UCD Impact Case Study

Shining the Food Safety Spotlight on Viral Contamination in Food

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ECONOMIC HEALTH ENVIRONMENTAL ACADEMIC

SUMMARY

Food safety is vitally important to the wellbeing of a community and setting standards to prevent the spread of microbial contamination is an important role for regulators. But regulators across the world have found it far more difficult to set standards for viral than for bacterial contamination. At a biological level, the main difference between the two is that while bacteria are free-living cells that can live inside or outside a body, viruses are a non-living collection of molecules that need a host to survive.

Now new technologies and approaches are opening the door to an increased awareness of viruses, their identification and assessment of the risks they pose to human health. Researchers in the UCD School of Biosystems and Food Engineering, in conjunction with the Marine Institute, have helped to improve understanding of the difficulties and limitation of existing techniques used to measure viral contamination in a single species – in this instance Norovirus in oysters – and made an important contribution to the debate on how meaningful standards can be set and monitored for viral contamination in foods.

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A Huge but Unquantifiable Problem for Human Health

Contamination of food by microbes causes illness and death daily throughout the world. However, the full burden of foodborne disease remains unknown. Most cases are not reported – for example, only about one in every 50 cases of non-typhus Salmonella is recorded in public health data in Europe – and thus the reported incidence only represents the tip of the iceberg. Not all ill people seek medical care, errors are possible in the diagnosis or classification of those that do and there are also inconsistencies in approaches to surveillance and data collection at national levels.

The WHO Regional Office for Europe attempted to estimate the true scale of the problem a decade ago. It found, on what it believed to be a conservative basis, that every year more than 23 million people fall ill in Europe from eating contaminated food, resulting in some 5,000 deaths and more than 400,000 "disability-adjusted life years" (a time-based measure of the overall burden of disease combining years of life lost due to premature mortality with time lived in states of less than full health or disability).

The most frequent causes of foodborne disease are diarrhoeal disease agents, which account for over half of the burden. The most common of these, by far, is Norovirus, accounting for just

Oysters, which are filter feeders and consumed in their raw state, are one of the big culprits in causing viral illnesses such as Norovirus in humans.

under 15 million of the 23 million cases in the WHO survey, while non-typhoidal Salmonella was responsible for the majority of deaths.

Professor Francis Butler, UCD School of Biosystems and Food Engineering, has been engaged in food safety research since 1990, focussing initially on bacterial risk assessment and more recently, reflecting advances in the available technology, in virology risk assessment. "We've solved some of the major bacterial related food safety issues, so in a sense it's allowing us to increase our focus on the viruses," he says.

He has been assisted in this growing area of research by Dr Kevin Hunt, who was a researcher and food safety microbiologist at the Marine Institute in Galway before joining UCD's Biosystems and Food Engineering team in 2018.

New Ways of Looking at Viruses

"Viruses are much trickier to measure than microbes and bacteria because they cannot be cultured easily in the lab without huge investment. It is only really in the past 15 years or so that a number of new molecular biology techniques have been developed," says Dr Hunt. "So unlike bacteria, it is quite difficult to detect and quantify viruses and the method developed in recent years is limited in the information it provides – for example in detecting whether the virus is actually 'live' and how infectious it might be. The reason Norovirus is not covered by legislation is that it was impossible to detect on a routine level until maybe as recently as 15 years ago.

"Today we have access to Whole Genome Sequencing (the process of determining all or nearly all of a particular DNA sequence) and PCR (polymerase chain reaction) testing to directly screen for the presence of viral Ribonucleic Acid (RNA). We also have bioinformatics and big data – fields which barely existed at the end of the last century," he says. "With these tools a lot of new data is becoming available on viruses and as a result we're becoming more aware of them," adds Prof Butler.

Food safety continues to be a priority area in the EU and over the past two years the European Food Safety Authority has undertaken a survey to assess the baseline contamination levels in all the countries across Europe, their institutional capacities to deal with food contamination and what the economic impact would be of introducing particular regulatory standards.

"These discussions are all ongoing, so it is a live conversation in that sense," says Butler. "There is certainly evidence of interest at policy-making levels within Europe. The reality is that a lot of raw foods have the potential for microbial contamination, from meat and fish products to vegetables and fruits. But from a food safety perspective the real issue is the contamination level at the point of consumption. That can be a difficult thing to explain convincingly to consumers."

Another problem, as Prof Butler and Dr Hunt see it, is that food safety regulatory agencies like to set specific limits, even though may not always be easy to establish or even particularly meaningful in respect of viruses in foods.

A search for Pearls of Wisdom

Research undertaken by the two researchers in conjunction with the Marine Institute is helping to improve understanding of the difficulties and limitation of existing techniques used to measure viral contamination in a single species – in this instance Norovirus in oysters – and contributes to the debate on how meaningful standards can be set and monitored for viral contamination in foods.

"One issue in the food industry is shellfish, and in particular oysters, because they are consumed raw," explains Prof Butler. "They are filter feeders, so if there is human effluent in the water they will accumulate virus particles that bind with the intestine of the oyster, even though the virus doesn't actually replicate there. When Norovirus populations are high in humans, typically in winter, the virus is discharged by wastewater treatment plants and oyster farms in the vicinity will pick it up."

This particular problem is compounded in winter by what he refers to as a "double whammy". Not only is the population of Norovirus circulating in the human community especially high at this time but also the water in which the oysters live is colder, slowing down their metabolism and causing them to expel less of the accumulating viral load.

Dr Hunt has undertaken a quantitative risk assessment of Norovirus in oysters. Taking samples from a site in Carlingford Lough, an East-coast fjord that forms part of the border between the North and the Republic of Ireland, he was able to identify distribution of the virus within an entire oyster farm and to build a prediction model on top of that using risk assessment methods. "We went from the experimental measurements that the Marine Institute would carry out in their routine monitoring to an estimate of risk, expressed in terms of likelihood of human illness, and we attempted to quantify that," he says.

Being Clear about the 'Known Unknowns'

An important aspect of Dr Hunt's research was investigating the actual test method currently being used. "If you get a test result, what does it actually mean? That's especially true when you are talking about regulatory thresholds, which are so seductive to the regulatory mindset. There are even differences in results between labs, so part of my work was drilling down on what information could be taken from the sampling.

"The sampling protocol at the moment is to take 10 oysters from a point closest to the sources of potential contamination and pool them into a single sample. But that leads to a sampling uncertainty because we just don't know how a virus might be distributed within a site. Because of my work we do now know, or at least we have a much better idea, and that improves the certainty of tests. However, part of the challenge is not so much in reducing uncertainty as in identifying it and recognising the limitations of the sampling protocols."

This work is ongoing, with a combined UCD and Marine

Institute team now exploring the effectiveness of risk management procedures in terms of purifying oysters once they have been contaminated. “There’s a centuries long history of putting oysters in fresh water and waiting till they flush a virus out,” Dr Hunt says. “But once again, this is a very uncertain science and there’s a lot that isn’t known about the effectiveness of this approach. You’re still using the same testing method, with the same limitations with regard to certainty, on the pre and post- treatment samples.”

Significant Potential Impacts

Oyster farming is an important economic activity in Ireland, with 128 Irish farms producing just under 9,500 tonnes of oysters in 2014. Over 5,000 tonnes of this production went to a single export market – France. The value of production increased from €14m to over €40m between 2008 and 2014 due to increased production and prices and with production costs growing at a more moderate pace over the same period the sector’s Gross Value Added rose from €5m to €30m. The contribution of the research into improvement of the monitoring of the stock for viral contamination will play an important part in helping to sustain the industry and employment within it and to protect the quality of its output and therefore its access to international markets.

This research also makes invaluable contributions to public health in Ireland and in across the EU. The well-nuanced understanding of the benefits and limitations of new testing techniques and protocols makes a vital contribution to policy and regulatory decision-making.

In Europe an overall picture has begun to emerge, after many years of discussion and debate amongst various stakeholders, that a limit of somewhere between 200 and 1,000 copies of virus per gramme should be set as the regulatory limit for the sale of oysters contaminated with Norovirus. But it is still an open question as to precisely what the appropriate level of detected virus is for food safety because of the uncertainties in the process.

“There are some key limitations on the detection methods that make interpretation difficult and while legislation and regulatory standards are in place for e-coli bacterial contamination, for example, we’ve discovered that those are insufficient for dealing with viral contamination, simply because it is so much smaller and behaves differently. So the work I’ve done has been highly relevant to these ongoing discussions in Europe at a policy level,” Dr Hunt says.

The study of Norovirus risk assessment in oysters has also marked a significant expansion of the School of Biosystems and Food Engineering activity in the area of viral contamination and has spawned several other projects in this area. Dr Hunt’s research, for example, has extended to looking at Norovirus in other food products, such as berries, and also into the risks associated with other human viruses such as Hepatitis and Sapovirus, which has symptoms very similar to those of Norovirus.

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