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Foodborne toxinfections caused by virus: Characteristics of the main viruses, prevention, treatment and clinical method of laboratory diagnosis by RT-qPCR

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Foodborne viruses were recognized among the top-rated food safety priorities and have become a greater concern to the food industry over the past few years. Food safety experts agreed that control measures for viruses throughout the food chain are required. This manuscript provides a description of foodborne viruses (Rotavirus, Adenovirus, Norovirus, Astrovirus, Hepatitis A, Hepatitis E, and Poliovirus) and their characteristics, and technologies developed for viral detection and control. A bibliographical research was carried out to collect data and information on viral diseases of the last nineteen years. The research sites accessed were: Books, theses and the database of Scielo, Google Scholar, Medline, Pubmed, Science Direct, CAPES periodical portal and virtual health library. This study was carried to clarify to the health professionals the importance of the need for a greater notification and update of these viral food toxinfections, in order to reduce the cases number of these diseases. Effective prevention and biological technologies to ensure control of viruses in the food chain can significantly reduce foodborne toxinfections caused by virus.

Key words: Enteric viruses, virus in food, quantitative reverse transcription polymerase chain reaction (RT-qPCR) in virus detection.

INTRODUCTION

Outbreaks and diseases caused by microorganisms in food, in particular viruses, pose a major health problem, not only because they cause disease, but also through the costs associated with measures taken to reduce impacts on world populations. In today's world with its global reach, the potential for the spread of foodborne viral diseases on all continents is immense (CDC, 2016; MDS, 2018).

Viruses are inert particles when they are outside their hosts, and their associated risk depends on maintaining their ability to become infected by causing diseases (Trabulsi and Alterthum, 2008). In the viral constitution

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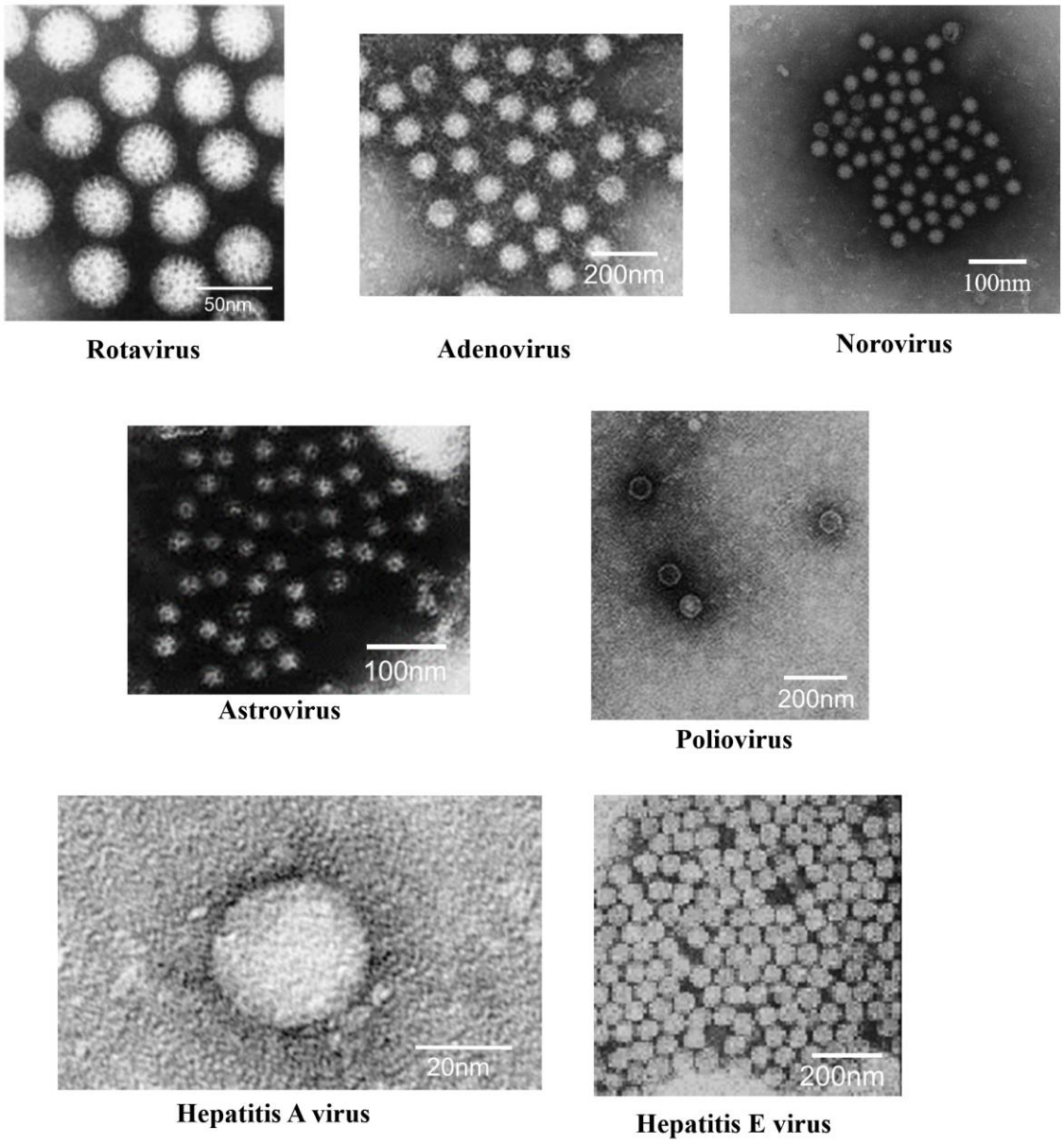

Figure 1. Electron micrograph of viral particles causing foodborne toxinfections. Created by the author. Negative staining technique by direct electron microscopy 33000 X increase.

there is usually only one type of nucleic acid.

Single stranded or double stranded DNA or RNA. Viruses also have proteins, glycoproteins and/or glycolipids (Trabulsi and Alterthum, 2008).

Foodborne toxinfections caused by virus is predominantly transmitted via fecal-oral through ingestion of contaminated food and/or water or through a secondary route of infection and/or person-to-person contact. The major pathogens causing viral foodborne diseases are Rotavirus, Enteric Adenovirus, Norovirus, Astrovirus, Hepatitis A virus, Hepatitis E virus, and Poliovirus (Figure 1) (Xavier et al., 2009; Kokkinos et al., 2015; Polo et al., 2015; Jacxsens et al., 2017; Müller et al., 2017; Sarno et al., 2017; Donia, 2018; Liu et al., 2018). A large number of these viral particles may be found in the human gastrointestinal tract samples (Table 1).

The ways to prevent foodborne toxinfections caused by virus are by applying good personal hygiene practices, utensils, proper food hygiene and proper water treatment for cleaning and consumption. (Polo et al., 2015; MDS, 2018). Foodborne toxinfections caused by virus needs to be published so that the community knows the ways of contagion, prevention, diagnosis and treatment of these foodborn toxinfections.

Most methods currently used for the detection of

Table 1. Viral particles found in human gastrointestinal tract samples.

Genus	Genome	Popular name	Disease caused	Reference
Enterovirus	ssRNA	Poliovirus	Paralysis, meningitis, fever	Donia (2018); Liu et al. (2018)
Hepatovirus	ssRNA	Hepatitis A virus	Hepatitis	Costafreda et al. (2006); Liu et al. (2018)
Rotavirus	Segmented dsRNA	Rotavirus	Gastroenteritis	Bwogi et al. (2016); Liu et al. (2018)
Hepevirus	ssRNA	Hepatitis E virus	Hepatitis	Liu et al. (2018)
Mamastrovirus	ssRNA	Astrovirus	Gastroenteritis	Liu et al. (2018)
Norovirus	ssRNA	Norovirus	Gastroenteritis	Ozawa et al. (2007); Liu et al. (2018)
Mastadenovirus	dsDNA	Adenovirus	Gastroenteritis	Liu et al. (2018)

foodborne viruses are based on polymerase chain reaction (PCR) techniques and variants. Recent technical developments offer opportunities to improve detection, quantification and identification of foodborne viruses such as RT-qPCR. Closed-loop detection of the RT-qPCR assay can effectively prevent and reduce the incidence of false positives (Sedlak and Jerome, 2013; Zhao et al., 2013; Jia et al., 2019).

The objectives of this review constitute the purpose of an academic study, intended to contribute to the knowledge of the main foodborne toxinfections caused by virus, its transmission, prevention, treatment and clinical methods of laboratory diagnosis. A bibliographic survey on foodborn toxinfections caused by virus worldwide was carried out to clarify to health professionals the importance of the need for greater notification and updating of foodborn toxinfections caused by virus, in order to reduce the number of cases of these foodborne toxinfections.

METHODOLOGY

A bibliographic research study was conducted to collect data and information on foodborne illnesses of viral origin from the last nineteen years. The research sites accessed were: e-books, theses and the Scielo database, Google Scholar, Medline, Pubmed, Science Direct and CAPES periodical portal and the virtual health library. The index terms used for single searches were Rotavirus, Adenovirus, Norovirus, Astrovirus, Hepatitis A virus, Hepatitis E virus, and Poliovirus. The combined search for words were viral foodborne diseases, viral gastroenteritis, viral foodborne infections, clinical methods of laboratory diagnosis of foodborn toxinfections caused by viruses. The term "RT-qPCR in virus detection" was searched. The justification is as follows: When qPCR is coupled with a preceding reverse transcription reaction, it can be used to quantify gene expression (RT-qPCR). qPCR has been shown to be a robust, highly reproducible and sensitive method to quantitatively track phylogenetic and functional gene changes across temporal and spatial scales under varying environmental or experimental conditions. The provision of qPCR data sets that describe the abundance of specific bacterias, yeasts and viruses or genes to complement other quantitative environmental data sets is of increasing importance in microbial ecology as it furthers understanding of the roles and contributions of particular microbial and functional groups within ecosystem functioning.

Furthermore, reverse transcription (RT) analyses are now increasingly combined with Q-PCR methods in RT-qPCR assays, offering a powerful tool for quantifying gene expression (in terms of numbers of rRNA and mRNA transcripts) and relating biological activity to ecological function of viruses.

Papers that did not match the searched words were excluded, as well as those that did not fit in the pre-selected years from 2000 to 2019. The exclusion criterion also applies to articles that after reading that did not refer to the main objective of the study. In total 39 articles were recruited, among them 34 in English and 4 in Portuguese.

DEVELOPMENT

Viruses that cause foodborne toxinfections

Rotavirus

A genus of double-stranded ribonucleic acid (RNA) viruses, belonging to the Reoviridae family, are predominantly transmitted fecal-orally and have been found in various foods (Kittigul et al., 2015; Jones and Muehlhauser, 2017). Rotavirus is a virus that causes infectious gastroenteritis and mortality in infants and children worldwide, especially in children under 5 years of age, despite its occasional occurrence as pathogens in adolescents and adults (Mizukoshi et al., 2015; Bwogi et al., 2016). There is no specific medicine to treat rotavirus infections. Nonspecific antiviral drugs and administration of a variety of fluids are used to alleviate clinical symptoms for rotavirus infections (Nan et al., 2014; Liu et al., 2018).

Transmission may occur through ingestion of contaminated water and/or food, person-to-person contact, contaminated objects, and respiratory secretions (Jones and Muehlhauser, 2017). The main symptoms caused by rotavirus toxinfection are diarrhea, vomiting, nausea, anorexia, cramps and malaise (Nan et al., 2014; Bwogi et al., 2016; Liu et al., 2018).

Rotavirus toxinfection is diagnosed by direct detection of rotavirus virus in the stool. Prevention is accomplished by hygienic measures such as proper hand washing and proper water treatment (Nan et al., 2014; Bwogi et al., 2016; Liu et al., 2018). The main treatment for rotavirus toxinfection is oral rehydration (Nan et al., 2014; Bwogi et al., 2016; Liu et al., 2018). Another form of prevention is vaccination. Rotavirus vaccination is part of the Brazilian immunization calendar and round the world. The vaccine is given free of charge to the population in two doses at 2 and 4 months of age (Brasil, 2009).

Adenovirus

It is a family of envelopeless icosahedral double-stranded deoxyribonucleic acid (ADN) viruses with diameters ranging from 65 to 80 nm (Hur et al., 2013; Liu et al., 2018). Adenoviruses usually cause mild infections involving the upper or lower respiratory tract, gastrointestinal tract, or conjunctiva (Hur et al., 2013). Enteric adenovirus infection can increase appetite and food intake, lowering leptin hormone levels (effect on appetite control and body mass), increasing the prevalence of obesity (Hur et al., 2013; Liu et al., 2018).

Enteric adenovirus infection has the symptoms of diarrhea, vomiting and fever. Diagnosis is made by isolating the adenovirus virus in cell culture or by detecting an increase in the number of antibodies (Hur et al., 2013; Liu et al., 2018). There is no antiviral therapy. There are vaccines only against the adenovirus virus that reaches the respiratory tract. Prevention is done through good sanitary conditions and by personal hygienic measures. The main treatment of infection is fluid and electrolyte replacement to prevent dehydration (Hur et al., 2013; Liu et al., 2018).

Astrovirus

Viruses belonging to the *Astroviridae* family, comprising two genera: *Mamastrovirus* and *Avastrovirus*. *Mamastrovirus* include astrovirus that infect humans and animals. *Avastrovirus* includes astrovirus that infect birds (Jeong et al., 2012). Astrovirus is classified into eight classic human types (HAstV-1/8) and seven other less prevalent types, described as HAstV VA1, VA2, VA3, VA4, MLB-1, MLB-2, and MLB-3. Astrovirus has three protein icosahedral capsid and is made up of double-stranded RNA (Jeong et al., 2012).

During outbreaks by astrovirus, the elderly and children are the most affected, and the spread of the virus is associated with person-to-person contact, food intake and contaminated water. Astrovirus infection has as its main symptom mild watery diarrhea, headache, nausea, vomiting and general malaise (Jeong et al., 2012). The most serious infected may also have anorexia, abdominal pain, fever and mild dehydration (Medici et al., 2015).

Diagnosis of astrovirus toxinfection is made by detecting viral particles or specimens in the stool or rectal swabs (Jeong et al., 2012). Preventing astrovirus toxinfection is sanitation, eating well-cooked food, and personal hygiene of food and utensils (Jeong et al., 2012). There is no vaccine or antiviral therapy against Astrovirus and treatment is to prevent dehydration or rehydrate the patient in more severe cases (Jeong et al., 2012; Medici et al., 2015).

Norovirus

Norwalk virus is the human norovirus. Noroviruses are made up of a capsid and a nucleic acid, measuring about 27 to 30 nm in diameter. They have no wrap. The nucleocapsid is rounded and exhibits icosahedral symmetry (Ozawa et al., 2007). The viral genome consists of a linear single-stranded positive-polarity RNA molecule. Genomes with these characteristics serve as mRNA. Viral particles penetrate the target cell they bind to cellular ribosomes and protein translation occurs (Ozawa et al., 2007).

Noroviruses are the leading cause of outbreaks of gastroenteritis in the world. These viruses cause outbreaks in including schools, cruise ships and restaurants. Noroviruses have been detected in environmental samples and foods such as salads, shellfish, sandwiches and fruits (Yamashita et al., 2001; Lee et al., 2007; Tu et al., 2008).

The main route of transmission is oral fecal through person-to-person contact. Norovirus is extremely infectious and has a resistance that allows it to remain on infected surfaces. This results in a problem with the use of shared objects and collective spaces. Norovirus can be spread through saliva particles or contaminated water, and infection is also strongly associated with poor hygiene (no hand washing) (Ozawa et al., 2007). The most widely used method of detecting Norovirus is RT-qPCR, which has high sensitivity (Vinjé et al., 2004; Ozawa et al., 2007; Liu et al., 2018).

Hepatitis A virus

Hepatitis A virus is 27 nm in size and belongs to the *Picornavirus* family, such as the polio virus. The hepatitis A virus genome is composed of RNA and has no envelope (Costafreda et al., 2006; Liu et al., 2018). Hepatitis A virus is found all over the world, especially in places where hygiene conditions are poor. The virus spreads through the fecal-oral route through water, contaminated food and objects and by person-to-person contact. There are rarely cases of percutaneous (accidental inoculation) and parenteral (transfusion) transmission of direct or indirect contact with fecal material. Hepatitis A virus has 7 genotypes named I through VII with genotypes I, II, III and IV capable of infecting humans (Costafreda et al., 2006).

The hepatitis A virus settles in the intestinal mucosa. Later the hepatocytes are infected by the virus from the primary viremia (Costafreda et al., 2006; MDS, 2018). The virus replicates in hepatocytes generating inflammation in the liver by activating the immune system. The virus is excreted in faeces and can survive under environmental conditions for a long time. Astrovirus toxinfection has mild water diarrhea, headache, nausea, vomiting and general malaise as symptoms (Costafreda et al., 2006). In more severe cases the infected person may also have anorexia, abdominal pain, fever and dehydration (Costafreda et al., 2006).

Hepatitis A virus transmission occurs fecally-orally, through intimate contact with infected persons, and from drinking contaminated food and water (Costafreda et al., 2006). The diagnosis of the disease is made by detecting viral particles in the stool and/or rectal swabs. Prevention against Astrovirus toxification is basic sanitation, eating well-cooked food and proper hygiene of hands, food and utensils (MDS, 2018). There is no vaccine or antiviral therapy against hepatitis A virus. Treatment consists of preventing dehydration or rehydrating more severe patients (MDS, 2018).

Hepatitis E virus

Hepatitis E virus is small (27-34 nm) not enveloped with an RNA genome. Hepatitis E virus belongs to family *Hepeviridae* (Lu et al., 2006; Ahmad et al., 2011). Hepatitis E is a toxicity transmitted by ingestion of the virus present in contaminated water and food and/or by human and animal waste. Transmission can also occur vertically (from mother to child) (Lu et al., 2006). The virus replicates first in the gastrointestinal tract and then migrates to the liver by multiplying in hepatocytes. Virus particles are excreted in faeces (Lu et al., 2006; Ahmad et al., 2011). The main symptoms of infection are abdominal pain, nausea, vomiting, anorexia and jaundice (Lu et al., 2006; Ahmad et al., 2011). Hepatitis E can happen asymptomatically (Krawczynski et al., 2011). Mortality is low, but in pregnant women mainly in the third trimester of pregnancy this percentage can reach 25% (Ahmad et al., 2011; Krawczynski et al., 2011). Hepatitis E is diagnosed by the detection of antibodies (immunoglobulin M [IgM] and immunoglobulin G [IgG]) in serum. There is no vaccine marketed for hepatitis E. Usually the cure of the disease is spontaneous, but treatment is suggested rest and prohibition of alcohol use (Ahmad et al., 2011). Prevention is through adequate public hygiene and sanitation conditions (Ahmad et al., 2011).

Poliovirus

Poliovirus belongs to family Picornaviridae. Polovirus is the agent that causes polio in humans. It is a simple virus with only one single stranded RNA without envelope and with a 30nm icosahedral protein capsid (Donia, 2018; Liu et al., 2018).

Poliovirus is usually transmitted via the fecal-oral route (by water, contaminated food or objects), the direct route (person-to-person) and/or orally by droplets of secretions when speaking, coughing or sneezing (Donia, 2018). The poliovirus replicates in the oropharynx and subsequently migrates to the small intestine. In paralytic poliomyelitis, poliovirus is spread in the bloodstream to the central nervous system, mainly destroying motor neurons, causing muscle weakness and flaccid paralysis in the patient. Polio lethality ranges from 2 to 10% (Donia, 2018).

Paralytic forms of polio are uncommon, occurring in 1 to 1.6% of cases. When polio is symptomatic, it is divided into three classes: First class absorptive polio there is the appearance of fever without signs of localization in the central nervous system. In the second class there is the onset of fever and aseptic meningitis with rapid and complete recovery. In the third class paralytic polio the infected presents fever associated with meningeal irritation and asymmetrical flaccid paralysis. In the affected parts arise cramps and muscle spasms. In acute paralytic poliomyelitis toxinfection poliovirus invades the central nervous system generates a total or partial injury to spinal motor neurons disrupting some innervations of muscle fibers causing flaccid paralysis (Donia, 2018). People who have had paralytic poliomyelitis may have symptoms of neurological disorders, weakness, fatigue, muscle atrophy, muscle and joint pain, sleep disturbance, cold intolerance, breathing and swallowing difficulty, and weight gain. These symptoms are referred to as “post polio syndrome” (Donia, 2018).

Polio vaccines are vaccines used to prevent poliomyelitis (polio). Two types are used: an inactivated poliovirus given by injection (IPV) and a weakened poliovirus given by mouth (OPV). World Health Organization (WHO) recommends all children be fully vaccinated against polio. The two vaccines have eliminated polio from most of the world, and reduced the number of cases reported each year from an estimated 350,000 in 1988 to 33 in 2018 (MDS, 2018). In Brazil the polio vaccine is part of the vaccination schedule. The vaccine is distributed free and administered in four doses at 2 months, then 4 months, 6 months and 15 months of life (booster vaccine) (MDS, 2018). Diagnosis is made by isolating the poliovirus in throat material, feces or by raising antibodies. Quarantine those infected with poliovirus is ineffective because excretion of poliovirus in faeces occurs before symptoms appear. There is no antiviral therapy for polio. Treatment is based on relieving symptoms, assisting breathing and physiotherapy of the affected muscles (MDS, 2018).

Virus detection in food

Cell culture based methods can be used to detect some

Table 2. Foods most commonly related to outbreaks in each type of virus.

Virus	Foods	References
Norovirus	Frozen raspberries[a], leafy green vegetable[a], berry fruit[a], drinking water[b], seafood[a], lettuce[a], prawns[a]	Sumner (2011), Bouwknegt et al. (2015), Jacxsens et al. (2017)
Poliovirus	Chicken[a], prawns[a]	Golden et al. (2009)
Hepatitis A virus	Leafy green vegetable[a], berry fruit[a], drinking water[b], seafood[b], lettuce[a], prawns[a]	Sumner (2011); Bouwknegt et al. (2015); Jacxsens et al. (2017)
Rotavirus	Prawns[a], fish[a]	Sumner (2011)
Hepatitis E virus	Leafy green vegetable[a], berry fruit[a], drinking water[b], seafood[a], lettuce[a], pork and wild boar products[b]	Bouwknegt et al. (2015); Jacxsens et al. (2017); Müller et al. (2017)
Astrovirus	Chicken[a], prawns[a]	Golden et al. (2009); Sumner (2011)
Adenovirus	Chicken[a], prawns[a]	Golden et al. (2009); Sumner (2011)

[a]High incidence of outbreaks, [b] Moderate incidence of outbreaks.

foodborne viruses using a series of concentration and purification steps to elute the food matrix virus taking special care to avoid reducing virus infectivity. Table 2 shows the foods most commonly related to outbreaks in each type of virus.

Cell culture-based methods have been used to initially amplify viral nucleic acids and remove inhibitors prior to detection of RT-qPCR. This RT-qPCR assay has been used to detect Rotavirus, Adenovirus, Norovirus, Astrovirus, Hepatitis A, Hepatitis E, and Poliovirus in food (Sánchez et al., 2012; Stals et al., 2013; Zhao et al., 2013; Perrin et al., 2015; Bwogi et al., 2016; Donia, 2018; Liu et al., 2018; Jia et al., 2019).

Virus quantification represents a breakthrough in outbreak investigations and routine monitoring as it can provide data to develop food acceptance levels and the development of quantitative risk assessments (Sánchez et al., 2012). qPCR quantitation can be done using a standard curve generated from known quantities of the target sequence represented by synthetic or *in vitro* transcribed DNA or RNA (Sánchez et al., 2012; Stals et al., 2013; Zhao et al., 2013; Perrin et al., 2015; Bwogi et al., 2016; Donia, 2018; Liu et al., 2018; Jia et al., 2019). Regardless of the method used, the most critical step is the reverse transcription reaction (RT) (Vimont et al., 2015). Sensitive and quantitative detection of foodborne enteric viruses is classically achieved by quantitative RT-PCR (RT-qPCR). Recently, digital PCR (dPCR) was described as a novel approach to genome quantification without need for a standard curve. The performance of microfluidic digital RT-PCR (RT-dPCR) was compared to RT-qPCR for detecting the main viruses responsible for foodborne outbreaks (human Noroviruses) and Hepatitis A virus in spiked lettuce and bottled water. Two process controls (Mengovirus and Murine Norovirus) were used and external amplification controls were added to examine inhibition of RT-qPCR and RT-dPCR (Vimont et al., 2015).

However, virus quantification may vary with the use of different standard materials by each analytical laboratory. This suggests that the use of certified standard reagents may reduce the variation (Vimont et al., 2015). Importantly, viruses are often unevenly distributed in a food batch making it necessary to test replicates or a set of samples for reliable qualitative or quantitative results (Sánchez et al., 2012; Stals et al., 2013; Zhao et al., 2013; Perrin et al., 2015; Bwogi et al., 2016; Donia, 2018; Liu et al., 2018; Jia et al., 2019). There are currently no regulatory microbiological criteria (eg. standards, guidelines or specifications) applied to viruses. Most food companies and authorities mainly request qualitative results as part of production hygiene tests or outbreak investigations (MDS, 2018). To confirm a positive virus presence signal by RT-qPCR and to assist epidemiological studies, systematic typing of disease outbreak strains and virus surveillance in “healthy” foods without viral contamination is recommended (Sánchez et al., 2012; Stals et al., 2013; Zhao et al., 2013; Perrin et al., 2015; Bwogi et al., 2016; Donia, 2018; Liu et al., 2018; Jia et al., 2019).

Control and prevention of foodborne diseases

There is a growing demand for food safety information at the international, national and local level. The following are information about control

and prevention of foodborne diseases (Brasil, 2009).

(i) Wash your hands before handling food and often during food preparation
(ii) Wash your hands after going to the toilet
(iii) Wash and sanitize all surfaces and equipment used for food preparation
(iv) Protect kitchen areas and food from insects, pests and other animals
(v) Separate raw meat, poultry and seafood from other foods
(vi) Use separate equipment and utensils such as knives and cutting boards for handling raw foods
(vii) Store food in containers to avoid contact between raw and prepared foods
(viii) Cook food thoroughly, especially meat, poultry, eggs and seafood
(ix) Bring foods like soups and stews to boiling to make sure that they have reached 70°C. For meat and poultry, make sure that juices are clear, not pink. Ideally, use a thermometer
(x) Reheat cooked food; thoroughly keep food at safe temperatures
(xi) Do not leave cooked food at room temperature for more than 2 h
(xii) Refrigerate promptly all cooked and perishable food (preferably below 5°C)
(xiii) Keep cooked food piping hot (more than 60°C) prior to serving
(xiv) Do not store food too long even in the refrigerator
(xv) Do not thaw frozen food at room temperature
(xvi) Use safe water or treat it to make it safe
(xvii) Select fresh and wholesome foods
(xviii) Choose foods processed for safety, such as pasteurized milk
(xix) Wash fruits and vegetables, especially if eaten raw
(xx) Do not use food beyond its expiry date.

Future trends in viral food safety

Given the importance of foodborne viruses and the impact that different factors (globalisation of the market, increased international travel, consumer demands, changes in food-processing, pathogen evolution, etc.) may have on the emergence of disease, it is clear that priority needs to be given to expanding foodborne disease surveillance to cover foodborne viruses. The expansion should include a more complete coverage of qualified laboratories per country. Inclusion of more countries in international surveillance networks and development and implementation of detection methods of more classes of viruses in the surveillance programs (Brasil, 2009).

Virus detection in clinical samples

The diagnosis of viral infections has emerged in recent decades as an important tool in medicine effectively contributing to the identification of the pathogen directing the treatment of the disease (Tavares et al., 2005; Sedlak and Jerome, 2013; MDS, 2018). Until recently, virus diagnosis was not performed in clinical laboratories or hospitals because the techniques used were very slow and expensive, reagents were not available and there was no treatment for viral infections limiting the use of diagnostic tests (Sedlak and Jerome, 2013; Wylie et al., 2018).

Laboratory diagnosis of viruses has been divided into classical diagnosis including serology and rapid diagnosis of viruses aimed at direct demonstration of virus, antigens or viral nucleic acids in clinical specimens. Some techniques for virus identification are not immunological and do not depend on antigen and antibody binding. These techniques are based on the molecular biology of viruses specifically in identifying unique nucleic acid sequences. Molecular biology techniques are essential tools for viral disease detection, viral load monitoring, antiviral therapy monitoring and genotyping of various viruses (Liu et al., 2018). The development of RT-qPCR allowed the application of a quantitative method in the laboratory diagnosis of viral infections (Donia, 2018; Wylie et al., 2018). Quantitative PCR (qPCR) is used to detect, characterize and quantify nucleic acids for numerous applications. Commonly, in RT-qPCR, RNA transcripts are quantified by reverse transcribing them into cDNA first, as described above and then qPCR is subsequently carried out. As in standard PCR, DNA is amplified by 3 repeating steps: denaturation, annealing and elongation. However, in qPCR, fluorescent labeling enables the collection of data as PCR progresses. This technique has many benefits due to a range of methods and chemistries available (e.g. dye-based qPCR (typically green) and probe-based qPCR (Donia, 2018; Wylie et al., 2018).

Currently, in all the world, another technique presents a remarkable demand to identify viruses in clinical specimens in a fast selective and accurate manner, the use of biosensors (Mokhtarzadeh et al., 2017). Several biosensors have been designed and marketed for detection of pathogenic viruses in clinical specimens. However, they present many challenges in the efficiency of results (Mokhtarzadeh et al., 2017). Nanotechnology overcomes these challenges and performs direct detection of molecular targets in real time. In this overview studies on nanotechnology-based biosensors for detection of pathogenic viruses are being studied and applied in clinical sample analysis. Technologies include nanotubes based on nanotubes (carbon, gold, silver and zinc) and magnetic nanoparticles (Mokhtarzadeh et al., 2017).

Conclusion

Based on the results of this research it was concluded

that: food viruses occupy a prominent place causing major problems in the health of the world population. Through this bibliographic research it was possible to verify the different toxin infections caused by viruses in foods showing that there is a need for greater notification of these food viruses in order to reduce the cases number of these pathogens. The spread of the virus is due to inadequate sanitary conditions since the main route of transmission of these infections is the fecal-oral route and the developing countries are the hardest hit. Prevention against food contamination is necessary by ensuring the control of viral transmissions significantly reducing toxinfections.

The RT-qPCR methodology offers an advantage of using molecular biology to detect different types of viruses in clinical and food samples. Technological improvements to biological protocols, instruments, and strategies drive greater popularity of the RT-qPCR methodology for virus detection in clinical and food samples. It is hoped that in the near future all technologies applied for virus detection in clinical samples may also be effective in detecting pathogenic viruses in food samples.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

REFERENCES

Ahmad I, Holla RP, Jameel S (2011). Molecular virology of hepatitis E virus. Virus Research 161(1):47-58.

Bouwknegt M, Verhaelen K, Rzeżutka A, Kozyra I, Maunula L, von Bonsdorff C-H, Vantarakis A, Kokkinos P, Petrovic T, Lazic S (2015). Quantitative farm-to-fork risk assessment model for norovirus and hepatitis A virus in European leafy green vegetable and berry fruit supply chains. International Journal of Food Microbiology 198:50-58.

Brasil (2009). Guia de vigilância epidemiológica / Ministério da Saúde, Secretaria de Vigilância em Saúde, Departamento de Vigilância Epidemiológica. – 7. ed. – Brasília. Ministério da Saúde 816 p. – (Série A. Normas e Manuais Técnicos).

Bwogi J, Malamba S, Kigozi B, Namuwulya P, Tushabe P, Kiqui S, Byarugaba DK, Desselberger U, Iturriza-Gomara M, Karamagi C (2016). The epidemiology of rotavirus disease in under-five-year-old children hospitalized with acute diarrhea in central Uganda, 2012-2013. Archives of Virology 161(4):999-1003.

Centers for Disease Control and Prevention (CDC) Norovirus worldwide (2016) Disponível em: <https://www.cdc.gov/norovirus/worldwide.html>. Acesso em: 19 set. 2019.

Costafreda MI, Bosch A, Pintó RM (2006). Development, evaluation, and standardization of a real-time TaqMan reverse transcription-PCR assay for quantification of hepatitis A virus in clinical and shellfish samples. Applied and Environmental Microbiology 72:3846-3855.

Donia DT (2018). qRT-PCR for enterovirus detection: Conversion to ultrafast protocol. Journal of King Saud University Science 30(2):180-184.

Golden NJ, Schlosser WD, Ebel ED (2009). Risk assessment to estimate the probability of a chicken flock infected with H5N1 highly pathogenic avian influenza virus reaching slaughter undetected. Foodborne Pathogens Disease 6:827-835.

Hur SJ, Kim DH, Chun SC, Lee SK (2013). Effect of adenovirus and influenza virus infection on obesity. Life Sciences 93(16):531-535.

Jacxsens L, Stals A, De Keuckelaere A, Deliens B, Rajkovic A, Uyttendaele M (2017). Quantitative farm-to-fork human norovirus exposure assessment of individually quick-frozen raspberries and raspberry puree. International Journal of Food Microbiology 242:87–97.

Jeong HS, Jeong A, Cheon D-S (2012). Epidemiology of astrovirus infection in children. Korean Journal of Pediatrics 55(3):77-82.

Jia S, Feng B, Wang Z, Ma Y, Gao X, Jiang Y, Cui W, Qiao X, Tang L, Li Y, Wang L, Xu Y (2019). Dual priming oligonucleotide (DPO)-based real-time RT-PCR assay foraccurate differentiation of four major viruses causing porcine viral diarrhea. Molecular and Cellular Probes 47:1-10.

Jones TH, Muehlhauser V (2017). Frequency of hepatitis E virus, rotavirus and porcine enteric calicivirus at various stages of pork carcass processing in two pork processing plants. International Journal of Food Microbiology 259(16):29-34, 2017.

Kittigul L, Singhaboot Y, Chavalitshewinkoon-Petmitr P, Pombubpa K, Hirunpetcharat C (2015). A comparison of virus concentration methods for molecular detection and characterization of rotavirus in bivalve shellfish species. Food Microbiology 46:161-167.

Kokkinos P, Bouwknegt M, Verhaelen K, Willems K, Moloney R, Roda Husman AM, D'Agosyino M, Cook N, Vantarakis A (2015). Virological fit-for-purpose risk assessment in a leafy green production enterprise. Food Control 51:333-339.

Krawczynski K, Meng XJ, Rybczynska J (2011). Pathogenetic elements of hepatitis E and animal models of HEV infection. Virus Research 161(1):78-83.

Lee N, Chan MC, Wong B, Choi KW, Sin W, Lui G, Chan PK, Lai RW, Cockram CS, Sung JJ, Leung WK (2007). Fecal viral concentration and diarrhea in norovirus gastroenteritis. Emerging Infectious Disease Journal 13:1399-401.

Liu P, Lu L, Xu M, Zhong H, Jia R, Su L, et al. (2018). A novel multiplex PCR for vírus detection by melting curve analysis. Journal of Virological Methods 262:56-60.

Lu L, Li C, Hagedorn CH (2006). Phylogenetic analysis of global hepatitis E virus sequences: genetic diversity, subtypes and zoonosis. Reviews Medical Virology 16(1):5-36.

MINISTÉRIO DA SAÚDE (MDS). Doenças transmitidas por alimentos (2018). Disponível em: <https:www.portalms.saude.gov.br/saude-de-a-z/doencas-transmitidas-por-alimentos>. Acesso em: 25 set. 2019.

Medici MC, Tummolo F, Martella V, Banyai K, Bonerba E, Chezzi C, Arcangeletti MC, De Conto F, Calderaro A (2015). Genetic heterogeneity and recombination in type-3 human astroviruses. Infection. Genetics and Evolution Journal 32:156-160.

Mizukoshi K, Kuroda M, Tsukaqoshi H, Sekizuka T, Funatoqawa K, Morita Y, Noda M, Katayama K, Kimura H (2015). A food-borne outbreak of gastroenteritis due to genotype G1P[8] rotavirus among adolescents in Japan. Microbiology and Immunology 58(9):536-539.

Mokhtarzadeh A, Eivazzadeh-Keihan R, Pashazadeh P, Hejazi M, Gharaatifar N, Hasanzadeh M, Baradaran B, de la Guardia M (2017). Nanomaterial-based biosensors for detection of pathogenic virus. TrAC Trends in Analytical Chemistry 97:445-457.

Müller A, Collineau L, Stephan R, Müller A, Stärk KDC (2017). Assessment of the risk of foodborne transmission and burden of hepatitis E in Switzerland. International Journal of Food Microbiology 242:107-115.

Nan X, Jinyuan W, Yan Z, Maosheng S, Honqujun L (2014). Epidemiological and clinical studies of rotavirus-induced diarrhea in China from1994–2013. Human Vaccines and Immunotherapeutics 10(12):3672-3680.

Ozawa K, Oka T, Takeda N, Hansman GS (2007). Norovirus infections in symptomatic and asymptomatic food handlers in Japan. Journal of Clinical Microbiology 45:3996-4005.

Perrin A, Loutreul J, Boudaud N, Bertrand I, Gantzer C (2015). Rapid, simple and efficient method for detection of viral genomes on raspberries. Journal of Virological Methods 224:95-101.

Polo D, Feal X, Romalde JL (2015). Mathematical model for viral depuration kinetics in shellfish: an useful tool to estimate the risk for the consumers. Food Microbiology 49:220–225.

Sánchez G, Elizaquível P, Aznar R (2012). Discrimination of Infectious Hepatitis A Viruses by Propidium Monoazide Real-Time RT-PCR. Food and Environmental Virology 4(1):21-25.

Sarno E, Martin A, McFarland S, Johne R, Stephan R, Greiner M

(2017). Estimated exposure to hepatitis E virus through consumption of swine liver and liver sausages. Food Control 73:821-828.
Sedlak RH, Jerome KR (2013). Viral diagnostics in the era of digital polymerase chain reaction. Diagnostic Microbiology and Infectious Disease 75:1-4.
Stals A, Van Coillie E, Uyttendaele M (2013). Viral genes everywhere: public health implications of PCR-based testing of foods. Current Opinion in Virology 3(1):69-73.
Sumner J (2011). Food Safety Risks Associated with Prawns Consumed in Australia. http://australianwildprawns.com.au/wp-content/uploads/2017/02/2009-787-Foodsafety-risks-for-prawns.pdf
Tavares TM, de Paula Cardoso DD, Brito WMED (2005). Vírus entéricos veiculados por água: aspectos microbiológicos e de controle de qualidade da água. Revista de Patologia Tropical 34(2):85-104.
Trabulsi LR, Alterthum F (2008). Microbiologia. 5. ed. São Paulo: Atheneu 718 p.
Tu ET, Bull RA, Kim MJ, Mc Ivir CJ, Heron I, Mc Iver CJ, Heron L, Rawlinson WD, White PA (2008). Norovirus excretion in an aged-care setting. Journal of Clinical Microbiology 46:2119-121.
Vimont A, Fliss I, Jean J (2015). Efficacy and Mechanisms of Murine Norovirus Inhibition by PulsedLight Technology. Applied and Environmental Microbiology 81(8):2950-2957.
Vinjé J, Hamidjaja RA, Sobsey MD (2004). Development and application of a capsid VP1 (region D) based reverse transcription PCR assay for genotyping of genogroup I and II Noroviruses. Journal of Virological Methods 116:109-117.
Wylie K.M, Wylie TN, Buller R, Herter B, Cannella MT, Storch GA (2018). Detection of viruses in clinical samples by use of metagenomic sequencing and targeted sequence capture. Journal of Clinical Microbiology 56(12):1111-1123.
Xavier MPTP, Oliveira SA, Ferreira MSR, Victoria M, Miranda V, Silva MFM, Strina A, Barreto ML, Miagostovicht MP, Leite JPG (2009). Detection of caliciviruses associated with acute infantile gastroenteritis in Salvador, an urban center in Northeast Brazil. Brazilian Journal of Medical and Biological Research 42:438-444.
Yamashita T, Ito M, TsuzukI H, Sakae K (2001). Identification of Auchi virus infection by measurement of immunosorbent assay. Journal of Clinical Microbiological 39:4178-4180.
Zhao J, Shi BJ, Huang XG, Peng MY, Zhang XM, He DN, Pang R, Zhou B, Chen PY (2013). A multiplex RT-PCR assay for rapid and differential diagnosis of four porcine diarrhea associated viruses in field samples from pig farms in East China from 2010 to 2012. Journal of Virological Methods 194:107-112.