International Journal of Agricultural and Life Sciences

ISSN: 2454-6127(Online) Journal homepage: http://www.skyfox.co

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To cite this article : Muthukumaran, P., Karthikeyan, R., Nirmal Kumar, R.(2021). A Review of Microbial Contamination in Processed and Street Foods. Int J Agric Life Sci, 7(2), 338-341. doi: 10.22573/spg.ijals.021.s122000104.

To link to this article : https://doi.org/10.22573/spg.ijals.021.s122000104

Data Availability Statement : All relevant data are within the paper and its Supporting Information files.

Funding : The author(s) received no specific funding for this work.

Competing Interests : The authors have declared that no competing interests exist.

Published online: 30 June 2021.

International Journal of Agricultural and Life Sciences- IJALS (2021), Volume 7 (2) pp.338-341
http://dx.doi.org/10.22573/spg.ijals.021.s122000104
Available online at http://www.skyfox.co
ISSN: 2454-6127

REVIEW ARTICLE

A Review of Microbial Contamination in Processed and Street Foods

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Received: 30 Mar 2021/ Revised: 08 Apr 2021/ Accepted: 28 May 2021/ Published: 30 June 2021

Abstract: As a basic physiology need threat to sufficient food, production is threat to human survival food security was a main issue that has gained global concern. This paper looks at the food borne contamination by assessing the availability of food and accessibility of the available food from a food as a microbiologist's perspective, there are several microorganisms similarly viruses, bacteria, fungi, protozoans, and parasites for which foods serve as vehicles of transmission. Among these agents, several bacteria are most commonly implicated in foodborne outbreak episodes. Foodborne diseases in human beings are caused either by straight contact with infested food animals/animal products (zoonotic) or humans, such as a food handler, or by direct absorption of polluted foods. There are three important terms with regard to foodborne diseases foodborne infections, foodborne toxicoinfections and foodborne intoxications. Foodborne infection is the condition caused by the incorporation of viable cells of a pathogen. For example, Salmonella Enteritidis and Escherichia coli infections are brought about by the ingestion of food contaminated with living cells of these pathogens. Finally, foodborne toxicoinfection is that in which the ingestion of viable pathogenic cells causes the toxins productions inside the human body, leading to infection episodes. For example, Vibrio cholerae produces cholera toxin inside the body after being ingested by the host. The morphology, Gram's reaction, biochemical properties, and associated foods with important foodborne bacteria.
Keywords: Contamination, foodborne pathogens, toxin, bacteria

Introduction

The food industries in India are thriving with immense profit every year. Thirty-six percentage of India's intake market is led by groceries and food industries and which enterprise the government of India to grow efficient food processing industries. The Indian food industries are in sixth position among the world's largest markets. The food industry deals with the collection of raw materials for production and processing of food followed by selling the foods to consumers. This indicates that the food industries should be very much aware of customer satisfaction and safety, as well as maintaining the commercial viability. Therefore, the workers in food industries concentrate on maintaining the hygiene of the food products manufactured by them. Numerous safety related experiments are handled by the food industries, which are evaded by the consumption of biotechnological techniques. Chemical and biological analyses are conceded out by the industries to preserve the food left from infection and hence avert the consumers from food terrorism and food borne diseases. However, the food adulteration is quiet a severe issue complicated in food processing industries. The US Food and Drug Administration (FDA) has introduced corporate social responsibility programs that help to overcome the health and safety issues. Corporate social responsibility justifies the corporation being controlled socially and ethnically by a group of people, which includes customers, employees, government, and also media, investors, unions.
Strategies to eliminate or control these pathogens start with elimination of those that are naturally present in our environment. The origin of foodborne pathogen related illness could be caused by the pathogen itself (e.g. viruses, bacteria, parasites, prions) or biological toxins produced by microorganisms in the food which becomes unsafe for human consumption. The emerging or evolving pathogens, along with relatively low minimum infectious doses and/or combined with multidrug resistance, have also been increasingly reported and have become a new challenge (Critzer and Doyle 2010; Doyle 2015). Control of foodborne pathogens needs to be closely monitored at various stages along with the following complex food supply chain: food production, processing, and consumption. The importance of Hazard Analysis and Critical Control Point (HACCP) principles, an official systematic approach of evaluating, ascertaining and controlling biological and hazards foodborne pathogens in contributing to food safety has been recognized by professionals in this field since the 1970s (Sneed et al. 2004). In this article, we will follow these HACCP principles discussing traditional and recent advances of some basic concepts and terms which can be reasonably used for exposure and controller of foodborne pathogens. The traditional computational approaches rely on information systems, data management, surveillance networking, predictive and computational modeling.

Contamination

Contamination, in a general term it can be understood as occupancy of nonessential element in one's body, food, concerned material or an environment. Food assassination is careful to be a major goal for the ongoing escalation of contamination in food supply chain. Agreeing to the WHO statement, food assassination is explained as a hazard of intended contamination of food with biological, radio nuclear agents or chemical, which once depleted causes death of a huge population (Manning et al., 2005). Food assassination is mainly proficient by food suppliers along with the manufacturers who deliberately incorporate hazardous or undesirable or components in food. Contamination is the largest concern in the food industry, whereas consumers are far more

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ISSN: 2454-6127

conscious of food safety. In a survey, about food concerns among consumers conducted in Australia and Japan, consumers in Japan were more concerned about the food item's safety. Though, in the both places disquiet about food adulteration was observed. The well-known fact reveals that food safety dimensions are recognized on a consumer's trust on food supply chains because consumers are inept to measure the food safety.

Food borne Pathogens

Foodborne bacteria follow the classical sigmoidal growth curve that involves lag phase, log phase, stationary phase, and the death phase, albeit the Gompertz, Baranyi, and the three-phase models do not recognize the death phase (Buchanan et al. 1997). In the lag phase, bacteria will sense the environment and prepare for an active multiplicative period. Bacterial will synthesize cell components such as ribosomes, ATP, and cofactors with no increase in cell numbers. Then, in the log phase, bacteria will grow and divide at a maximal rate in an exponential pattern. The time that is required for bacteria to double the number at a specific temperature - known as the generation time - remains constant during this phase. The stationary phase starts when the cell density reaches approximately 10^8-10^9 colony-forming units (CFU). This follows with the death phase, in which there will be a gradual decline in the number of living cells because of the nutrient-deprived environment and the accumulation of toxic biochemical wastes.

Normally in foods, there will be a mixed population of microorganisms including bacteria, fungi, yeasts, and molds. Since these organisms have different optimum growth conditions, the counts of some microorganisms at a given temperature at a certain time may be higher than the others. The temperature of 35°C allows the growth of many bacteria, whereas during storage at 4°C (refrigeration), some bacteria will outcompete those that will grow better at 35°C. There is another situation wherein at the same temperature two or more organisms can grow, but because of the differences in their generation times, one overcomes the other(s) (Ray 2001; Sinell 1992). This is true about bacteria predominating yeasts and molds, resulting in spoilage of foods. There are certain foods that exploit the qualities of symbiosis in which two or more bacteria grow together in a given food for their benefit, helping in the development of a desired quality in those foods. For example, two lactic acid bacteria, *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus,* utilize their biochemical machineries to help each other's growth in foods such as yogurt (Tamime 2002). Individually, they produce fewer flavor compounds such as acetaldehyde, whereas when put together, they produce more than the additive amount of acetaldehyde produced by them individually, thereby bringing about the desired flavor in yogurt, an interesting example of synergism or proto-cooperation in foods. On the contrary, there are conditions where one bacterium inhibits or reduces the growth of the other, known as antagonistic growth (Sinell 1992).

Microorganisms Involved in Food contamination

Gram-Positive microbes Involved in the Food contamination

Among the various species of Gram-positive bacteria responsible for foodborne outbreaks, *L. monocytogenes* causes fatal conditions in pregnant women, children, the elderly, and the immunocompromised. *Staphylococcus aureus* causes serious outcomes due to the heat-stable enterotoxin in foods, resulting in food poisoning. Certain foodborne pathogens are difficult to inactivate due to their capacity to produce spores. Spores are survival structures that help bacteria to tide over unfavorable environmental conditions. Many spores are resistant to cooking temperatures and can survive freezing and drying. Bacteria execute resistance in spores by synthesizing new enzymes such as dipico- linic acid synthetase and heat-resistant catalase, by increasing or decreasing other enzymes, by synthesizing calcium dipicolinate in the spore core, and by producing a keratin spore coat. *Bacillus cereus*, *Clostridium perfringens,* and *C. botulinum* are examples of bacteria that produce spores. Spores of *C. botulinum* type A and B are heat-resistant, whereas spores of type E are heat-labile. *C. botulinum* produces a neurotoxin (botulinum toxin) resulting in a condition called botulism (Latin, *botulus,* meaning "sausage"), a rare but serious paralytic illness caused by botulinum toxin. There are three types of botulism associated with foods, namely, (1) foodborne botulism caused by ingestion of foods contaminated with botulinum toxin, (2) infant botulism due to intestinal colonization and toxin production in infants, and (3) adult intestinal toxemia botulism, an uncommon form of intestinal colonization and toxin production by *C. botulinum* in adults (Sobel 2005). In infant botulism, the toxin will be present in the stool excreted by the infected infant. Poorly canned alkaline vegetables and smoked fish are implied in adult botulism. Honey is commonly associated with infant botulism. Another *Clostridium* species, *C. perfringens,* causes enteritis in humans.

Gram-negative bacteria microbes Involved in the Food contamination

Many of the Gram-negative bacteria causing foodborne contaminations are pathogens. In general, the Gram-negative bacterial infections result in manifestations such as diarrhea, abdominal cramps, and intestinal disorders. Although diarrhea is difficult to define quantitatively, it is the passage of stool in excess than normal with a changed consistency observed with a recent change in the bowel movements. The syndrome of dysentery is characterized by blood and pus in the stools, abdominal cramps, tenesmus, and fever. Gross blood in the stools is the most reliable sign (Ghai et al. 2004; Winn et al. 2005). Many Gram-negative foodborne pathogens such as *Campylobacter, Salmonella, Shigella, E. coli* O157:H7, enteroinvasive *E. coli* (EIEC), and *Y. enterocolitica* produce bloody diarrhea, whereas enterotoxigenic *E. coli* (ETEC), *Vibrio cholerae,* and *C. perfringens* cause watery diarrhea.

Yeast and molds Involved in the Food contamination

Foodborne molds can be of spoilage or pathogenic significance. Pathogenic molds produce myco- toxins, which are the secondary metabolites produced at the end of the exponential (log) phase of growth. Among the spoilage causing fungi, *Aspergillus* species are involved in spoilage of foods such as jams, cured ham, fruits, and vegetables. Other fungi such as *Alternaria*, *Geotrichum*, and *Mucor* cause spoilage of vegetables. *Penicillium expansum*, a pathogen in fresh fruits, is psy- chrotrophic and can grow at temperatures as low as -2 to -3°C. They produce a toxin called *patulin,* which is potentially carcinogenic and produces immunological, neurological, and gastrointestinal toxic effects in animals (Davis and Diener 1987). Other species such as *Penicillium verrucosum* and P *commune* are also capable of producing toxins. *Aspergillus flavus* and *A. parasiticus* produce toxins called aflatoxins (Kurtzman et al. 1987), and the common ones are B1, B2, G1, G2, M1, and M2 (Ayres et al. 1980). In humans, aflatoxins are reported to cause liver cancer. It results in stunted growth in children if they are exposed to toxic levels during the neonatal period.

Parasites and Protozoa Involved in the Food contamination

Foods can play an important role in the transmission of a variety of parasites of eukaryotic origin, including nematodes, cestodes, and protozoans. Parasites such as *Taenia saginata*, *T. solium*, and other *Taenia* spp. can be transmitted to humans by the consumption of raw or undercooked meat or meat

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products. In addition, raw sea and freshwater foods including fish, mollusks, and frogs can serve as vehicles of some parasites (Pozio 2003). Important foodborne protozoans are *Cryptosporidium, Giardia, Entamoeba* spp., and *Cyclospora,* which are commonly associated with fresh produce. The use of untreated water for food preparation also plays a role in their transmission to humans. Like foodborne viruses, parasites do not multiply in foods but survive in moist foods for months (Dawson 2005; Dawson et al. 2005).

Bacteria Involved in the contamination of Foods

Among the various bacteria in foods, some cause spoilage of foods and food products. Spoilage is a condition resulting from microbial activity that is detected by changes in odor, flavor, and appearance. In foods such as meat, bacteria use the low-molecular-weight substances such as lactate, glu- cose-1-phosphate, and glucose-6-phosphate followed by the use of creatine, and peptides such as carnosine and anserine. Once these compounds are used up, amino acids are potentially utilized as substrates. Finally, proteins are catabolized, resulting in the production of ammonia, cadaverine, putrescine, and hydrogen sulfide; the signs of spoilage start to appear. In general, bacterial spoilage occurs when the bacterial population of food reaches 10^7-10^8 per g or cm^2 or mL (ICMSF 2005).

Among several factors favoring spoilage, water activity (a_w) is critical in meat spoilage. Water activity refers to the water available for the biochemical reactions. It is the ratio of the vapor pressure of water in the food to the vapor pressure of pure water at the same temperature. If meat is stored anaerobically at higher water activity ($a_w > 0.95$), *Pseudomonas, Flavobacterium, Alcaligenes, Moraxella,* and *Bacillus* constitute the predominant spoilage flora. These bacteria cause proteolysis and lipolysis and result in pigment and slime production. If meat is stored anaerobically at a relatively high water activity ($a_w > 0.95$) at a lower temperature, lactic acid bacteria dominate, resulting in acid production. Slime and green color development follow. If meat is stored anaerobically at a higher water activity at a high temperature, *Clostridium* spp. take the upper hand, resulting in noxious odors due to anaerobic catabolism of proteins. When spoilage occurs in eggs, *Pseudomonas*, *Flavobacterium*, *Proteus,* and *Salmonella* grow exuberantly in the decaying menstruum. In case of spoilage of fish, apart from *Pseudomonas* and *Flavobacterium*, *Vibrio* and *Micrococcus* may be involved (Vanderzant and Splittstoesser 1992). Spoilage of fruits and vegetables is generally encountered with *Pseudomonas, Bacillus, Clostridium,* and *Emma* (Kraft 1992; Vanderzant and Splittstoesser 1992). Although not commonly seen, there are certain spoilage bacteria that produce spores. For example, *Sporolactobacillus,* a Gram-positive organism, and *Desulfotomaculum,* a Gram- negative spore former, cause the spoilage of canned food.

Summary and Conclusion

The biology of unicellular organisms has always provided important insides on the host-pathogen interactions and in the way bacteria, viruses, and other organisms survive in and contaminate different environments. Prokaryotes are still grouped based on the staining of their cell walls, although new insights into their cellular composition reflect a vast diversity within this group of microorganisms. The survival, and in some instances the growth, of bacteria in foods is the response to factors associated with the microorganisms themselves or the foods. Many microorganisms from foods have been used beneficially to impart flavors, to preserve foods, or to create new food products, as in the case of yeast used to make bread. Yet some microorganisms can be harmful to humans. Foodborne diseases are classified as infections, intoxications, and toxicoinfections based on how bacteria produce disease. Some bacteria are often used as indicators of possible food contamination.

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ISSN: 2454-6127

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How to cite this article
Muthukumaran, P., Karthikeyan, R., and Nirmal Kumar, R. (2021). A Review of Microbial Contamination in Processed and Street Foods. Int J Agric Life Sci, 7(2), 338-341. doi: 10.22573/spg.ijals.021.s122000104.

CONFLICTS OF INTEREST

"The authors declare no conflict of interest".