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STAPHYLOCOCCUS AUREUS :A COMMON THREAT TO FISH AND ITS PRODUCTS

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Abstract

Fish is a highly nutritious food containing protein, lipids, vitamins and minerals. The protein source of fish is easily available and better absorbed in the body as compared to other source of animal's protein such as chicken, beef and mutton. The lipid content of fish includes Omega-3 fatty acids which is good fat for human body. In addition, fish is also a rich source of many vitamins such as vitamin A, B, and D. Fish contains important minerals including calcium, iron, iodine, phosphorus and potassium, which are absents in other source of food consumed by poor people. Due to high nutrition value of fish, it is used in a huge number for human consumption. However ,it can undergoes many types of bacterial contamination such as Thermotolerant coliforms, E. coli, Mycobacterium, Aeromonas, Staphylococcus, Streptococcus, Pseudomonas, Closteridium and Edwardsiella . Bacterial contamination comes through many sources such as during transportation, processing and handling. Many studies found Staphylococcus aureus contamination of fish which access to the fish during handling and processing. When Staphylococcus aureus get suitable condition for growth, it produces different enterotoxin causing food poisoning. So more study is to be carried out regarding fish contamination caused by Staphylococcus aureus and serious precautionary measures need to be taken to lower the incidence of fish contamination causing food poisoning.

Keywords: *Fish, Staphylococcus aureus, Enterotoxin, Biofilm, Antibiotic resistance*

INTRODUCTION

FISH AS A FOOD SOURCE

Fish has been consumed enormously by men from vey early beginning of their civilization in different ways by being used in different dishes. Fish is a vital diet of human's food **(1).** It is easily available protein source and can be easily digested than other sources of protein such as chicken and beef. It is a healthy food since fish contain proteins, vitamins, oils and minerals. Due to the presence of lower level of connective tissue and high concentration of Amino acid (85-95%), fish is healthier to be consumed than other source of protein content food. Being a cheapest source of protein, fish can be used in preventing protein-calorie malnutrition (PCM) diseases. In addition, all the essential amino acids such as cysteine and methionine are present in fish which are lacking in plant protein. The protein source of fish is also useful for healthy body such as the protein contents of fish is involved in the construction and repair of muscle, boosting immunity and blood quality. Along with protein, fish is also rich source of vitamins including

vitamin A, D, E and B groups of vitamins. These all vitamins are important for normal body functioning of human being **(2).** Fish is a good source of fatty acid such as omega-3 fatty acids (unsaturated fatty acid) that decreases the risk of cardiovascular disorders. Moreover, fish also contain minerals (calcium, potassium, iodine and iron) which has also has great role for making a healthy body (3).

CONTAMINATION OF FISH

Due to much nutrition of fish it can easily undergo bacterial contamination. Many studies regarding fish contaminations were carried out. Some of studies found that most of fish were free from microbes; on the other hand the other researchers examined different bacterial contamination of fish samples. This contamination might be due to congested sewage discharge into the areas of harvest, illegal catching of fish from contaminated sewage waters, and sewage run off after flooding and rain from the land to the catching areas (4). Likewise, some researchers found that fish and other sea foods may undergo contamination during its processing, handling or preparation. Others factors might be their storage and transportation at unsuitable temperatures. Fish can also be infected by food handler, by exposure with contaminated equipments or seawater (5).

BACTERIAL CONTAMINATION

Microbes are concern with fish quality and fish product safety. Among which bacteria are most important primary microorganism causing contamination of fish (6). Different studies found that the contamination of fish caused by different bacteria. According to them fish were contaminated with aerobic bacteria such as also Thermotolerant *coliforms* and *E. coli* in different edible fish. The important bacterial pathogens causing fish contamination are greater than 92 genera including *Mycobacterium*, *Aeromonas*, *Staphylococcus*, *Streptococcus*, *Pseudomonas*, *Closteridium* and *Edwardsiella*. These bacteria can infect fish and its products at (7). *S. aureus* is mostly found in the nostril and skin of 25% of healthy people and animals. For this reason *staphylococcus* are commonly involved in fish contamination as it is easily transferred to fish through contact with fish handlers. The genus *Staphylococcus* consists of 31 species among which 19 are related to food poisoning. The prominent species among all *Staphylococci* is *Staphylococcus aureus* which is involved in food poisoning all over the world (8). Fish, meat, Poultry, egg and milk can easily get contaminated by *S. aureus* (9).

STAPHYLOCOCCUS AUREUS

Staphylococcus aureus is a Gram-positive, none motile, none spore forming and facultative anaerobic bacterium that is arranged in a grape like cluster. They show yellow colonies cells on selective media Mannitol salt agar (MSA). They are resistance in dry condition and hyper saline environment due to which it can easily attach to skin**.** *It* is found as the normal flora of many animal including 20-40% of human (10).

BIOCHEMICAL TESTS

Coagulase test is used to differentiate pathogenic *S. aureus* from nonpathogenic strains. The pathogenic *S. aureus* show coagulase positive. The other biochemical tests used for *S. aureus* identification are catalase and oxidase test. *S. aureus* produce positive result for catalase and negative result for oxidase test (11).

PATHOGENECITY OF *STAPHYLOCOCCUS AUREUS*

The Pathogenicity of *Staphylococcus aureus* is related to its biofilm forming ability, enzyme and toxins production and antibiotic resistance (12).

BIOFILM FORMING ABILITY OF *STAPHYLOCOCCUS AUREUS*

S. aureus is among those bacteria which has the ability to form biofilm. Biofilm is a collection of bacterial cells attached with any surface composed of polysaccharide (13, 14). Biofilm forming ability of *S.*

aureus makes it resistance to harsh environments and different disinfectant so it is difficult to remove *S .aureus* in any surfaces because of biofilm formation. Due to this ability it might attach itself with fish catching equipments and processing instruments and surfaces and get easily access to fish.

ENZYMES PRODUCING ABILITY OF *STAPHYLOCOCCUS AUREUS*

Quite a lot of enzymes are released by *S. aureus* which catalyses different molecules of the hosts. These enzymes are protein such as nucleases and proteases which deactivate different defensive mechanism such as reducing the antibacterial function of neutrophil and complement system. Hemolysins enzyme released by *S. aureus* damage the cell membrane of human and animals RBCs and aids in in Biofilm formation. Hyaluronidase catalyses the degrading of hyaluronic acid, a key polysaccharide of the extracellular matrix of tissues.

Lipases released by *S. aureus* cleave bactericidal fats on the skin that inhibit the attacking microbes and control the abscesses on the skin (15).

TOXINS PRODUCTION OF *STAPHYLOCOCUUS AUREUS*

Several bacteria are capable of producing toxins which are damaging substances which increase the pathogenicity of microbes by interfereing the metabolic activity of host cells **(16)**. *S. aureus* also has the ability of producing toxins such as toxic shock toxin, exfoliate toxins and staphylococcal enterotoxins that is accountable for various diseases such as toxic shock syndrome, scalded skin syndrome and staphylococcal food poisoning (SFP) correspondingly (17).

Enterotoxins released by *S. aureus* are resistant to heat. Various types of enterotoxins are responsible for intestinal abnormalities. There are various types of enterotoxins; however, the most important enterotoxin is enterotoxin A (SEA) which is responsible for 50% of gastrointestinal problems in human **(18)**. Enterotoxin is encoded by the genes present on the staphylococcal pathogenicity islands (SaPIs). Enterotoxins can also be encoded by the plasmid of the bacteria. Many S. *aureus* can have more than one enterotoxins gene (19).

The different enterotoxins released by *S. aureus* in fish cause food poisoning in human. Very minute amount of staphylococcal enterotoxin can cause food poisoning. According to one of study only 0.5 ng/mL amount of SEs was causing epidemic. The symptoms begins quickly after consumption of contaminated food which commonly include vomiting, intestinal pain, cramping and diarrhea even sometimes it causes dehydration and low blood pressure (20). Though staphylococcal food poisoning SFD is self-limiting diseases but can be lethal sometimes in infants, old people and in immunocompromised people. Antibiotics cannot be used for treating food poisoning.

Table I: The prevalence of *S. aureus* and its enterotoxin among different fish and fish products

Types of samples	Positive samples for *S. aureus* (%)	Positive samples for enterotoxins (%)	Types of enterotoxins	References
Fresh water fish and marine water fish	36	8.3	SEA and SEE	(21)
Fish and meat	34.25	2.38	SEB	(22)
Unprocessed fish	26	48.4	SEA	(23)
Grocery store sold fish	87	14.2	SEB and SED	(24)
Fishery product	34.3	64	SEA and SEB	(25)

ANTIBOITIC RESISTANCE TO *STAPHYLOCOCCUS AUREUS*

Infections caused by *S. aureus* are very difficult to be treated because of emergence of multidrug-resistant strains. Methicillin resistant *S. aureus* (MRSA) are resistant to the entire β-lactam rings of antibiotics

which augment the pathogenicity of *S. aureus* causing various clinical symptoms (26). Animals can transfer MRSA to human and human can transfer it to animals respectively (27).

The presence of MRSA in any kind of food is fatal for the consumption of human. Nevertheless, the MRSA transmission from fish to humans has not any proof as yet. The presence of MRSA in fish is responsible for food poisoning in humans while the fish acquire *S. aureus* from infected handles or any contaminated surface (28). MRSA strains are causing many health problems so it is important to carry studies regarding contamination of fish by *S. aureus*. The contamination of fish caused by *S. aureus* is responsible for less quality of fish and causing financial loss to all over the world.

Table II: The prevalence of *S. aureus* and methicillin resistance gene among different fish and its products

Types of samples	Positive samples for *S. aureus* (%)	Presence of methicillin resistance gene (%)	References
Food samples	34.25	11	(22)
Ready-to-eat shellfish	65 (92.86)	50	(29)
Raw and processed food	30.91	6.9	(30)
Marine finfish	62.9	16.3	(31)

THE IMPACT OF FISH CONTAMINATION

The contaminated fish can spoil the quality of fish and can cause the bad effect to the global trade. According to the study carried by Centers for Disease Control and Prevention (CDC) in 2009 to 2018, fish was the most commonly food concerned with forborne outbreaks. Contaminated fish can transfer their pathogenic bacteria to the nearby environment and to others fish posing harm to be consumed (32).

Antibiotic-resistant genes (ARGs) in this bacterium can be responsible for spreading of antibiotic resistance microorganisms (AMR) to the surroundings and human beings (33).

PREVENTION

A variety of decontamination methodology have been suggested and tested to lower the chances of fish contamination. Several studies found that incorrect handling of fish, little awareness about the food among food industry workers may be responsible for SFD. The likely of fish contamination can be lowered by applying following strategies.

1) Giving awareness among the folk for safe handling of the fish will be helpful in stopping contamination and cross-contamination (34).

2) The fish catchers or handlers should be protected from acquiring any infection.

3) The appropriate temperature for bacterial growth and its toxins production is 6 to 46 ^{0}C. Therefore for fish cooking temperature must be higher than 60 ^{0}C and lesser than 5 ∘C for storage.

4) For the safety of public health the consumer knowledge regarding the food safety is necessary.

5) Proper temperature should be used for storage of fish to reduce the incidence of food poisoning.

6) Using of protective masks, hairnets and disposable gloves while handling and processing of all food including fish can lower the chances of fish contamination.

7) Personal hygiene of the food handlers is also involved in precautionary measure.

8) Adequate washing and disinfection of food equipment and processing surfaces can also lower the contamination with *S. aureus* (35).

CONCLUSION

Fish is a full of nutritious food containing protein, unsaturated fatty acid, vitamin and others micronutrients. These nutrients found in fish are very important for building a healthy body. However; sometimes it undergoes bacterial contamination during handling and processing. The bacterial contaminates comes through various sources such as from infected worker, contaminates surfaces and contaminated area of harvesting. Many bacterial pathogens were found to cause fish contamination although; *S. aureus* was most common among them. *S. aureus* produces different enterotoxins causing food poisoning. In addition, it

has biofilm forming ability, by which it can easily adhere at any surfaces causing contamination of fish and others food. New emerging antibiotic resistance *S. aureus* is more troublesome and a threat to different fishes and its product. Bacterial contamination of fish can be controlled by different preventive method such as maintaining the hygiene condition among fish industries workers, disinfecting fish processing surfaces, storing the fish at less than 5 ∘ C and cooking it higher than 60 ∘C.

Abbreviations: PCM: Protein-Calorie Malnutrition; SE: *Staphylococcal* Enterotoxin; MRSA: Methicillin Resistant *S. aureus;* MSA: Mannitol salt agar; CDC: Centers for Disease Control and Prevention; ARG: Antibiotic-Resistant Genes; AMR: Antibiotic Resistance Microorganisms; SFD: *Staphylococcal* Food Poisoning.

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