by Roger Clemens And Peter Pressman

Food and the Threat of **Zoonotic and Phytoviral Spillover**

Nearly 20 years ago, IFT sponsored an expert report on the next generation of pathogens that might spread through the food supply (IFT 2002). A disturbing observation at that time remains true in the present: "Today, clinical labs are using molecular biology techniques such as the polymerase chain reaction to facilitate diagnosis of [virus] infected patients, although these methods are not yet adapted to the routine detection of viruses in contaminated foods."

Zoonoses, or zoonotic diseases, are infectious diseases caused by bacteria, viruses, and parasites that are able to spread or "spill" between animals and humans. Phytoviruses are those viruses highly prevalent in plants worldwide, including vegetables and fruits. Spillover events are defined as pathogen transmission from a reservoir host population to a novel host population (Lloyd-Smith et al. 2009; Plowright et al. 2017).

In a 2006 report, the World Health Organization (WHO) noted the importance of controlling zoonotic diseases, which are often neglected, especially among populations that live in poverty and rely on livestock (WHO 2006). More recently, the organization declared that 75% of all emerging pathogens during the past decade are zoonotic. Except for the emerging zoonoses such as Severe Adult Respiratory Syndrome (SARS) and avian influenza H5N1, "the vast majority are not prioritized by health systems at national and international levels and are therefore labelled as neglected" (WHO 2019).

A recent paper by Rohr et al. (2019) drove the point home from an agricultural perspective: "Examples of recent zoonotic disease emergences with enormous impacts on either livestock, humans, or both, many of which might have agricultural drivers, include avian influenza, salmonellosis (poultry and humans), Newcastle disease (poultry), swine flu, Nipah virus (pigs and humans), Middle East respiratory syndrome (camels and humans), bovine tuberculosis, brucellosis (mostly cattle and humans), rabies (dogs and humans), West Nile virus, severe acute respiratory syndrome (SARS), and Ebola (humans)."

A truly catastrophic and arguably the most dramatic example of a zoonotic disease is AIDS, caused by the Human Immunodeficiency Virus (HIV). HIV and the closely related retrovirus Simian Immunodeficiency Virus (SIV) are obligate parasites that invade host cells and utilize their cellular transcriptional machinery to reproduce. It is commonly accepted that SIV, originally from African monkeys, was transmitted to humans, giving rise to HIV and resultant multiple outbreaks of HIV infection and ultimately AIDS (Korber et al. 2000).

Humans and animals are exposed daily to a huge constellation of animal and plant viruses through a myriad of routes. It has been historically and conventionally accepted that a strict separation exists between plant and vertebrate viruses regarding their host range and pathogenicity; insect viruses are thought to infect only insects, and plant viruses are believed to infect only plants. Notwithstanding this belief, there are many examples where phytoviruses circulate and propagate in insect vectors and have also been detected in humans (Balique et al. 2015).

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The most abundant plant virus, called pepper mild mottle virus (PMMV), exists as a dynamic and genetically diverse population in the human gut. Zhang et al. (2006) found PMMV in subjects' food and at exponentially higher levels in their feces. It remains unclear whether plant viruses inhabit intestinal cells or utilize the microbiome in order to achieve apparent stability.

The most critical question is this: If plant viruses readily cross the kingdom barrier to colonize humans, might they contribute to illness that has been hitherto unrecognized or misdiagnosed as some idiopathic entity? Balique et al. (2015) point out that there is close relatedness between some plant and animal viruses, and almost identical gene repertoires. Moreover, increasing numbers of studies suggest that plant viruses can be detected in non-human mammals and human samples; that there is evidence of immune responses to plant viruses in invertebrates, non-human vertebrates and humans; and that there is experimental data demonstrating entry of plant viruses or their genomes into non-human mammal cells and tissues.

Mankind has likely been considerably exposed to both plant and insect viruses for several thousand years, and this supports the paradigm that these viruses are safe for humans. However, this conclusion may rest on increasingly shaky ground, especially when considering the anti-food processing movements initially promoted in Brazil and France.

If a virus was to completely break down the host specificity border and become able to multiply in vertebrates, this multiplication could remain unnoticed if it is not associated with a specific symptomatology. Additionally, in the context of plant and insect-based foods or alternative protein sources, the inevitably concentrated matrix might concomitantly increase viral exposure, particularly if processing fails to neutralize any viral contamination.

Certainly, there is no robust evidence to date that plant or insect viruses are causative agents of disease in humans and other animals. And it must be acknowledged that modified plant viruses have been used recently in new vaccine approaches. However, the role of plant and insect viruses as potential human pathogens deserves to be specifically studied further.

Today, the food and dietary supplements industries focus on novel and concentrated plant-based and even insect-based products. People have consumed insects for centuries, but now the insect industry cultivates crickets like livestock and processes them into a highly concentrated flour and protein bars that contain hitherto unprecedented "doses" of pulverized insects. This means that any resident and viable microorganisms are likely concentrated as well. Consider the AdDNV, or Acheta domesticus densovirus, a virus that causes paralysis in crickets. Despite their best efforts, breeders have not identified or created AdDNV-resistant Acheta domesticus crickets (Liu et al. 2011).

As viral concentration in foods may be increasing and as population density increases, spillover epidemiology suggests that virulence should also increase (Lenski et al. 1994; Parker et al. 2015). Novel dietary ingredients or foods that may be consumed raw, or those manufactured from highly concentrated components, may enhance the probability of transmission of pathogenic organisms, that may in turn be acted upon by increasing environmental pressures to augment virulence through antigenic drift and shift. Drift is a mechanism for variation that involves the accumulation of mutations within the genes that code for such antibody-binding sites. Shift is the process by which two or more different strains of a virus, or strain of two or more different viruses, combine to form a new subtype having a mixture of the surface antigens of the two or more original strains.

From the standpoint of safety, it is tempting to suggest that extracts of cannabinoids, especially THC and CBD that may be concentrated as oils and either consumed orally or inhaled, be examined for viruses and processed accordingly. A common virus in this plant is tobacco mosaic virus, which affects plant health and water quality and may significantly impact those with pulmonary diseases (Shrestha et al. 2018; Carpenter and Le Clair 1968). This raises the question of food processing. Research into both thermal and nonthermal processing and their respective efficacy in neutralizing potential viral pathogens seems increasingly salient and perhaps even critical in terms of public health.

As the food industry explores foods and food ingredients, it is reminded that the marine environment is not immune to zoonotic spillover. In conjunction with climate variability, circumpolar declines in sea ice and rising water and air temperatures, the liberation of viral pathogens may be increasing (VanWormer et al. 2019). For example, phocine distemper virus (PDV), which has caused extensive mortality in Atlantic seals, was confirmed in sea otters in the North Pacific Ocean in 2004. Clearly, additional follow-up relative to public health and the health of sea life is important for us to understand.

Interestingly, the Zoonotic Disease Unit in Kenya, the Zoonotic Disease Secretariat in Cameroon, and the Guidelines for Coordinated Prevention and Control of Zoonotic Diseases in Vietnam seem far ahead of U.S. Department of Agriculture and Food and Drug Administration scrutiny. Creation of mechanisms with dedicated financial and human resources will facilitate outbreak detection and response, prevention and control of high-priority endemic zoonotic diseases, and early detection and response to emerging health threats.

Decision-makers and governments must be encouraged to achieve greater levels of effectiveness in the surveillance and monitoring of infectious diseases in humans, wildlife, crops, and livestock. Current information technology tools and methods now available can enhance communication and coordination among all stakeholders in the wildlife health, agriculture, and public health sectors —including federal and state government agencies, multilateral organizations, the public health community, nongovernmental organizations, private sector corporations, and scientific and professional organizations. For such efforts to be effective, however, clear policy mandates must be in place to encourage and ensure the rapid worldwide sharing and dissemination of information on potential zoonotic and phytoviral infectious disease outbreaks. The food industry and federal regulatory agencies must recognize and proactively respond to a potential biothreat that could rival the magnitude of that of HIV. **FT**

References cited are available via hyperlinks in the digital version of this column.

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