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# Viruses in food – in the light of the new coronavirus pandemic

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## 1. SUMMARY

**In the relation to the 2019-2020 years pandemic caused by SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2), this manuscript compiles a summary of the characteristics, mode of transmission and economic significance of human pathogen viruses related to food and food chain safety.**

**In the initial period of the pandemic, it was uncertain whether SARS-CoV-2 could be spread through food. All major European and world food safety and epidemiological organizations (EFSA, WHO, CDC, FDA, etc.) claim that SARS-CoV-2 does not spread through food. However, we know that the virus is stable in aerosols and on certain surfaces for a few hours to days (up to 3 days).**

**At the same time, the consequences of the COVID-19 pandemic on food, nutrition, health, the environment, and the entire food network are very diverse, which the author briefly reviews.**

### 2. Introduction

Viruses are important agents of foodborne disease. Viruses are generally transmitted to humans via foods as a result of direct or indirect contamination of the foods with human faeces. Viruses transmitted by a faecal-oral route are not strongly dependent on foods as vehicles of transmission.

Food associated viruses are responsible for a high number of infectious diseases in humans, mainly gastroenteritis and hepatitis. The most important viral agents are noroviruses (NV) (formerly known as Norwalk-like viruses), rotavirus (RV) and hepatitis A-Virus (HAV).

The rate of foodborne infections caused by viruses can only be estimated (approx. 20% of total cases). Regretfully, only a very small part of viral gastroenteritis can be diagnosed and notified.

Bivalve molluscs, fresh produce and minimally processed products are typically contaminated with viruses in the primary production environment. Many of the documented outbreaks of foodborne viral illness have been linked to contamination of prepared, ready-to-eat food by an infected food handler. Enteric virus contamination in drinking water (used for drinking, ice production or in food processing) has been documented for many years.

Most foodborne viruses of concern tend to be more persistent in the environment and less susceptible to intrinsic and extrinsic parameters commonly used in food preservation (refrigeration, freezing, pH, etc.). Freezing and refrigeration temperatures preserve viruses and are believed to be the single most important parameter that increases the persistence of foodborne viruses in the environment. Thorough cooking will kill viruses.

Unlike foodborne gastrointestinal viruses like norovirus and hepatitis A, that make people ill through contaminated food, SARS-CoV-2, which causes COVID-19, is a virus that causes respiratory illness. This virus is thought to spread mainly from person to person. Foodborne exposure to this virus is not known to be a route of transmission (US FDA, 2020). According to the European Food Safety Authority (EFSA), no reported cases of the new coronavirus (SARS-CoV-2) circulating across the globe, have been linked to contamination of food (EFSA, 2020).

The Center for Disease Control (US), the US Food and Drug Administration (FDA), the US Department of Agriculture (USDA), and the World Health

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Organization (WHO) all say that food is not known to be a route of transmission of the novel coronavirus.

There is no evidence of human or animal food or food packaging being associated with transmission of the coronavirus that causes COVID-19 (US FDA, 2020). There is currently little scientific information about the survival of the SARS-CoV-2 on the surface of open food. However, this virus is stable for several hours to days (up to 3 days) in aerosols and on surfaces. The novel coronavirus survives longest time on plastics (72 hours), followed by stainless steel (48 hours) and only for 4 hours on copper (IFST, 2020).

It is important to maintain good hygiene practices around open food (e.g. unpackaged bread, cakes, fruit, salad bars etc.) and this will reduce the risk of contamination of the food. The advice to food businesses and consumers is to maintain good hygiene practices and to have stringent food safety measures.

FDA does not anticipate that food products would need to be recalled or withdrawn from the market for reasons related to the outbreak, even if a person who works in a human or animal food facility (e.g. a food packager) is confirmed to be positive for the COVID-19 virus.

However, several other potential consequences of the current COVID-19 pandemic on the food system, are to be thought carefully. The potential consequences on the food, nutrition, health and environment are manyfold.

## 3. Food-associated viruses

Viruses are submicroscopic agents, that replicate only inside a living cell of an organism. They require a living host to grow as they invade the host's cells and take them over to generate millions more virus particles.

Dmitri Ivanovsky, considered now as a founder of virology, described in his article in 1892 a non-bacterial pathogen infecting tobacco plants, than Martinus Beijerinck discovered the tobacco mosaic virus in 1898 **[1]**. There have been more than 6.000 virus species described in detail, of the millions of types of viruses in the environment **[2]**.

Food associated viruses are responsible for a high number of infectious diseases in humans, mainly gastroenteritis and hepatitis. The most important viral agents are Noroviruses (NV) (formerly known as Norwalk-like viruses), rotavirus (RV) and hepatitis A-Virus (HAV).

It's been only two decades since viruses had been increasingly recognized as important causes of outbreaks of foodborne disease.

The viruses most often foodborne were the hepatitis A virus and the Norwalk-like (today called noroviruses) gastroenteritis viruses **[3]**. A joint meeting of WHO and FAO experts held in 2008 concluded, that while noroviruses and hepatitis A were recognized as the most important foodborne viruses, a range of other enteric viruses have also been linked to foodborne illness **[4]**. Noroviruses (NoV) were the most common cause of foodborne viral gastroenteritis worldwide, and hepatitis A virus (HAV), which can also be transmitted by foodborne routes, continued to pose an international health threat. Rotaviruses, Enteroviruses and Astroviruses were also considered important, albeit to a lesser extent **[5]**.

Rotaviruses became the most common cause of severe diarrhoeal disease in young children throughout the world. Rotaviruses infect nearly every child by the age of 3-5 years and are globally the leading cause of severe, dehydrating diarrhoea in children aged <5 years. According to WHO estimates in 2013 about 215 000 children aged under 5 years die each year from rotavirus infections; the vast majority of these children live in low-income countries **[6]**.

FAO and WHO experts identified more than a decade ago as so-called emerging viruses HEV, HPAI-H5N1 virus, SARS-CoV and Nipah virus as the viruses of primary concern in terms of foodborne transmission.

Viruses can be passed on to humans in different ways, but the major foodborne viruses are those that infect via the gastrointestinal tract and are excreted in faeces and, in some cases, in vomitus.

Viruses are transmitted to humans via foods as a result of direct or indirect contamination of the foods with human faeces. Viruses transmitted by a faecal-oral route are not strongly dependent on foods as vehicles of transmission, but viruses are important among agents of foodborne disease **[7]**.

Vehicles are most often molluscs from contaminated waters, but many other foods are contaminated directly by infected persons.

Enteric virus contamination in drinking water (including water used for drinking, ice production, or in food processing) has been documented for many years. Water and ice used in processing and packaging of food can be a potential source of contamination. When contaminated water is used to reconstitute food products (such as dried or powdered milk, infant formula, or juice), virus transmission may occur. Both edible ice and packing ice, if made from contaminated water, can also be a source of virus contamination of food.

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Infectious avian influenza virus has been cultured from frozen exported meat, raising questions about the possible dissemination of such viruses via the food chain. Although this mode of spread is considered to be rare, the potential consequences of such spread dictated that such viruses should be considered.

Viruses play a major role in the burden of infectious intestinal disease, but under-reporting, the lack of surveillance systems and the inability of existing systems to determine the proportion of disease that is transmitted by foodborne routes relative to other common routes make it difficult to estimate the proportion of viral illness that is foodborne **[8]**.

### 4. Viruses of concern in the food chain

Pandemic influenza outbreaks have been predictably unpredictable in the years since 1918 – but always global, and needing a global response. One million people around the world died in a 1957 outbreak which started in China but spread globally. In 1968, another outbreak took 1 to 3 million lives. In 2003, A(H5N1) or so-called Avian Influenza highlighted how the virus could pass from animals to humans, but it did not reach the pandemic stage because it did not pass from human to human. The 2009 "Swine flu" A(H1N1) pandemic, started in Mexico and spread to over 214 countries and overseas territories or communities. The world was lucky: it turned out to be even milder than some seasonal epidemics **[9]**.

Animal influenza viruses are distinct from human seasonal influenza viruses and do not easily transmit between humans. However, zoonotic influenza viruses - animal influenza viruses that may occasionally infect humans through direct or indirect contact - can cause disease in humans ranging from a mild illness to death.

Birds are the natural hosts for **avian influenza viruses**. After an outbreak of A(H5N1) virus in 1997 in poultry in Hong Kong SAR, China, since 2003, this avian and other influenza viruses have spread from Asia to Europe and Africa. In 2013, human infections with the influenza-A (H7N9) virus were reported in China **[10]**.

Most **swine influenza viruses** do not cause disease in humans, but some countries have reported cases of human infection from certain swine influenza viruses. Close proximity to infected pigs or visiting locations where pigs are exhibited has been reported for most human cases, but some limited human-to-human transmission has occurred.

Just like birds and pigs, other animals such as horses and dogs, can be infected with their own influenza viruses (canine influenza viruses, equine influenza viruses, etc.).

**Avian flu H5N1**: A highly pathogenic H5N1 virus was isolated from a farmed goose in Guangdong province, China in 1996. The following year (1997), outbreaks of highly pathogenic H5N1were reported in poultry, at farms and live animal markets in Hong Kong, while human infections with avian influenza H5N1 were reported, resulting 18 cases (6 fatal) in the first known instance of human infection with this virus **[11]**. Six years later (2003) two human cases of avian influenza H5N1 infection were confirmed in Hong Kong. The Republic of Korea also reported H5N1 in poultry the same year, where outbreaks continued through September 2004. 2 tigers and 2 leopards, fed on fresh chicken carcasses died unexpectedly at a zoo in Thailand. Subsequent investigation identified a H5N1 virus similar to that circulating in poultry. Vietnam and Japan reported H5N1 in poultry at the beginning of 2004. Hong Kong reported H5N1 in a wild bird the same time and this was the first report of H5N1 in birds in Hong Kong since the poultry outbreak in 1997. In January 2004, Thailand reported first H5N1 in poultry, than confirmed cases of human infection with H5N1. Cambodia, Laos and soon after Indonesia and China followed. 9 million poultry were culled in China. Case studies of 10 patients in Vietnam showed close contact with infected poultry as the probably source of human infection in most cases **[12]**.

A case report was published indicating atypical human H5N1 infection in Thailand (from March 2004), with fever and diarrhoea but no respiratory symptoms **[13]**.

In August 2004 Chinese researchers reported preliminary findings of H5N1 infection in pigs. No evidence suggested that pig infections were widespread, and the finding appeared to have limited epidemiological significance **[14]**.

Research published in September 2004 showed, that domestic cats experimentally infected with H5N1 developed severe disease and could spread infection to other cats. Prior to this research, domestic cats were considered resistant to disease from all influenza-A viruses **[15]**.

Poultry outbreaks continued at the end of 2004 in Indonesia, Thailand and Vietnam and possibly also in Cambodia and Laos, more less continuously in Indonesia, in Thailand and Vietnam through 2005 and 2006. Japan reported LPAI H5N2 in poultry in June 2005. The Russian Federation and Kazakstan reported the first H5N1 outbreaks in poultry in July 2005. Indonesia reported H5N1 in poultry and pigs in August 2005. Several countries (e.g. Romania, Croatia, the UK) and Turkey reported the first H5N1 outbreaks in poultry in October 2005. In the course of 2005-2006 nuerous countries reported outbreaks in poultry and wild birds. Based on the experience of the avian flue outbreaks caused by the highly pathogenic H5N1 virus, experts had already widely discussed the likelyhood of a pandemic influenza.

**Swine flu H1N1**: Concerns over a dramatic rise in cases of swine flu – influenza-A (H1N1) infection – in Australia and Chile have led the World Health Organization (WHO) in June 2009 to raise its disease alert level to 6, representing a pandemic **[16, 17]**. Raising the alert level to 6 represents widespread human-to-human transmission of the infection. That was the first time since 1968 that the WHO had raised the alert to the highest level. As of 26 April 2009, the United States Government had reported 20 laboratory confirmed human cases of swine influenza-A (H1N1) and the Government of Mexico had reported 18 laboratory confirmed cases of swine influenza-A (H1N1). The virus was described as a new subtype of influenza-A (H1N1) not previously detected in swine or humans **[18]**.

An overall peak in the number of pandemic H1N1 cases was recorded in India during mid December 2009. As of 31 January 2010, worldwide more than 211 countries and overseas territories or communities have reported laboratory confirmed cases of pandemic influenza H1N1 2009, including at least 15,174 deaths. In Europe, transmission of pandemic influenza virus remaind active in a limited number of countries as overall activity remained low in most places. The overall rate of sentinel respiratory samples testing positive for influenza fell to 14% after reaching a peak of 45% during early November 2009 **[19]**.

**Avian flu H7N9**: Avian influenza-A (H7N9) is a subtype of influenza viruses that have been detected in birds in the past. This particular A (H7N9) virus had not previously been seen in either animals or people until it was found in March 2013 in China. However, since then, infections in both humans and birds have been observed. The disease is of concern because most patients have become severely ill. Most of the cases of human infection with this avian H7N9 virus have reported recent exposure to live poultry or potentially contaminated environments, especially markets where live birds have been sold. This virus does not appear to transmit easily from person to person, and sustained human-to-human transmission has not been reported **[20]**. An increase in human infections with avian influenza-A (H7N9) virus has been reported by China since October 2016 **[21]**.

The objective of this paper is not to cover avian and swine flu zoonotic events and pandemics, but it is worth to mention that other new influenza viruses, such as H1N1, swine flu in 2009, H7N7 avian flu in 2017 in the UK, H5N8 in 2015 & 2017 were of wide concern, as emerging risks and endemics posing the risk of human-to-human infections besides their zoonotic nature.

## 5. Coronaviruses: SARS, MERS, novel coronavirus

Coronaviruses (CoV) (order Nidovirales, family Coronaviridae, subfamily Coronavirinae) are enveloped, positive stranded RNA viruses. The subfamily Coronavirinae contains the four genera Alpha-, Beta-, Gamma-, ad Deltacoronavirus. These little agents or invaders are zoonotic, meaning they can live in animals or in humans. Coronaviruses infect birds (gamma- and deltacoronaviruses) and several mammalian species (mainly alpha- and betacoronaviruses), including humans **[22]**.

Coronaviruses are made up of one strip of RNA, and that genetic material is surrounded by a membrane studded with little spike proteins. Under a microscope, those proteins stick up in a ring around the top of the virus, giving its name "corona" which is Latin origin from "crown." When the virus gets into the body, those spike proteins attach to host cells, and the virus injects that RNA into the cell's nucleus, hijacking the replication machinery there to make more virus. Infection ensues.

Coronaviruses are a family of viruses that usually cause respiratory illness. They include viruses that cause the common cold and more serious illnesses such as Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS) and the novel coronavirus called SARS-CoV-2 causing COVID-19.

In addition to endemic CoVs, two epidemic CoVs have emerged in humans in the last 2 decades, the Severe Acute Respiratory Syndrome (SARS) CoV and the Middle East Respiratory Syndrome (MERS) CoV discovered in 2003 and 2012, respectively **[23, 24]**. Both viruses belong to the genus *Betacoronavirus* and were responsible for outbreaks involving high case fatality rates. SARS-CoV was responsible for an outbreak of viral pneumonia in 2002/2003. This outbreak affected at least 8000 individuals and was characterized by a case fatality rate of approximately 10% **[25, 26]**.

SARS-CoV-2, the cause of COVID-19, is defined as a novel type of SARS-CoV, which caused a similar epidemic in 2003. Coronavirus is common in humans and animals (camels, cattles, cats and bats).

Animal coronaviruses, which include important livestock pathogens such as transmissible gastroenteritis virus (TGEV) of swine, bovine CoV (BcoV), and feline coronavirus (FCoV) have been known for more than 80 years **[27]**.

**SARS-CoV 2003:** Severe acute respiratory syndrome (SARS) is a viral respiratory illness caused by a coronavirus, called SARS-associated coronavirus (SARS-CoV). SARS was first reported in Asia in February 2003. The illness spread to more than two dozen countries in North America, South America, Europe, and Asia before the SARS global outbreak of 2003 was contained. Severe acute respiratory syndrome (SARS) is caused by a virus similar to the viruses that cause colds. The first report of SARS in people was in 2003, with an outbreak in China that quickly spread to other countries. Most people with SARS will develop pneumonia. Based on the limited experience of the original outbreak in February, 2003, many people had only a mild illness. However, SARS can cause death in over 9% of the people who contract the virus **[28]**.

The World Health Organization (WHO) issued a global alert on 12 March 2003 about cases of atypical pneumonia in Guangdong Province and Hong Kong Special Administrative Region, China and in Vietnam **[29]**. They pointed out, that no link has so far been made between these outbreaks of acute respiratory illness in Hanoi and Hong Kong and the outbreak of `bird flu,` A(H5N1) in Hong Kong reported on 19 February of the same year.

An early investigation by Xu et al. reported, that several observations support the hypothesis of a wild animal origin for SARS. Cases apparently occurred independently in at least five different municipalities; early case-patients were more likely than later patients to report living near a produce market but not near a farm; and 9 (39%) of 23 early patients, were food handlers with probable animal contact **[30]**.

„SARS-causing Coronavirus", such as Highly Pathogenic Avian Influenza (HPAI) were considered as „emerging viruses" by a FAO-WHO joint expert panel in 2008 **[31]**. The potential for foodborne transmission is a concern with every new emerging infection, and ruling out such concerns is often difficult. Although initially considered to be unlikely, faecaloral spread in particular conditions has been proven for the primarily respiratory pathogens Nipah virus, HPAI virus and SARS-CoV.

**MERS-CoV 2012**: The other highly pathogenic CoV infecting humans – the MERS-CoV – was incidentally discovered in a fatal human case of pneumonia in Saudi Arabia in 2012 **[32]**. A large body of subsequent work suggests that humans regularly and frequently acquire MERS-CoV as a zoonotic infection from dromedary camels, a major livestock species in the Middle East. Owing to the role of dromedaries as a major livestock species in the Middle East, MERS-CoV represents a serious zoonotic threat involving an unknown epidemic and pandemic potential **[33]**.

In extension of our knowledge on origins of MERS- and SARS-CoV in bats, it has been proposed that all HCoVs may be of zoonotic origin, and may indeed originate from bats **[34, 35, 36]**. The common scenario of CoV evolution then involves past transitions into intermediate hosts such as livestock that have closer interaction with humans, and that may carry a diversity of viruses including variants directly related to ancestral strains. Discovering intermediary viruses may enable comparisons between original and current viral characteristics in humans, elucidating the process of human adaptation. However, there is still a gross lack of comprehensive data on the evolutionary history of most HcoVs **[37]**.

Six years after the first case of the highly pathogenic MERS coronavirus, when 100 passengers on a flight from Dubai to New York in September 2018 fell ill with respiratory symptoms, health officials were concerned that they might be carrying the same serious respiratory illness (MERS-CoV) and quarantined the plane until further health checks could be completed. Testing showed that several were positive for the influenza virus **[38]**. 2018 marked the 100$^{th}$ anniversary of one of the most catastrophic public health crises in modern history, the 1918 influenza pandemic known colloquially as "Spanish flu". The intensity and speed with which the 1918 influenza pandemic struck were almost unimaginable – infecting one-third around 500 million people of the Earth's population. By the time the pandemic subsided two years later, more than 50 million people are estimated to have died. Globally, the death toll eclipsed that of the First World War, which was around 17 million **[39]**.

**SARS-CoV-2 2019**: Now a name has been developed for the novel coronavirus **[40]**, that was discovered in December 2019 and which is believed to originate in a food market in the Chinese city of Wuhan in Hubei Province in central China. The virus has been named SARS-CoV-2 (or earlier written as: 'sars-cov2') and can trigger the disease COVID-19 or 'covid-19'. 'Co' is from Corona, 'vi' are virus, 'd' is disease and '19' is the year 2019.

The "Severe Acute Respiratory Syndrome coronavirus 2" (SARS-CoV-2) is the strain of coronavirus that causes coronavirus disease 2019 (COVID-19). Colloquially known as coronavirus, it was previously referred to by its provisional name, 2019 novel coronavirus (2019-nCoV) **[41]** It is the successor to SARS-CoV-1.

SARS-CoV2 is contagious in humans. There are currently seven types of coronavirus that infect and can cause disease in humans. SARS-CoV-2 is the seventh coronavirus known to infect humans **[42]**; SARS-CoV, MERS-CoV and SARS-CoV-2 can cause severe disease, whereas HKU1, NL63, OC43 and 229E are associated with mild symptoms **[43]**. The virus is commonly transmitted through direct mucous membrane contact by infectious droplets, e.g. breathing in airborne virus from the sneeze of someone who is infected, or through hand to mouth or nose contact after fingers have touched a contaminated surface.

While the viruses that cause both COVID-19 and seasonal influenza are transmitted from person-to-person and may cause similar symptoms, the two viruses are very different and do not behave in the same way. ECDC estimates (2020), that between 15.000 and 75.000 people die prematurely due to causes associated with seasonal influenza infection each year in the EU, the UK, Norway, Iceland and Liechtenstein. This is approximately 1 in every 1.000 people who are infected. Despite the relatively low mortality rate for seasonal influenza, many people die from the disease due to the large number of people who contract it each year. The concern about COVID-19 is that, unlike influenza, there is no vaccine and no specific treatment for the disease. It also appears to be more transmissible than seasonal influenza. As it is a new virus, nobody has prior immunity, which means that the entire human population is potentially susceptible to SARS-CoV-2 infection **[44]**.

Previous experience with outbreaks of illness due to MERS-CoV, SARS-CoV and other respiratory viruses (e.g. avian influenza) suggests that novel coronavirus may have been originally transmitted from animals to humans **[45]**. The source of the COVID-19 virus is believed to be animals, but the exact source is not yet known.

In the midst of the global COVID-19 public-health emergency, it is reasonable to think about why the origins of the pandemic matter. Detailed understanding of how an animal virus jumped species boundaries to infect humans so productively will help in the prevention of future zoonotic events. For example, if SARS-CoV-2 pre-adapted in another animal species, then there is the risk of future re-emergence events. In contrast, if the adaptive process occurred in humans, then even if repeated zoonotic transfers occur, they are unlikely to take off without the same series of mutations. In addition, identifying the closest viral relatives of SARS-CoV-2 circulating in animals will greatly assist studies of viral function **[46]**.

At the time of the finalisation of the manuscript (mid-May 2020) the number of infected cases worldwide are above 4.2 million, more than 294 thousand death, half of those in the EU/EEA countries **[47]**. Underreported cases can be 72% of all cases (up to 79%) **[48]**.

## 6. Persistence and survival of viruses

There are clear differences in morphology, infectivity, persistence and epidemiology between viruses and the common foodborne bacteria. Control of viral hazards often requires measures different to those typically employed to combat bacterial hazards.

Contamination can be prevented by keeping faeces out of food or by treating vehicles such as water in order to inactivate virus that might be carried to food in this way. Virus cannot multiply in food, but can usually be inactivated by adequate heating. Other methods of inactivating viruses within a food are relatively unreliable, but viruses in water and on exposed surfaces can be inactivated with ultraviolet light or with strong oxidizing agents **[49]**.

Most foodborne viruses of concern are non-enveloped. Because of this structure, they tend to be more persistent in the environment and less susceptible to intrinsic and extrinsic parameters commonly used in food preservation (refrigeration, freezing, pH, etc.). Hepatitis-A virus can persist on raw food, such as fresh produce, beyond the shelf life of the product, and long enough in the environment to cause concern for additional spread. Freezing and refrigeration temperatures preserve viruses and are believed to be the single

most important parameter that increases the persistence of foodborne viruses in the environment. Heat and drying can be used to inactivate viruses, but there are virus-to-virus differences in susceptibility to these processes. The food matrix can influence relative survival to heat and desiccation.

Most theories on the temperature needed to affect the virus come from a single 2004 study done by the WHO multi-center collaborative network on SARS diagnosis on the SARS virus, not the new coronavirus **[50]**. In that one paper, they showed inactivation of the virus – from 10,000 virus particles down to 1 – after 3 minutes at 149 degrees, Chapman says. But it's important to note that we don't have enough information about this novel coronavirus to know if it reacts exactly the same way **[51]**.

Experts say that cooking your food to the same temperatures required to kill pathogens that cause foodborne illness is likely to also kill the coronavirus that can cause COVID-19. That's 145° F = 62.7 °C for fresh pork, beef roasts, steaks, chops, and fish; 160° F = 71.1 °C for egg dishes and beef; and 165° F = 73.8 °C for poultry, ground beef, casseroles, and leftovers, and to reheat precooked ham.

## 7. Novel coronavirus SARS-CoV-2: No transmission via food

The outbreak of coronavirus disease (COVID-19) is affecting a large number of countries across the globe. There is currently no evidence that food is a likely source or route of transmission of the virus **[52]**. According to the European Food Safety Authority (EFSA), no reported cases of the new coronavirus (SARS-CoV-2) circulating across the globe, have been linked to contamination of food.

EFSA states, that experiences from previous outbreaks of related coronaviruses, such as SARS-CoV and MERS-CoV show, that transmission through food consumption did not occur. At the moment, there is no evidence to suggest that coronavirus is any different in this respect.

The US Food and Drug Administration echoed that sentiment, saying on its website that it's not aware of any reports suggesting Covid-19 can be transmitted by food or food packaging **[53]**.

The Centers For Disease Control and Prevention (CDC) **[54]**, the Food and Drug Administration (FDA) **[55]**, the U.S. Department of Agriculture (USDA) **[56]**, and the World Health Organization (WHO) all say that food is not known to be a route of transmission of the virus.

FAO **[57]** added, that presently, there is no evidence that the virus responsible for the current COVID-19 pandemic is carried by domestic food-producing animals, such as chickens, ducks, other poultry, pigs, cattle, camels, horses, sheep, goats, rabbits, guinea pigs or fish. They emphasise, that – while live animals can be a source of pathogens –, all types of food can potentially be contaminated through contact with contaminated equipment, surfaces or environments. Proper cleaning and the prevention of cross-contamination are critical in the control of foodborne illnesses.

Chief of the Outbreak Response and Prevention Branch of the US Centers for Disease Control and Prevention (CDC), which investigates foodborne and waterborne illnesses, Dr. Ian Williams said, that the novel coronavirus is not likely to be transmitted by food itself (CNN, 2020). „There is no evidence out there that, so far with [Covid-19], that its foodborne-driven or food service-driven," Williams said in an information webinar. „This really is respiratory, person-to-person. At this point there is no evidence really pointing us towards food [or] food service as ways that are driving the epidemic" **[58]**. One of the most detailed guidelines on COVID-19 and food safety was issued by the European Commission **[59]**. It also provides a list of and link to the recommendations of the Member States. The EC had also laid down temporary measures in Reg. (EU) 2020/466 **[60]**.

There are studies conducted on the viruses in the same virus family with the SARS-CoV-2, which means that they have very similar genetic properties to the SARS-CoV-2. In the studies conducted during the outbreak of the SARS-CoV in 2003 and MERS-CoV in 2012, no evidence could be obtained as to the transmission of the SARS and MERS-CoV via food. Therefore, there seems to be no reason to worry that the SARS-CoV-2 virus is transmitted through food or not **[61, 62]**.

So, there is no evidence that the SARS-CoV-2 virus is transmitted via food. However, the fact that there is no evidence does not necessarily mean that there is no possibility of transmission or that it is absolutely impossible.

Very unlikely that the novel coronavirus could be transmitted by food sources. However, absence of evidence is not evidence of absence. This was pointed out at the webinar provided by IFST **[63]**.

In evaluating the findings of scientific research, using such descriptions as „never", „impossible", „not possible" is usually avoided. As required by scientific scepticism, it is avoided to use such definite statements as *„transmission of SARS-CoV-2 via food is impossible"* that will relieve everyone; because it is always possible that findings of a research can be published, showing how this low chance of transmission happens. So as a journalist (Şik, 2020) explains in a smart way, the statement that *according to the available information, there is no evidence that the SARS-CoV-2 virus is transmitted through food* is enough to ease our worries under current circumstances **[64]**.

Research on SARS-CoV indicates that this virus is relatively hardy and survives in serum, sputum and faeces for at least 96 hours. In urine, it could remain alive at least 72 hours with a low level of infectivity **[65]**.

The stability of SARS-CoV-2 similar to the original SARS virus. This virus is stable for several hours to days (up to 3 days) in aerosols and on surfaces **[66]**.

The novel coronavirus survives longest time on plastics (72 hours), followed by stainless steel (48 hours), for 24 hours on cardboard and for 4 hours on copper.

In the case of **food packaging**, the risk of transmission is low. In a preliminary study published in mid-March 2020, researchers tested the stability of the new coronavirus on a variety of surfaces. They found that the virus remained on plastic and stainless steel for up to 72 hours. On cardboard, they found no viable virus after 24 hours **[67]**. But the virus begins to degrade quickly. The half-life – or the time it takes for the concentration of virus to drop by 50 percent – was 5.6 hours on stainless steel and 6.8 hours on plastic. The half-life on cardboard was a little more than 3 hours, although the researchers said there was a wider variation among the samples they tested than for stainless steel or plastic.

The food safety measures that are already in place to prevent foodborne illness — such as strict food hygiene measures, frequent hand-washing, regular cleaning of surfaces and utensils, and cooking food to the right temperature — would also reduce the transmission of any virus particles through food. So it is very unlikely, that the novel coronavirus would be transmitted via processed food.

Unlike bacteria causing foodborne illness, viruses don't multiply in or on foods. Current research shows that it can survive for only a limited time on most surfaces. So even if a product or packaging were carrying the virus, it would be likely to die during transport. However, contamination of raw food (like fruits and vegetables) or non-packaged food (such as bakery products) could be contaminated taken, that an infected person (even if not showing any symptoms of COVID-19) would sneeze or otherwise spread the virus by respiratory droplets on the surface of the foods or of the food packaging.

The US North Carolina State University has created an informational FAQ, based on information from the Centers for Disease Control and Prevention, the Food & Drug Administration and the U.S. Department of Agriculture, concerning off-premises foodservice during the coronavirus. It also points out, that there is no current indication, that takout or drive-through meals would increase illness. The same applies to food delivery, as these help to maintain social distancing and reduce the number of touch points between preparation and serving of food **[68]**.

### 8. Food safety and dietary guidelines and advice

More and more guidelines prepared by food safety authorities, scientific societies and consumer associations point out the need of careful and responsible behaviour at food stores and outlets, such as preparing food at home during the coronavirus pandemic. Some are general food hygiene rules, some are more specific, some are focusing on consumer behavior, some on retail etc. They include advice, summarized in ***Table 1***.

In stores, the biggest risk of contamination remains contact with other people and 'high-touch' surfaces, although most stores sanitize those regularly and replaced touch screens.

Good hygiene practice, social distancing, and isolating those who are infected are the best-known ways to prevent infection **[69]**.

Social distancing is only one aspect on how to avoid contamination while shopping food. There is very little discussion about other vehicles when doing shopping, namely the shopping carts and baskets. Those are usually very contaminated and not regularly disinfected or even cleaned by stores. One might shop with his/her own shopping basket or reusable bag, once cleaned on a regular basis and handled with outmost care (e.g. not put on the bench in the kitchen).

There is limited information available on the survival of the novel coronavirus on textiles or in the washing machine. As enveloped viruses, in which the genetic material is coated by a layer of fat (lipid layer), coronaviruses generally react sensitively to substances that dissolve fat, such as surface-active agents, which are contained in detergents as grease remover. In normal everyday life, people in private households can wash their laundry as usual. Textiles that have come into contact with infectious body fluids should be washed in the washing machine at a temperature of at least 60 °C with a heavy-duty detergent and dried thoroughly **[70]**.

While maintaining good hygiene practices and following these simple food safety practices, you would minimise the risk of foodborne illnesses.

In the same time it is important to state, that safe food handling practices are widespread and have been expected to be followed for a long time. It has been estimated that each year 1.8 million people die worldwide as a result of diarrhoeal diseases and most of these cases can be attributed to contaminated food or water. Proper food preparation can prevent most foodborne diseases. Thus, international organisations have widely distributed their guidelines and manuals **[71]**.

However, it is unbelievable how strange fake news spread after every emerging issue, new threat, unknown or not widely known and understood phenomenon. A highly reputable international organisation, such as WHO felt it necessary to fight against some myth and explain for example, that drinking alcohol does not protect you against COVID-19 and can be dangerous **[72]**. The World Health Organisation has opened a site to confute fake news called "Coronavirus disease (COVID-19) advice for the public: Myth busters" **[73]**. It is almost unbelievable, what kind of beliefs need to be argued, such as "5G mobile networks do not spread COVID-19" as "viruses cannot travel on radio waves/ mobile networks. COVID-19 is spreading in many countries that do not have 5G mobile networks" etc. For more information on how to protect yourself against COVID-19 see WHO's Basic protective measures against the new coronavirus.

Some also try to take advantage of the fear of consumers by providing advice, advertise and promote food supplements which would boost the immune system. Food scientists face increasing number of questions regarding how to boost the human immune system by the means of an improved dietary pattern during the current COVID-19 pandemic. While we always advise, that a balanced diet rich in fruits and vegetables, which allows you to get certain nutrients through your food should be followed, we all know, that these days with our current lifestyle and other limitations, it is rather difficult to do so and it is of outmost importance to ensure that the human body has access to the necessary amount of vitamins and minerals. There are several nutrients (vitamins A, B6, B12, C, D and E and copper, folate, iron, selenium, zinc) that play an important role in our immune system. Still, there is currently no convincing evidence that any food or dietary pattern can 'boost' our immune system and prevent or treat COVID-19. In addition to a balanced diet, getting enough sleep, reducing stress and having some physical activity would also help to support normal immune functioning.

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## 9. COVID-19 and its impact on the global food system

The objective of this paper is to mainly focus on the food safety aspects of the novel coronavirus however one has to see that the current pandemic will substantially influence our food system. Some of the socio-economic consequences, the need for more careful planning and prevention, risk analysis and contingency plans are obvious. The lessons learnt will influence the way we do our shopping we communicate and hopefully will trigger more research and collaboration to understand emerging risks in the food chain.

The global food sector is being impacted both economically and socially, across the entire food chain, in relation to: human resources, such as changes in key personnel; supply chains of ingredients, packaging, finished products and equipment; sourcing as manufacturers may need to rely on alternative suppliers at short notice; along with the transportation of people, materials and good. This has the potential to impact negatively on food safety (IFST, 2020). The risk of food crime has soared during the pandemic as the collapse of foodservice and the closure of meat processing plants has created a dramatic imbalance in supply and demand. With huge volumes of food now unprofitable and buyers often turning to the spot market to meet increased retail demand, many supply chains are increasingly exposed to exploitation **[74]**. Processed foods are believed to be most susceptible to food fraud.

Diaz-Amigo performed a stress test on retailers re online food shopping and had a major concern re the breach of the cooling chain re the first delivery one of the major retailers. The temperature of the items that were supposed to arrive frozen or refrigerated was not maintained. Some items were partially thawed **[75]**. This is a major safety deficiency which requires improvement. This experience might not be unique, especially when the demand for home delivery had high rocketed.

The pandemic has highlighted our reliance on long and complex (and fragile) supply chains, and just-in-time delivery. One of the few good things to come out of the pandemic is that it has made people think in terms of their interdependence with each other and with our planetary resources. It has made us more likely to think about an integrated food system, about global interconnections **[76]**.

Short food supply chains and local productions, which feel less the effect of international restrictions and which, since their rooted presence in the territory, could be closer to the consumers **[77]**.

The coronavirus panic has boosted demand for durable foods, as reported by the Trade Magazin in 2020 sourcing privatebankar.hu. The coronavirus disease is on the rise in Europe, prompting people to accumulate durable foods in Hungary as well. Members of the National Trade Association (including Tesco, Aldi, Spar, Lidl, Auchan and other supermarket chains) issued a statement and confirmed, that while demand for some durable foods at member companies has increased, shelves that have been "looted" and may be filled up a little slower, it will not be a problem **[78]**.

As consumers prioritise food hygiene over (food) waste, previous efforts on the reduction of waste are challenged. Bloomberg (2020) reported, that single-use plastics make a comeback on pandemic fears. About 15 million tons of polystyrene are produced globally every year, and the material is used widely in cars and hospital ventilators as well as takeaway coffee cups and food packaging **[79]**. The fear of contagion via shared items and the importance of physical protection has driven up demand for disposables. Colliding with a collapse in oil prices that has made it cheaper to produce plastic. Some companies have suspended charging for plastic bags, while some retailers have temporarily banned reusable cups out of health concerns.

Although the current article is focusing on the food safety aspects, but nutrition and health issues are closely related and questions arise in this respect. Irregular and heavy consumption of food, both in terms of quantities, frequency and composition may lead to an increased problem of obesity during lockdown, when physical activities are also limited. In the same time consumers wish to strengthen their immune system to be able to more efficiently fight against COVID-19, once being infected. Non-reliable advertisements with misleading information are popping up on internet sites, promising to boost your immune system. So, it is important to emphasize, as FAO (2020) did, that good nutrition is very important before during and after an infection. While no foods or dietary supplements can prevent COVID-19 infection, maintaining a healthy diet is an important part of supporting a strong immune system **[80]**.

The COVID-19 pandemic has underlined the importance of a robust and resilient food system, that is capable of ensuring access to a sufficient supply of affordable food for citizens and functions in all circumstances.

Although it is too soon to analyse and understand the impact of the current pandemic on the food chain, but some of the social, economic, organisational and other potential consequences, which would be worthwhile to be further analysed, are summarised in ***Table 2.***

*Table 1. Food safety advice under the COVID-19 pandemic*

- Maintain good hygiene practices at all times.
- Wash your hands before and during food preparation on a regular basis. Wash them thoroughly for 20 seconds.
- Wash fruits and vegetables before eating them. It's always important – even when there's no pandemic — to rinse fresh fruit and vegetables with water to remove dirt, debris and pesticides, and reduce levels of foodborne germs.
- There's no need to wash food with soap. Soap is for hands, not for food.
- Disinfect surfaces and objects before and after use.
- Keep raw and cooked foods separate to avoid harmful microbes from raw foods spreading to ready-to-eat foods.
- Use different utensils/chopping boards for raw and cooked foods to prevent cross-contamination.
- If you are concerned about food packaging, you can wash your hands after handling the packaging.
- If you are concerned about your food, you can cook it at 65 degrees Celsius for 3 minutes or at 72 degrees Celsius for 2 minutes, which will significantly reduce levels of any virus particles.
- Change kitchen towels and sponges more frequently and regularly wash them in hot water.
- Do not swipe kitchen bench surfaces with the same towel you use for drying or touching food.
- Do not put your purse, basket or other shopping bags on the kitchen bench.
- In stores, use your own shopping basket and gloves, if possible, to avoid touching 'high-touch' surfaces, such as shopping-cart handles, weighing scales and elevator buttons.
- Keep social distance (minimum recommended distance vary from 1.5 to 2 meters) from other people when shopping.
- Avoid touching foods unless you are going to buy them.
- Do not go shopping if you are sick. Order food online or ask someone to drop groceries off.
- Try to limit trips to the supermarket by planning in advance, shop at odd hours and pay through electronic means, if possible. Keep some stable food at home.

*Table 2. Some potential consequences of the COVID-19 pandemic in/on the food chain.*
*Food-Nutrition-Health-Environment related consequences of COVID-19:*

- Food insecurity in less developed countries and regions.
- Disruption in the food supply may lead to food safety issues.
- More focus on food hygiene and food safety – including the HoReCa, retail sector and the households.
- Increasing responsibility of food business operators to demonstrate that preventive measures are always in place during food production and that they are effective by means of checks and testing on their production process and food (so-called own-controls).
- Weakening of the official food control activities caused by the re-deployment of human resources fighting against SARS-CoV-2.
- More food authenticity related risks. Rise in food fraud. Criminals may target food supply chains disrupted by the pandemic.
- Increasing demand for durable foods.
- The impact of the imbalance in supply and demand on food price.
- Sourcing issues as manufacturers may need to rely on alternative suppliers at short notice.
- Impact on transportation of people, materials and good.
- Limited eco-consumerism. Consumers are putting hygiene ahead of the environment.
  The production and perception of food packaging, thus waste is changing.

o Increasing need for big plastic.

o More food waste and packaging waste.

- Potentially shorter food supply chains.
- Local food prioritized (– or not, if not competitive). Decreasing reliance on imported food.
- Online shopping, ordering food, takeaway, drive-through gaining momentum.
- Emergence of start-ups, such as home delivery of foodstuffs, medicine and essential products organized and delivered by flexible young entrepreneurs.
- Disruption of the cold chain during home delivery by non-specialised personnel may lead to food safety issues.
- Labelling problems leading to food allergenicity issues while ordering food.
- Obesity problems due to increasing and more frequent food consumption during lockdown.
- Focus on the prevention and fight against NCDs.
- Changing kitchen and cooking practices, learning (lost) good (hygiene) practices, need for slow food.
- Higher demand for food supplements (due to unbalanced diet during lockdown and home office and aiming to boost the immune system and also triggered by profit-oriented producers and aggressive marketing strategies).

- Fake news, misinformation, misunderstanding leading to increasing loss of trust in authorities and the food business operators. Fighting the disinformation pandemic will be necessary.
- Social distancing (physical) while strengthening social relationship (communication, support) during lockdown.
- Rising food insecurity for some of the poorest and most vulnerable people.
- Enhancement of research efforts to understand, treat and prevent a similar pandemic, to understand the spread of similar viruses.
- Development of analytical and diagnostic tools for viruses.
- Turning towards a more sustainable food system.
- Intensification of the food system using agro-tech innovations (such as robotics, AI [Artificial Itelligence], precision farming, cellular agriculture).
- Focus on agroecology – production of organic, seasonal, local food, shorter food chains etc.
- Changing balance between soft measures (such as health messaging consumer advice) and hard measures (such as taxation).

***Editor's note:*** *The manuscript was created during the current coronavirus epidemic and arrived to our editorial office in May 2020. Therefore, data related to the events after the receipt of the article could not be included in the final text.*

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