

Survival of SARS-CoV-2 on food surfaces: Introduction

The World Health Organization (WHO) were notified in late December 2019, of a cluster of cases of pneumonia of unknown cause in Wuhan City, Hubei Province, China. Most early cases were associated with visiting Wuhan South China Seafood City market, which reportedly sold meat, poultry, seafood and live animals. In early 2020, WHO received further evidence, from the National Health Commission of the People's Republic of China, identifying the cause of these infections as a novel coronavirus (WHO, 2020a). It has since been transmitted rapidly around the world and as of June 2022 is responsible for 543 million reported cases and over 6.4 million deaths globally (Worldometer, 2022). In England, there have been 19 million cases and 159,000 deaths (UKHSA, 2022).

The primary route of transmission for SARS-CoV-2 is inhalation of contaminated respiratory droplets ($>100\ \mu\text{m}$ particles) or aerosols ($<100\ \mu\text{m}$ particles) from symptomatic and asymptomatic patients produced during breathing, talking, coughing and sneezing, particularly in poorly ventilated indoor areas (Morawska et al., 2020). However, there is the possibility that SARS-CoV-2 might spread via direct contact with droplet-contaminated surfaces (fomites). This could lead to the virus being transferred from the hand to the eyes, nose and mouth (WHO, 2020b). One study estimated that there are an average of 17000 viral copies per sputum sample collected during a typical cough, which could be deposited on the surfaces of foods or food packaging (Yu, 2020). There is currently no documented evidence that food and food packaging materials are a significant source and/or vehicle for the transmission of SARS-CoV-2. A recent literature review on the potential for food borne transmission, stated that there is limited evidence of fomite-related transmission (Kingsbury, 2022). However, the virus might contaminate food and packaging materials during processing and whilst on retail display and could thus act as a vehicle of transmission. It is assumed the main route of SARS-CoV-2 transfer to foods and food packaging is cross-contamination from infected individuals.

A risk assessment published by the Foods Standards Agency (FSA) in 2020 concluded that it was very unlikely that you could catch coronavirus via food (FSA, 2020). This assessment included the worst-case assumption that, if food became contaminated during production, no significant inactivation of virus would occur before consumption. However, the rate of inactivation of virus on products sold at various temperatures was identified as a key uncertainty. This project was commissioned to reduce this uncertainty by measuring the rate of inactivation of virus on the surface of various types of food and food packaging. The results will be used to consider whether the assumption currently made in the risk assessment remains appropriate for food kept at a range of temperatures, or whether a lower risk is more appropriate for some. A recent report by SAGE-EMG (SAGE, 2020) states that ventilation is a key mitigation for controlling transmission of SARS-CoV-2 by aerosols ($< 10\ \mu\text{m}$), between people who share the same indoor space. They state, however, that ventilation is not likely to have any significant impact on transmission via fomites, such as foods or food surfaces.

We conducted a laboratory-based study artificially contaminating infectious SARS-CoV-2 virus onto the surfaces of foods and food packaging. We then measured how the amount of infectious

virus present on those surfaces changed over time. The food and packaging types studied included: fresh vegetables, fresh fruit, baked produce, delicatessen (deli) items, polyethylene terephthalate (PET) plastic bottles; PET material such as ready meal containers; aluminium cans and composite drinks cartons. They were studied at a range of temperatures and humidity levels and over time periods that reflect their typical storage conditions.

There is no consensus on the definition of ambient temperature. WHO guidance (WHO, 2022c) states that 'ambient' is not widely used due to significant variation in ambient temperatures. Generally, 'ambient' describes 'room temperature' or normal storage conditions, i.e. storage in a dry, clean, well-ventilated area at room temperatures between 15°C to 25°C or up to 30°C (depending on climatic conditions). The Division of Military and Naval Affairs (DMNA) recommend between 10°C and 21°C for ambient storage of foods (DMNA, 2006). The Mayo Foundation for Medical Education and Research recommend normal ambient relative humidity should be between 20-50% (MFMER, 2021). It is clear from the available literature and supermarket websites that there is little consensus as to what is considered ambient humidity or temperature. This varies between supermarkets and is dependent on the individual company's guidelines, the outside temperature and relative humidity, whether the supermarket has air-conditioning and the size of the supermarket. While UK guidelines recommend that supermarkets maintain a temperature of 19-21°C in winter, and 21-23°C in summer (GMP Compliance, 2017), different supermarkets have varying policies. In an article by Pursglove, (2021), different supermarkets were approached for their policies on ambient temperature. In the article, Tesco stated 'There is no policy on ambient air temperature'. Lidl said 'We do regulate the store temperatures through a Building Management System, according to set guidelines and specifications. We have a minimum and maximum temperature for each area of the store, from 19-24°C for the sales area to 20-24°C'. Morrisons said 'We do not have a specific set of guidelines for store temperatures and Asda have 'temperatures between 19-24°C' (Pursglove, 2021). UK guidelines state: 'it is recommended that refrigerators and chilled display equipment should be set at 5°C or below. This is to make sure that chilled food is kept at 8°C or below' (FSA, 2021). This is a legal requirement in England, Wales and Northern Ireland, and recommended in Scotland (FSA, 2021 and FSS, 2016).

To study conditions more representative of real-world scenarios, for packaging materials, we investigated SARS-CoV-2 survival in medium enriched with mucin. Salivary mucin has been described as one of the factors that prolong the survival of SARS-CoV-2 on surfaces (Riddell et al., 2020). Mucin is the principal glycoprotein of saliva and is the main non-water, gel-like component of the mucus layer that covers epithelial surfaces throughout the body (Çelebioğlu et al., 2020). We investigated whether added mucin had any effect on the survival of SARS-CoV-2 on the surfaces of some packaging materials: plastic bottles, composite drinks cartons and aluminium cans.