containing ice (the ice helped to reduce or slow down the rate of microbial activity and hence the rate of deterioration of the shrimps). The plastic container was covered with its lid and transported immediately to the laboratory for analysis.

Preparation of Media and Preparation of Diluent

All glassware used during the study was sterilized in the hot oven at a temperature of 1600C for one hour. The different media used for this study include: Potato Dextrose agar (PDA) and Sabouraud Dextrose agar (SDA). These media were used to cultivate heterotrophic fungi (PDA) and pathogenic fungi (SDA) respectively. The different media were prepared according to manufacturer's specifications.
Exactly 0.85g of sodium chloride (NaCl) was weighed and dissolved in 100ml of sterile distilled water 9ml of the normal saline was transferred into sterile lost tubes and autoclaved at 1210C for 15 minutes at 15 pounds/pressure and allowed to cool. The diluent was used to carry out serial dilution of the fresh shrimp samples. Normal saline was used as a diluent because it helps to reactivate stressed microorganisms.

Cultivation and Enumeration and Isolation of Fungi in the Fresh Shrimp.
The fresh shrimp samples were divided into two portions. One portion comprised the head, exoskeleton, and telson/uropod (HET) while the other portion was the flesh (F). The samples were analyzed separately to have a thorough sampling study of the presence of fungi in the samples purchased from the three (3) different markets.
Each portion (sample) was separately ground in a sterile ceramic mortar and pestle. One gram (1.0g) of each portion was transferred into 9mls of the normal saline and thoroughly shaken to make a 10-1dilution. This dilution was further diluted serially up to the 10-3 dilution. This was done so as to obtain discrete colonies or spore forming units when plated out on the different media for fungi.
From the 10-2 and 10-3 dilution an aliquot (0.1ml) was collected aseptically onto separate freshly prepared PDA and SDA plates to which 0.2ml of 0.5% ampicilin was added to inhibit the growth of bacteria and allowing the growth of fungi (Harrigan and McCance, 1990). A sterile glass spreader was used to spread the inoculum evenly on the whole surface of the media. The cultured plates were also prepared in duplicates

and inoculated plates were incubated at ambient temperature for 3-5 days. Colonies or spore forming units which developed on the PDA and SDA plates after 5 days were counted and the average count for duplicate cultures were recorded as total viable heterotrophic fungi and total viable pathogenic fungi in the sample respectively. The colour and colonial morphologies or characteristics were also recorded.
Discrete colonies were subcultured onto freshly prepared PDA and SDA plates and incubated at 280C for 5 to 7 days to further purify the fungal isolates. The fungal spore forming units which developed were further subcultured onto agar slopes or slants and incubated at 280C for 5 to 7 days. The isolates which developed were pure cultures which were stored in the refrigerator as stock cultures for subsequent characterization tests.

Characterization and Identification of Fungi in the Shrimps
Fungal cultures were observed while still on plates and after wet mount in lacto-phenol on slides under the compound microscope.
The following standard characterization tests were performed in duplicate: Macroscopic examination of fungus was carried out by observing the colony morphology -diameter, colour (pigmentation), texture and surface appearance.
Microscopic examination was done by needle mount or wet mount method (Harrigan and McCance, 1990) and by observing sexual and asexual reproductive structures like sporangia, conidial heads, arthrospores and vegetative mycelium.
A wet mount was done for each fungal isolate. A drop of lacto-phenol was dropped on a clean slide aseptically, a piece of fungal hyphae under test was teased into it using 2 (two) sterile needles. The teasing was done carefully and slowly so as to make good spread of the fungal hyphae. The slides were then gently covered with a cover slip to avoid air bubbles. The slides were observed under low and high power objective for the cultural characteristics, sporangia, conidia, arthrospores, vegetative mycelium, septate and non-septate hyphae. Observed characteristics were recorded and compared with the established identification key of Barnett and Hunter, 1972 and Malloch, 1997.

Results and Discussion

Evaluation of Total Heterotrophic Fungi and Total Pathogenic Fungal Counts from the Various Markets
The results of mean count of total heterotrophic and pathogenic fungi in the various portions of the shrimps from the markets are as shown in Table 1 and 2 respectively.

Table 1: Total Heterotrophic Fungal Count (sfu/g) of the Shrimps from the Markets

Head, exoskeleton and telson		**Flesh**	
Before deterioration	**About deterioration**	**Before deterioration**	**About deterioration**
Creek Road Market			
5.1×10^4	6.5×10^4	1.0×10^4	5.1×10^4
6.0×10^4	3.0×10^4	3.0×10^4	9.0×10^4
Mean 5.6×10^4	4.8×10^4	2.0×10^4	7.1×10^4
Mile One Market			
4.1×10^4	4.1×10^4	4.5×10^4	3.1×10^4
9.0×10^4	2.0×10^4	9.0×10^4	6.0×10^4
Mean 6.6×10^4	3.1×10^4	6.8×10^4	4.6×10^4

"Town Market"			
5.1×10^4	6.5×10^4	1.0×10^4	5.1×10^4
6.0×10^4	3.0×10^4	5.0×10^4	9.0×10^4
Mean 5.6×10^4	4.8×10^4	3.0×10^4	7.1×10^4

Table 2: Pathogenic Fungal Count (sfu/g) of Shrimps from the Markets

Head, exoskeleton and telson		**Flesh**	
Before deterioration	**About deterioration**	**Before deterioration**	**About deterioration**
Creek Road Market			
4.8×10^4	3.6×10^4	2.3×10^4	5.2×10^4
8.0×10^4	6.0×10^4	1.0×10^4	5.0×10^4
Mean 6.4×10^4	4.8 x 104	1.7×10^4	5.1×10^4
Mile One Market			
3.0×10^4	4.1×10^4	4.1×10^4	1.5×10^4
7.0×10^4	6.0×10^4	8.0×10^4	5.0×10^4
Mean 5.0×10^4	3.7×10^4	6.4×10^4	3.3×10^4
"Town Market"			
4.8×10^4	3.6×10^4	2.3×10^4	5.2×10^4
8.0×10^4	6.0×10^4	1.0×10^4	9.0×10^4
Mean 6.4×10^4	4.8×10^4	1.7×10^4	7.1×10^4

The mean results of the total count of heterotrophic fungi per gram of head, exoskeleton and telson/uropod (HET) of shrimps from Creek Road market, Mile One market and Town market before deterioration, ranged from 5.1×10^4 sfu/g to 6×10^4sfu/g, 4.1×10^4sfu/g to 6×10^4sfu/g for and 5.1×10^4sfu/g to 6×10^4sfu/g respectively while counts about deterioration ranged from1.0×10^4sfu/g to 3×10^4sfu/g, 4.5×10^4sfu/g to 9×10^4sfu/g, 1.0×10^4sfu/g to 5×10^4 sfu/g.

The mean results of the total count of heterotrophic fungi per gram of flesh of shrimps from Creek Road market, Mile One market and Town market before deterioration ranged from 6.5×10^4sfu/g to 3×10^4sfu/g, 4.1×10^4sfu/g to 2×10^4cfu/g, and from 6.5×10^4sfu/g to 3×10^4sfu/g while fungal counts in flesh of shrimps about deterioration ranged from 5.1×10^4sfu/g to 9×10^4sfu/g, 3.1×10^4sfu/g to 6.0×10^6sfu/g and from 5.1×10^4sfu/g to 9×10^{-4}sfu/g respectively.

The mean counts of the total pathogenic fungi per gram of head, exoskeleton and telson/uropod (HET) of shrimps from Creek Road market, Mile One market and Town market before deterioration ranged from 4.8×10^4cfu/g to 8.0×10^4cfu/g, 3.0×10^4cfu/g to 7.0×10^4cfu/g and from 4.8×10^4cfu/g to 8.0×10^4cfu/g respectively. While counts in HET of shrimps about deterioration ranged from 3.6×10^4cfu/g to 6.0×10^4cfu/g, 1.4×10^4cfu/g to 6.0×10^4cfu/g, and from 3.6×10^4 to 6.0×10^4cfu/g respectively.

The mean results of the total count of pathogenic fungi per gram of flesh of shrimps from Creek Road market, Mile One market and Town market before deterioration ranged from 1.0×10^4cfu/g to 2.3×10^4cfu/g, 4.1×10^4cfu/g to 8.0×10^4cfu/g, and from 1.0×10^4cfu/g to 2.3×10^4cfu/g respectively. While counts in the flesh of the shrimps about deterioration ranged from 5.0×10^4sfu/g to 5.2×10^4sfu/g, 1.5×10^4sfu/g to 5.0×10^4sfu/g and from 5.2×10^4sfu/g to 9.0×10^4sfu/g respectively.

Analysis of variance (F-distribution) showed that generally, except for the fungal count in the flesh of the shrimps before deterioration which showed significant difference at $P \geq 0.05$ (with Mile One shrimps recording the highest counts), there is no significant difference in the fungal count of shrimps between the various markets.
The frequencies of occurrence (%) of heterotrophic and pathogenic fungi in shrimps from the markets are as shown in Table 3 and 4 respectively.

The heterotrophic fungi and their percentage occurrence in the H/E/T (head, exoskeleton and telson/uropod) before deterioration and about deterioration were: *Aspergillus clavatus* (20%), *Aspergillus flavus* (20%), *Penicillium* sp (20%), *Rhizopus* sp (20%), *Rhodotorula* sp (20%), and *Aspergillus flavus* (28.6%), *Mucor hiemalis* (14.3%), *Penicilllium* sp (14.3%), *Rhizopus* sp (14.3%), *Rhizopus stolonifer* (14.3%), Yeast sp (14.3%) respectively. While the pathogenic fungal occurrence before deterioration and about deterioration in the H/E/T were: *Aspergillus clavatus* (11.1%), *Aspergillus flavus* (22.2%), *Penicillium* sp (33.3%), *Rhizopus oryzae* (11.1%), *Rhodotorula* sp (11.1%), Yeast sp (11.1%), and *Aspergillus clavatus* (12.5%), *Aspergillus flavus* (12.5%), *Mucor hiemalis* (12.5%), *Penicillium* sp (12.5%), *Rhodotorula* sp (12.5%)and Yeast sp (37.5%) respectively. Heterotrophic fungi in the flesh before deterioration and about deterioration were, *Aspergillus flavus* (33.3%), *Penicillium* sp (33.3%), yeast sp (33.3%) and *Aspergillus flavus* (22.2%), *Aspergillus niger* (11.1%), *Mucor plumbeus* (11.1%), *Penicillium* sp (22.2%), *Phialophora fastigiata* (11.1%), *Rhizopus stolonifer* (11.1%) and *Rhodotorula* sp (11.1%) respectively. While the pathogenic fungal occurrence before deterioration and about deterioration in the flesh were *Aspergillius flavus* (28.6%), *Penicillium* sp (14.3%), *Rhizopus oligosporus* (28.6%), *Rhizopus stolonifer* (14.3%), Yeast sp (14.3%), and *Aspergillus niger* (10%), *Mucor hiemalis* (10%), *Mucor plumbeus* (20%), *Penicillium* sp (10%), *Rhizopus stolonifer* (10%), *Rhodotorula* sp (20%), and Yeast sp (20%) respectively

Table 3: Occurrence (%) of Heterotrophic Fungi in Shrimps from the markets

	Head, exoskeleton and telson		**Flesh**	
Fungus	**Before deterioration**	**About deterioration**	**Before deterioration**	**About deterioration**
Aspergillus clavatus	20			
Aspergillus flavus	20	28.6	33.3	22.2
Aspergillus niger				11.1
Mucor heimalis		14.3		
Mucor plumbeus				11.1
Penicillium sp	20	14.3	33.3	22.2
Phialophora fastigiata				11.1
Rhizopus stolonifer		14.3		11.1
Rhizopus sp	20	14.3		
Rhodotorula sp	20			11.1
Yeast sp		14.3	33.3	

Table 4: Occurrence (%) of Pathogenic Fungi in Shrimps from the Markets

	Head, exoskeleton and telson		**Flesh**	
Fungus	**Before deterioration**	**About deterioration**	**Before deterioration**	**About deterioration**
Aspergillus clavatus	11.1	12.5		
Aspergillus flavus	22.2	12.5	28.6	
Aspergillus niger				10
Mucor heimalis		12.5		10
Mucor plumbeus				20
Penicillium sp	33.3	12.5	14.3	10
Rhizopus oligosporus			28.6	11.1
Rhizopus oryzae	11.1			
Rhizopus stolonifer			14.3	10
Rhodotorula sp	11.1	12.5		20
Yeast sp	11.1	37.5	14.3	20

Among the heterotrophs isolated, only *Aspergillus flavus* and *Penicillium* sp were isolated from the H/E/T and flesh respectively in all three (3) markets. Among the Pathogenic fungi isolated from the H/E/T and flesh only Yeast sp, *Penicillum* sp, *Rhizopus stolonifer,* and *Aspergillus flavus* were isolated from the H/E/T in all three (3) markets, while others were isolated from either one or two of the three (3) markets. *Phialophora fastigiata* was isolated from flesh of shrimp about deterioration from only Mile One market.

DISCUSSION

The present investigation has revealed some fungi that are associated with the head, exoskeleton, tail/telson (H/E/T) and flesh of shrimps before and about deterioration. The different fungal genera isolated were *Aspergillus, Mucor, Penicillium, Phialophora, Rhizopus,* and Yeast spp including *Rhodotorula*. These fungal genera appear to be associated with the spoilage of fresh shrimps.

The fungal counts recorded in the shrimps are considered very high ranging from 1.7 x 10^4sfu/g to 7.1 x 10^4sfu/g. Generally in all the markets, the population or mean count of total heterotrophic fungi in the H/E/T were higher before deterioration Except for Mile One market, counts were lower in the flesh of the shrimps before deterioration than about deterioration. The high fungal count is an indication of gross contamination of the environment where the shrimps were harvested and of the ecological niche where the fungi has developed. The results of both heterotrophic and pathogenic fungal counts were almost exactly the same in shrimps from the Creek Road and Town markets. This is not surprising because the distance between both markets is less than 200m. In-fact, they have virtually merged together. It is also a fact that shrimps from both market were harvested from the same environment. The isolation of *Phialophora fastigiata* from only Mile One market indicated that shrimps from this market were harvested from a different environment and hence the observed disparity in the fungal counts of shrimps from the three markets.

There was also an increase in the types of heterotrophic and pathogenic fungi in the shrimps about deterioration. These observations clearly indicate the utilization and exhaustion of nutrients in the shrimps and change in prevailing conditions such as pH

which in turn resulted in the succession of fungi over time during deterioration of the shrimps.

Among the pathogenic fungi isolated *Aspergillus, Penicillium* and yeast were more prevalent in H/E/T from all the markets, while *Aspergillus flavus, Mucor, Rhizopus oligosporus* and Yeast sp were prevalent in the Flesh. Apart from some *Rhizopus* species frequency of isolation of the fungi were higher in the H/E/T than in the flesh of the shrimps. This shows that the presence of these fungi in the shrimps is as a result of direct contamination from the environment and shrimp handlers.

Statistical analysis showed that generally, except for the fungal count in the flesh of the shrimps before deterioration which showed significant difference at $P \geq 0.05$ (with Mile One shrimps recording the highest counts) there is no significant difference in the fungal count (heterotrophic and pathogenic) of shrimps between the various markets. This is a proof that pathogenicity of some fungi is not as a result of their numbers but in the production of mycotoxins as most of the isolates in this investigation produce mycotoxins.

The potential for disease outbreaks attributed to sea food ingestion has been recognized for over a century (Richards, 1985). It is important to state here that most of the fungi are potential pathogens. Some diseases caused by these fungi in humans are aspergillosis, liver tumor, fungal balls in the lungs, chronic productive cough and haemoptysis, bronchial asthma, infection of the ear or paranasal sinuses, fungal cells within histiocytes, necrosis and eventual abscess formation, multiple brain abscesses and Verucose dermatitis, a chronic human mycosis. Others include rhinocerebral mucormycosis, infection of the nasal turbates and paranasal sinuses spreading rapidly to the eyes and brain; necrosis and thrombosis and invasive mucormycosis (Singleton and Sainsbury, 2001).

Conclusion and Recommendation

The study revealed the fungi associated with spoilage of fresh shrimp. The presence of these fungi in the shrimps is attributed to contamination of the marine environment and of the shrimp's food by fungi which also form part of the normal flora of the shrimp, but become active or acts against the shrimp immediately after the shrimp's death. Unfortunately, some of these normal mycoflora of the shrimps happens to be opportunistic pathogens or pathogens of humans. The presence of these fungi in the shrimps is also attributed to contamination from shrimp handlers or processors or sellers (mongers) (e.g. insertion of fingers into the nasal cavity without washing the hands properly before handling the shrimps) and through sneezing and coughing. The fungi isolated from the shrimps in this study are potential pathogens and they are capable of causing chronic illnesses in humans upon ingestion of food contaminated by them.

Owing to the health hazards associated with the fungi isolated from the brown shrimps used for this study, it is important that brown shrimps and other sea food product be properly and adequately cooked. Also unfavourable conditions should be created to prevent fungal growth, examples of such conditions are: regulation of the water holding capacity of the food (a_w), temperature, and pH. Adjustments in these areas will help prevent mycotoxin contamination of the shrimp as moulds have strains which produce toxins that are capable of causing serious chronic illnesses (e.g. liver tumor caused by *Aspergillus flavus)* in humans, if consumed.

Being that some fungi contaminated the shrimps through shrimps handlers or processors, there is therefore the need for the adoption, practice, and maintenance of good personal hygiene as regards handling of the shrimp from the moment of catch till it reaches the consumer, so as to ensure good quality and long storage life of the

shrimp. The maintenance of high personal and environmental hygiene as well as proper heating and cooking will improve fresh shrimp quality and prevent food-borne diseases.

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