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Foodstuff Contaminations with Foodborne Pathogens Vehicled by Insect Vectors

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Abstract

Transmission of certain diseases through food remained an important cause of illness in peoples both in developing and developed countries. This study aims to pinpoint the role of insect vectors for conveying foodborne pathogens for contamination of foodstuffs in the nearby houses and taking into consideration the possibility of tackling strategy. The public health importance of insect vectors cannot be overlooked as these cause illness that could be fatal or restrict working capacity, damage food and household goods and are a barrier to development of nation. There are several infectious diseases that are transmissible from non-human hosts to man, or from person to person. Humans may acquire infectious disease agents through a number of routes including food, water, direct contact and insect vectors. One of the most important issues associated with insects is their ability to transmit disease-producing pathogens such as protozoa, bacteria, viruses, tapeworms and nematodes to food. Insects may transmit these pathogens biologically to serve as an intermediate host (following an appropriate development of pathogen in the vector) or mechanically to act only as carrier (pathogen adheres to mouthparts, body, feet of vectors while feeding on infected hosts) to infect another food source. Food contaminating vectors such as flies, cockroaches, ants and stored products insects typically have high reproductive rates. The flies demonstrate significantly a higher prevalence for the presence of foodborne pathogens, and bacteria carried by these possess multi-antibiotic resistance profiles and enterotoxin. Humans commonly are exposed to high levels of potentially allergenic proteins associated with cockroaches, which can lead to significant respiratory ailments. Current studies displays that prevention of foodborne infections requires an integrated approach from farm to fork in food production systems. This involves measures aimed at eradication of infectious diseases within human population and prevention of contamination at all stages of the food supply chain. Amongst the most stringent guidelines is the rejection of food materials that could pose a risk to human health, adopting of human's welfare standards, monitoring of disease within resident population, identification and traceability of individual person, and health requirements for food products imported into or traded within the state. Food hygiene standards at critical points throughout the food production process, and implementation of eradication and control strategies are important in prevention of contamination of food. In addition, an integrated vector management including a combination of two or more methods is often more effective than using a single method of control.

Keywords

Vector, Foodborne Pathogens, Food Contamination, Health Safety

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1. Introduction

Many arthropods can contaminate or spoil food materials by conveying foodborne pathogens. Certainly, where insects such as cockroaches and house flies contaminate human or animal food with infectious disease organisms, this linkage is true associations between arthropods and peoples. For the most part, insects are regarded as annoying pests because, like mosquitoes and other bloodsucking arthropods they bite,

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or because like flies and cockroaches they contaminate food. Researchers do not understand the role of microorganisms and other parasites in diseases spreading until after the middle of the nineteenth century, and it can take even longer to discover the role of certain arthropods as vectors of disease pathogens. In addition to cause direct damage to food resources, arthropods or their parts e.g., setae, scales, shed cuticles, or body fragments may be accidentally ingested. This can lead to toxic or allergic reactions, gastrointestinal myiasis and other disorders. Insects such as the house fly may alight on food and regurgitate pathogen-contaminated fluids prior to, or during, feeding. While feeding they also may defecate for contaminating the food with potential pathogens. Because the alimentary tract of arthropods may harbour pathogenic microorganisms, subsequent consumption of the contaminated food can lead to the transmission of these pathogens to humans or other animals. Similarly, the integument of household pests such as flies and cockroaches (particularly their legs and tarsi) can serve as a contact source of pathogens which may be readily transferred to food items. Some of these arthropods previously may have visited faecal matter, garbage heaps, animal secretions, or other potential sources of pathogens, thereby further contributing to health risks (Gorham, 1991 a; 1991 b; Sarwar, 2015 a; 2015 b; 2015 c).

Many of the numerous species of insects that are attracted to food and to food-contact surfaces carry on or within their bodies a plethora of bacteria and other microbes, some of which are capable of causing disease in humans and domestic animals. Flies and cockroaches are notable for their habits of indiscriminately visiting both pathogen-laden substrates and food destined for human or domestic animal consumption. Ants that enter buildings are both indefatigable foragers and reliable carriers, and disseminators of any pathogens they happen to acquire. The moths and beetles that live in dry cereal foods are capable of transporting fungal spores within the food material. It is not possible to prevent all instances of contamination of food by pathogens carried by insects. Strict adherence to standard sanitation practices and constant vigilance at all levels of the food chain are the primary lines of defence against incidents of foodborne disease. However, this eventuality can be minimized by implementing a four-pronged program, anticipate- documenting of all possible scenarios by which insects might contaminate food; inform- training of all persons associated with the food chain to recognize danger when they see it; mitigate- developing and practicing protocols to quickly deal with any actual or potential incident of food contamination by insects; and frustrate- utilizing the first three action measures will neutralize or minimize any deliberate attempt to effect a bioterror incident (Olsen et al., 1996; Zurek and Gorham, 2008).

2. Public Health Importance of Insect Vectors

There are several infectious foodborne pathogens that are transmissible from non-human hosts to man, or person to person.

2.1. Common House Fly (*Musca domestica*)

House flies feed on many types of substances, including almost all food of humans, rotting vegetables, carcasses, excreta and vomit, or in fact forage on almost any organic material. The method of flies feeding differs according to the physical state of the food. For example, for thin fluids, such as milk and syrup, the labella are placed in contact with food, which is then sucked up through small openings in the pseudotracheae. When feeding on semisolids such as excreta, sputum and nasal discharges, the labella are completely everted and food is sucked up directly into the food channel. When flies feed on more solid materials such as sugar lumps, dried blood, cheese and cooked meats, the labella are everted, and minute prestomal teeth surrounding the food channel are exposed and scrape the solid food. The fly then moistens small food particles with either saliva or the regurgitated contents of its crop so that food can be sucked up. This latter type of feeding is clearly conducive to the spread of a variety of pathogens. House flies defecate (eliminate waste) at random, and frequently regurgitate their food, resulting in unsightly fly spots. House flies can transmit a large number of infections to humans because of their habits of visiting, almost indiscriminately, faeces and other unhygienic matter and people's food. Pathogens can be transmitted by three possible routes:-

1. By flies contaminated feet, body hairs and mouthparts. Most pathogens, though, remain viable on the fly for less than 24 hours, and there are usually insufficient numbers to cause a direct infection, except possibly with Shigella. However, if pathogens are first transferred to food they may then multiply sufficiently to reach the level of an infective dose.
2. By flies vomiting on food during feeding, which they do frequently.
3. By defecation, this often occurs on food, which is probably the most important method of transmission.

If food infected with fly maggots is eaten, then they may be passed more or less intact in the excreta, often causing considerable alarm and astonishment. However, there is no true intestinal myiasis in humans (Service, 2012 a). Most pathogens associated with insects include foodborne bacteria such as *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Campylobacter* and others. The potential of adult house flies

to transmit these human foodborne pathogens has been reported and demonstrated (Barreiro et al., 2013).

2.2. Greater House Fly (*Muscina stabulans*)

Adults frequently defecate on food, however, many of the pathogens transmitted by the house fly are probably also spread by this species. Larvae, like those of genera Fannia and Musca, are occasionally found in stools.

2.3. Lesser House Fly (*Fannia canicularis*)

The eggs of the lesser house fly (*F. canicularis*) are deposited on food, but also on urine-soaked bedding of humans and animals, compost heaps, decaying piles of grass, human and animal excreta and in poultry litter.

2.4. Bluebottles (Calliphora) and Greenbottles (Lucilia= Phaenicia)

The dirty habit of blowflies (greenbottles and bluebottles) of feeding on excreta, decaying material and virtually all foods makes them potential vectors of numerous pathogens. However, their medical importance is usually associated with facultative myiasis in which larvae are normally free-living, often attacking carcasses, but under certain conditions may infect living hosts. Occasionally intestinal myiasis is reported, this is usually caused by eating food contaminated with larvae of Lucilia or Calliphora, but usually the larvae are killed within the human alimentary canal and no serious harm is done. These flies can spread microorganisms through direct contamination of food items and consequent involve in the spread of foodborne illnesses like dysentery, typhoid and so on. Flies in several families, especially the family Chloropidae (frit flies and relatives) are attracted to body secretions (e.g., tears and mucous) as well as to open sores, and they tend to congregate around the mouth, nose, genitalia and anus. These habits set them up as the probable transmitters of conjunctivitis (pinkeye), yaws and bovine mastitis. Ingesting larvae of Cochliomyia and Lucilia spp., that have fed on carcasses or contaminated food containing *Clostridium botulinum* toxins can produce botulism in pheasants and poultry (Service, 2012 a).

2.5. Flies and Myiasis

Myiasis is the invasion of organs and tissues of humans or other vertebrate animals by fly larvae, which at least for some time feed on the living or dead tissues or in the case of intestinal myiasis, on the host's ingested food. Accidental myiasis usually involves eating food that is contaminated by eggs or larvae of flies that are not parasitic in mammals, such as house flies. Infestation is caused by ingestion of food or liquids contaminated with larvae or eggs (Service, 2012 b).

2.6. Triatomine Bugs (Triatominae)

Blood-sucking bugs in the family Reduviidae belong to the subfamily Triatominae and comprise *Triatoma infestans*, and *T. dimidiate*. The triatomine bug itself can also be a reservoir of infection, but in some areas humans are considered to be the principal reservoir host. Rarely peoples can also acquire infection by eating infected meat (e.g., inadequately cooked) or food contaminated with excrement of infected bugs (Service, 2012 c).

2.7. Ants

All ants are social and these are all readily identified by having a narrow petiole consisting of one or two segments, and bearing a dorsal lobe. Of concern to human health are the fire ants (*Solenopsis* and *Wasmannia* spp.), and harvester ants (*Pogonomyrmex* spp.). Some ant species are intermediate hosts for parasitic helminths of vertebrates. The Formica species are intermediate hosts for the lancet-fluke (*Dicrocoelium dendriticum*), which infests the bile ducts of cattle, sheep, pigs, goats, horses, dogs and occasionally, humans. Pavement ant workers and Pheidole ants also serve as intermediate hosts of the poultry tapeworms *Raillietina tetragona* and *R. echinobothrida* (Drees and Vinson, 1993; Akre and Reed, 2002).

2.8. Cockroaches

Cockroaches are common in kitchens, especially when food is left out overnight, and in restaurants, hotels, bakeries, breweries, laundries and aboard ships eating any type of food. Cockroaches habitually disgorge partially digested meals and deposit their excreta on almost anything, including food. Because of their dirty habits of feeding indiscriminately on both excreta and foods, and excreting and regurgitating partially digested meals over food, they have been suspected as aiding in the transmission of various pathogens, for example, bacterial infections including *Entamoeba histolytica, Escherichia coli, Klebsiella pneumoniae, Mycobacterium leprae, Shigella dysentariae,* and *Salmonella* species including *S. typhi* and *S. typhimurium*, *Serratia* species and *Staphylococcus aureus*. Eggs of the nematode *Enterobius vermicularis*, which is an extremely common worm in humans, can also be carried by cockroaches. Sometimes they may possibly be more important as mechanical vectors than house flies. The residual dusts should not be used in kitchen's surfaces in case they contaminate food. Residual insecticides such as permethrin or cypermethrin when painted on walls and other surfaces remain effective in killing cockroaches for several months (Mpuchane et al., 2006). Because of this diet, they, along with the filth flies, are common suspects in outbreaks of foodborne illness. Cockroaches can become infected with *Salmonella typhimurium* by feeding on a

contaminated food source, can infect each other as well as food and water, and can transport the bacteria to hatchery eggs in an incubator (Rivault et al., 1993; Service, 2012 d). Cockroaches can also serve as intermediate hosts for animal parasites. An extensive list of biotic associations between cockroaches and parasitic organisms that potentially infest humans has been reported. The eggs of seven species of helminths have been found naturally associated with cockroaches. These include hookworms *(Ancylostoma duodenale* and *Necator americanus)*, giant human roundworm *(Ascaris lumbricoides)*, other *Ascaris* species, pinworm *(Enterobius vermicularis)*, tapeworms (*Hymenolepis* species), and the whipworm *Trichuris trichuria.*

2.9. Food Insect Pests

There are certain reports of isolations from arthropods for virtually every pathogen that occurs in faeces or other decomposing organic matter. Food pests as a group frequently are involved in the mechanical transmission of pathogens, although not all food pests are of any sanitary significance. Even when arthropods contaminate food during processing before sterilization, arthropod fragments may still cause allergic responses. Pantry pests develop mainly in processed food, and thus are considered to be obligatory pests. Included in this category are the warehouse beetle (*Trogoderma variabile*), granary weevil (*Sitophilus granarius*), confused flour beetle (*Tribolium confusum*) and Mediterranean flour moth (*Anagasta kuehniella*). Pantry pests probably transmit few pathogens because their activities usually are confined to infested food. However, they can transfer microorganisms from infested to non-infested food products. Aflatoxins are the most commonly occurring and widely known mycotoxin contaminants produced by moulds such as Aspergillus that are found in grains and can cause human health concerns when ingested. Insects activity can have a profound effect on the spread of fungal diseases through transmitting the spores, which eventually increases the production of mycotoxins (Eaton and Groopman, 1994; Siddiqui and Sarwar, 2002; Sarwar, 2004; 2015 d; 2015 e; 2015 f).

An efficient mean to transfer the pathogen from infected to non-infected hosts is that the infected food handlers with poor personal hygiene serve well, as does untreated or inadequately treated drinking water. Higher incidences have been associated with communities with large populations of filth flies, large quantities of exposed human faeces and the frequent exposure of food to flies. Transmission dynamics of helminths in flies vary, Lawson and Gemmell (1990) demonstrated that the eggs of *Taenia hydatigena* and *Taenia pisiformis* will infect susceptible animal hosts after the hosts have ingested calliphorid flies (mostly *Calliphora stygia*) (Gorham, 1994; Olsen, 1998; Foil and Gorham, 2004).

3. Food Hygiene against Contaminants

Food safety has a high priority within the food chain, but consumers must also share the responsibility for ensuring food safety within the home because contamination of certain foods cannot be prevented. A few simple procedures should be employed to minimize the risk of foodborne disease, and these may be summarized in accordance with the WHO's 'five keys to safer food' strategy (Allos, 2002).

3.1. Keeping Food Clean

While most microorganisms do not cause disease, however, dangerous microorganisms are found in soil, water, animals and peoples. These microorganisms are carried on hands, wiping cloths and utensils, especially chopping boards. The slightest contact can transfer them to food and cause foodborne disease. Examples of zoonotic pathogens that may be transmitted in this way include Salmonella, Campylobacter and eggs of the tapeworm, *Taenia solium*.

1. Wash and dry hands before preparing any food and after handling raw foods, especially raw meat or poultry.
2. Ensure that food preparation areas and equipment are clean.
3. Ensure that hands are washed after going to the toilet.
4. Protect kitchen areas and food from insects, pests and other animals.
5. Peoples with gastrointestinal illness, such as vomiting or diarrhoea, should not handle food intended for consumption by others.

3.2. Separating Raw and Cooked Foods

Raw food, especially meat, poultry and seafood, and their juices, can contain dangerous microorganisms, such as Salmonella, Campylobacter, and Listeria, which may be transferred onto other foods during food preparation and storage.

1. Store raw foods (especially meat, poultry and seafood) separately from ready to eat foods to prevent cross contamination.
2. Store raw meat and poultry in sealable containers, preferably at the bottom of the fridge, to prevent juices dripping onto ready to eat foods.
3. Use different knives and chopping boards for preparing raw and ready-to-eat foods.

3.3. Cooking Food Thoroughly

Proper cooking kills almost all dangerous food microorganisms; studies have shown that cooking food to a

temperature of 70°C can help to ensure that it is safe for consumption. Foods that require special attention include minced meats, rolled roasts, large joints of meat and whole poultry. Although the few causative agents can be resistant to normal cooking, all other pathogens discussed in this review are destroyed or inactivated at temperatures above 70ºC.

1. Ensure that food is cooked thoroughly to the correct temperature.
2. Poultry, minced meat products (hamburgers and sausages) and rolled joints in particular, should not be served pink. Ideally, the centre of the food should reach a temperature of 70°C for at least two minutes.
3. Eggs should be cooked until the yolk is firm.
4. Soups and stews should be brought to the boil.
5. Reheated food should be piping hot before serving and only reheated once.

3.4. Keeping Food at Safe Temperatures

Microorganisms can multiply very quickly if food is stored at room temperature. By holding at temperatures below 5°C or above 60°C, the growth of microorganisms is always slowed down and in most cases stopped, notable exceptions include Listeria, which can still grow at temperatures below 5°C albeit slowly.

1. Store perishable foods at the correct temperature.
2. Chilled, ready to eat foods must be kept at temperatures below 5°C (41°F).
3. Hot foods must be kept at temperatures above 60°C (140°F) before serving.
4. Cool rapidly and refrigerate leftover foods if they are not to be used within 2 hours.
5. Food should be cold before placing in the refrigerator, since it may take a while to cool off in the refrigerator and hot food may warm up other foods.
6. Do not thaw frozen food at room temperature.

3.5. Using Safe Water and Raw Materials

Raw materials, including water and ice, may be contaminated with dangerous microorganisms. Toxic chemicals may be formed in damaged and mouldy foods. Care in selection of raw materials and simple measures, such as washing and peeling, may reduce the risk. Contaminated water, for example, has been found associated with outbreaks of Salmonella and Campylobacter, whilst infections with Salmonella, Campylobacter, Mycobacteria and Brucella can be acquired through the consumption of contaminated milk or dairy products that are not pasteurized.

1. Use safe drinking water to wash and prepare food and make ice.
2. Select fresh and wholesome foods.
3. Avoid consuming raw meat and unpasteurized milk.
4. Wash fruits and vegetables, especially if eaten raw.
5. Use produce before the expiry date printed on the packaging.

4. Sanitation and Hygiene Related Diseases

Sanitation and hygiene are critical to health, survival and development. A significant amount of disease could be prevented through better access to adequate sanitation facilities and better hygiene practices. Improved sanitation facilities (for example, toilets and latrines) allow peoples to dispose of their waste appropriately, which can help to break the infection cycle of many diseases. Hygiene refers to act that can lead to good health and cleanliness, such as frequent handwashing, face washing, and bathing with soap and clean water. Practicing personal hygiene in many parts of the world can be difficult due to lack of clean water and soap. Providing access to safe water and sanitation facilities, and promoting proper hygiene behaviour are important in reducing the burden of disease from sanitation and hygiene-related diseases.

5. Vector or Insect-Borne Diseases Associated with Water

Water plays a critical role in the spread of insect-borne diseases because many insects, such as mosquitos, breed around water. An increase in water, especially from flooding, can directly impact the number of mosquitoes and other insects that breed around water, potentially creating high-risk environments for disease. Infected insects can transmit deadly disease to humans through their bite, such as malaria, dengue fever and West Nile encephalitis. Worldwide, there are three main mosquito groups, Anopheles, Culex and Aedes. The Anopheles mosquitoes breed in stagnant, relatively clean water bodies; Culex breed in polluted water; and Aedes like relatively clean water.

6. Vector Management and Control

Vectors can be controlled using various methods and here are describe the few basic methods.

6.1. Basic Sanitation

This approach targets the elimination or reduction of that part of the environment that facilitates breeding and harbourage (places where vectors find refuge or shelter). It includes the elimination of all possible breeding places for insects, the prevention of stagnation of water to limit the breeding of mosquitoes, and proper solid waste management and use of a latrine to control the breeding of houseflies. The use of clean water from protected sources for drinking prevents the transmission of guinea worm

6.2. Physical Measures

These include methods that stop vectors from getting into close contact with humans, and methods that are used to kill vectors. They include bed nets for mosquitoes and wire mesh for flies and mosquitoes. Mosquito larvae can be controlled in some water containers by putting a thin layer of used oil on the surface of the water. This acts as a barrier between the water and the air so the larvae cannot access to oxygen and suffocate. Delousing by boiling or steaming infested clothes are physical methods for controlling of lice.

6.3. Use of Chemicals

Chemical insecticides can be used for the destruction of adults and larvae of insects wherein commonly used chemicals are malathion and pyrethrums. Pyrethrum containing aerosols are used for the destruction of cockroaches and flies in our homes. The indiscriminate use of these chemicals, however, could have undesired health effects on users and domestic animals. Extreme care should be taken during the application and storage of chemicals. It is always important to look at the instructions for using the chemical. Environmental health workers and technicians may be able to assist in the use of chemicals against vectors.

6.4. Biological Methods

These include several very advanced methods that prevent the successful reproduction of vector species. They include the sterilization of males (tsetse fly, mosquito), sex distortion or replacement of genes. All of these methods are expensive and often complex to monitor, but other biological methods involve introducing or encouraging of predators of the vector species. For example, small fish can be used to feed on larvae of mosquitoes, while reptiles, birds and frogs feed on adult insects.

6.5. Integrated Approach

Integrated vector management includes a combination of two or more of the above methods. This is often more effective than using a single method of control. For example, the sanitation can be combined with other cheap methods in order to be both sustainable and effective (Sarwar, 2012; 2013 a; 2013 b).

7. Conclusion

There are a number of insect vectors that transmit communicable diseases, for instance, lice, fleas, various types of flies, snails, rats and mosquitoes are extensively found worldwide. Vectors are found within or close to human habitation; some breed in open water that may be found around homes and others breed inside the home. Certain vectors participate in the destruction of grains and household materials as well. With this study session, anyone can learn about the types of vectors that are of public health importance, their contribution to disease transmission and measures that can be used to control them. The results showed that flies in the presence of animals demonstrate a significantly higher prevalence of the studied pathogens than those collected in the kitchens, and kitchens situated in the closest proximity to the animal husbandry have a higher count than the kitchens in private houses. Cockroaches and ants can serve as intermediate hosts for human parasites to poses a higher risk of transmission of foodborne pathogens. Generally, a clean home and environment can prevent the breeding of insects. The use of ventilation, latrines and adequate water supply might play a significant role in the control of insects. The importance of limiting vectors breeding by employing proper sanitation is of crucial importance. It is clear that without the use of proper sanitation methods, the vectors would continue to replicate and disperse from adjacent areas and will undermine any control measures.

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