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Detection Techniques Used For Foodborne Pathogens and Its Significant Financial and Human Behavioral Effects

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ABSTRACT: Foodborne infections have been linked to a broad range of illnesses throughout the globe, particularly in poor nations. This has a significant financial effect. It's critical to keep them under control, and early diagnosis is critical. Initially, detection and diagnosis focused on culture-based methods, but in more recent years, these processes have evolved to include immunological techniques like enzyme-linked immunosorbent assays (ELISA) and genetic biology-based methods like polymerase chain reaction (PCR) (PCR). The goal has always been to provide a quick, sensitive, targeted, and affordable strategy. Every strategy, from microbe culture to future biosensor technologies, has been centered on this objective. This overview highlights current trends and combines techniques that have been developed throughout time.

Keywords: Biosensors, Detection, Diagnostics, Pathogens, Human.

1. INTRODUCTION

Microorganisms, mainly bacteria, are found in the stomach and skin of humans as natural flora, and they are both safe and beneficial to the body's numerous activities. However, numerous harmful microbes, such as fungi, bacteria, and viruses, exist. Pathogens enter the human body via the gastrointestinal system, causing a variety of foodborne illnesses. Foodborne infections may enter the body via contaminated water or undercooked food. Because of this, it's essential to find viruses in food and drink before they enter the body and cause a serious pandemic. There is a great demand for detection in the fields of public health, water and food production, pharmaceuticals, environmental protection, and biodefense [1].

Powdered baby food (PIF), especially powdered milk, may contain pathogenic microorganisms. E was found to be present in Wyeth's powdered milk. When PIF contracted Salmonella sp., an outbreak of a similar kind occurred in France. Salmonella sp. was identified from the farms in a study done in Trinidad in 2010 utilising samples gathered from 15 farms. With an unusually high number of individuals suffering from hemolytic-uraemic syndrome (HUS), Germany had one of its worst epidemics.

In Canada, STEC was found in stool samples that were being examined for viral gastroenteritis. Milk contamination from a number of illnesses has been found in Tanzania's Tanga region, which is important for milk marketing. An optimal habitat for the growth of microorganisms is provided by milk. As shown in the US state of Oregon, mozzarella cheese is susceptible to infection by L. monocytogenes, E. coli, and Pseudomonas fluorescens, much like milk. Similar susceptibility to bacterial food contamination exists for the fermented milk beverage kefir. One of the most prevalent food pathogens reported in PIF, which was found in the United States, is L. monocytogenes. Listeria monocytogenes and L. Ivanovic have were proven to flourish at temperatures as low as 4°C, creating a severe threat since food that is thought to be contaminated with Listeria has to be tested right once to avoid disastrous effects. Gram-positive cocci and methicillin-resistant S. aureus outbreaks have been found in food products in China and Spain [2], [3].

Regardless of the location, foodborne bacteria have been shown to cause severe outbreaks. This causes illness to spread, especially among babies and the elderly. As a result, early identification is critical to halt the spread of the disease before it becomes a major epidemic. To identify foodborne pathogens, several methods have been developed. The attempt to enhance detection techniques is a never-ending activity. The detection techniques have been divided into categories based on their principles, benefits, and drawbacks, the majority of which are described in this study. For a better understanding of the progressive development of detection systems, each approach is accompanied by appropriate examples. The goal is to provide an overview of the many techniques for detecting foodborne bacteria[4].

1.1 Methods based on culture:

The earliest techniques for identifying microorganisms, including harmful strains, have been culture-based approaches. This technique provides a positive result for the presence of a specific pathogen. These techniques are proven to have a high success rate and are cost-effective. However, the most significant disadvantage of the culture-based technique is its sluggish development, which causes unnecessary time to pass before the final result is obtained, which may be deadly. It's worth noting that all of these media may take up to 18-24 hours to provide a precise answer, suggesting a long turnaround time.

Many bacteria enter a starving state of metabolism when under stress. However, they will continue to be viable but non-culturable (VBNC), which means they cannot grow on CC media but may still communicate pathogenic pathways The detection of these viruses, according to specialists in food safety, is a big problem. Alternative methods, such fluorescent dyes, are utilised to detect VBNC bacteria in a variety of colours since colonies wouldn't form otherwise. Acridine orange binding to VBNC infections is influenced by the cells' DNA to protein ratio. Slow-growing or non-reproducing cells look orange, while actively reproducing cells appear green. The fluorescent dye fluorescein isothiocyanate, which is also used to distinguish VBNC, is used to measure the enzyme activity of live cells. If there are any live cells, the substance takes on a violet or blue colour. VBNC may be present in processed foods, pasteurised milk, and drinking water. C. jejuni, E. faecalis, E. coli (including EHEC), Pseudomonas aeruginosa, Salmonella typhimurium, Salmonella dysenteries, Salmonella sonnei, and Vibrio cholera are among the foodborne pathogens included in the VBNC group [5].

1.2 Immunoassays:

Because they were less expensive, faster to get results, and easier to use, immunoassays were developed. As a consequence, immunoassays are often carried out before PCR-based procedures. The enzyme-linked immunosorbent assay is one of the most frequently used immunoassays (ELISA). The quality of the antibodies employed in immunoassays determines their effectiveness. Antibody specificity is a further factor that affects the test along with antibody purity. Polyclonal antibodies are those that have a polyvalence (multiple epitopes to react with). This might affect the reaction and lead to decreased specificity and sensitivity. The possibility of misleading positive results should be underlined [6].

the polymerase chain reaction-based techniques (PCR) PCR is regarded as one of the most important developments in recombinant DNA technology. The goal of PCR is to examine and amplify the genes connected to different diseases. Primer sets made specifically for each gene are created. PCR products are recognised using agarose gel electrophoresis and ethidium bromide staining. Since its invention, PCR has undergone several iterations, each with a unique nomenclature based on the modified processes of the original PCR. The straightforward and precise nature of PCR is one of its main benefits. Compared to culture- and immunoassay-based techniques, it advances more fast.

The amplified product may now be produced in as little as 30 minutes, and strain discrimination has become considerably simpler thanks to the use of several primer pairs. As detection limits improve over time, the detection limit for DNA amplicons may someday be as low as femtograms (10-15 g). In this situation, cultivating and diagnosing illnesses in food safety labs, which is a labor- and time-intensive process, could be a workable replacement. Although PCR technology has lost some of its cost-effectiveness, a low detection limit will still be a crucial necessity. The PCR technique has emerged as a potential tool for locating genes in pathogens, but it has a number of drawbacks that need the development of more potent techniques. Cell lysis and nucleic acid extraction are challenging procedures due to cross-contamination, ineffective reactions caused by inhibitory compounds, or competing DNA from non-target cells. This might provide erratic results, which would diminish the attraction of PCR as a trustworthy method. PCR techniques cannot discriminate between living and dead cells. The primary drawback of all PCR techniques is the potential for false positive findings brought on by the binding of non-specific double-stranded DNA sequences. Therefore, having well-designed primers that don't amplify non-target sequences is crucial [7].

1.3 Biosensors:

The most recent detection methods use biosensors, some of which have improved detection limits and minimise or totally do away with the limitations of PCR procedures. Biosensors, which are instruments for pathogen detection, consist of a biological capture molecule, a technique for converting capture molecule-target interactions into a signal, and data output.. Findings from molecular biology approaches may be impacted by dietary variables while having a better detection efficiency. One of these detection experiments focused on the pathogen Y. enterocolitica, which has the potential to cause yersiniosis in humans and animals. The detection process may become easier and quicker because to advancements in sample preparation, data processing, testing procedures, and molecular detection technologies. The primary advantage of biosensors is their ability to detect

infections with high specificity and sensitivity at low detection limits. However, accurate results will need expensive, highly specialised equipment in addition to the right computer software. As a consequence, these methods may not always be economical. Electro chemiluminescent experiments are carried out in 96-well plates and are based on the electrochemical activation of reporter molecules linked to antibodies, such as ruthenium (II) trisbipyridal (Ru(bpy)3)2+ chloride [8].

1.4 Other techniques of detection include:

Due to its speed, sensitivity, and specificity as well as its capacity for high-throughput analysis, DNA microarray is growing in popularity and has shown to be a useful tool. Research has been done to detect diseases prevalent in marine fish and waterborne illnesses that might be harmful to humans if ingested. Internal transcribed spacer (ITS)-focused foodborne pathogen microarrays have been found. In one of the research, the presence of eleven pathogens in PIF was assessed. The DNA microarray provided the solution to this problem. Each of the pathogen outbreaks is being identified with the use of Pulse Net, a national molecular subtyping network for foodborne disease surveillance. It mainly helps in the decrease of product recalls, restaurant closures, and other related operations after an outbreak. This is carried out at laboratories managed by local, state, and federal health and regulatory organisations [9], [10].

2. DISCUSSION

Many of the diseases caused by foodborne bacteria have major repercussions for both human health and the economy. Clostridium botulinum, Bacillus cereus, Campylobacter jejuni, Clostridium perfringens, Cronobacter sakazakii, Escherichia coli, Listeria monocytogenes, Salmonella spp., Shigella spp., Staphylococcus aureus, Vibrio spp., and Vibrio spp.) are among the most common harmful bacteria. Since conventional hazard-based food safety management methods have been proved to be ineffectual, well-known academics and organisations are now advocating a risk-based approach. Foodborne illnesses are a worldwide concern, and identifying and controlling all new foodborne issues that endanger human health and international commerce requires an united and collaborative effort from all nations and key international organizations. Despite their complexity in biology, research, and epidemiology, most foodborne diseases are avoidable. Certainly, a cross-disciplinary mix of knowledge and abilities is needed. Food contamination on the farm, in processing, in restaurants, and in homes must be avoided by public health authorities, regulatory agencies, the food business, and consumers. Foodborne disease cases may be reduced with appropriate food safety education initiatives for all parties involved.

3. CONCLUSION

A wide range of disorders, many of which have serious health and economic repercussions, are caused by foodborne microorganisms. The characteristics of the most prevalent pathogenic bacteria. The five most important requirements for just an ideal detection method are high specificity (ability to detect only the type of bacteria of involvement), high sensitivity (capable of detecting as few as a single live bacterial cell), short time (minutes to hours), easy operation, as well as cost effectiveness. Benefits from culture, for instance, take a while to materialise. On the other hand, PCR, antibody-based techniques, and biosensors have a shorter waiting period but are more expensive since they need expensive reagents and sophisticated equipment. This review describes many pathogen detection strategies that have been developed and improved throughout time, along with the advantages and disadvantages of each strategy. Here, it's crucial to stress that the pursuit of improved sickness detection techniques cannot be suspended at any time. This will be a research area to develop detecting technologies that are as quick, precise, sensitive, and affordable as is practical.

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