Coronavirus COVID-19 and Food Processing Parameters

The Coronavirus COVID-19 pandemic has prompted the food industry and the public to question what role, if any, food and beverages play in transmission of the virus. To date, there have been no evidence that COVID-19 can be transmitted by food. Neither SARS-CoV or MERS-CoV showed any transmission by way of food consumption. The data presented in this document should not be interpreted as evidence that there is a risk from Coronavirus in food. However, in an effort to understand the potential risk from Coronavirus if at some point it is shown to be foodborne, an assessment of traditional food processing operations has been conducted below from what is known about SARS-CoV, MERS-CoV and other known foodborne viruses.

Thermal Resistance

A thermal process of 52 seconds at 72°C will probably result in loss of infectivity.

There is no available literature on the thermal resistance of COVID-19. There are several papers where the thermal resistance of SARS-CoV was measured. Chan et al. (2011)[1] reported that 15 minutes at 56°C will result in loss of infectivity of SARS-CoV. Darnell et al. (2004)[2] measured a 5 log reduction in SARS-CoV after 15 minutes at 56°C and 3 minutes at 65°C. Bozkurt et al. (2015)[3] in their review of the thermal resistance of foodborne viruses found that the thermal resistance could be grouped into two predominate groups – most all viruses (Murine norovirus, Feline calicivirus, and Tulane virus) and Hepatitis A. Hepatitis A being more thermally resistance than the first group.

[1] K. H. Chan, J. S. Malik Peiris, S. Y. Lam, L. L. M. Poon, K. Y. Yuen, and W. H. Seto, 2011. The Effects of Temperature and Relative Humidity on the Viability of the SARS Coronavirus. Advances in Virology. Vol 2011, Art ID 734690, 7 pages.

[2] Miriam E.R. Darnell, Kanta Subbarao, Stephen M. Feinstone, and Deborah R. Taylor. 2004. Inactivation of the coronavirus that induces severe acute respiratory syndrome, SARS-CoV. Journal of Virological Methods. Vol. 121. pg 85–91.

[3] Hayriye Bozkurt, Doris H. D'souza, and P. Michael Davidson. 2015. Thermal Inactivation of Foodborne Enteric Viruses and Their Viral Surrogates in Foods. J. of Food Prot., Vol. 78, No. 8, Pages 1597–1617.

Bozkurt et al. (2015) found that published data on the thermal resistance of Murine norovirus, Feline calicivirus, and Tulane virus showed that at 56°C a 5 log reduction ranged from 17.35 – 31.8 minutes. These values are very similar to those reported by Chan et al. (2011) for SARS-CoV. Thomas and Swayne (2007)[4] measured the thermal resistance of H5N1 High Pathogenicity Avian Influenza in poultry meat and found that 31.8-34.4 minutes at 56°C resulted in a 5 log reduction of the virus. The thermal resistant H5N1 D-values reported by Thomas and Swayne (2007) for chicken breast meat were 4.48, 2.57, 1.27, 1.18, and 0.569 minutes for 57, 58, 59, 60, and 61°C respectively.

Bozkurt et al. (2015) showed that there is a correlation between the water activity of the product and the thermal resistance. As the water activity of the product goes down, the thermal resistance increases. Bozkurt et al. (2015) also reported that literature data for the thermal resistance of foodborne enteric viruses in fruit, vegetables, and herbs were lower than data collected from culture media or seafood.

Considering the close relationship that SARS-CoV has with COVID-19 and the low thermal resistance of SARS-CoV it is expected that any process sufficient to destroy pathogenic vegetative bacterial pathogens will destroy Coronaviruses.

High Pressure Processing

High pressure processing of 90 seconds at 500 MPa will probably result in a loss of infectivity (Temp >= 15°C).

Isbarn et al. (2007)[5] measured the thermal and pressure resistance of the highly pathogenic avian influenza A virus H7N7. A thermal treatment of 30 seconds at 65°C resulted in no longer being able to detect the H7N7 virus from a starting concentration of 1.5×10^5 PFU. Isbarn et al. (2007) also found that H7N7 was sensitive to pressure. The sensitivity depended on the temperature of the product. A greater than 5 log reduction was observed after 90 seconds at a pressure of 500 MPa (IT=15°C) when treated in a cell culture medium. When the cells were placed in chicken meat the time needed to deliver a 5 log reduction at 500 MPa was reduced.

[4] Colleen Thomas And David E. Swayne. 2007. Thermal Inactivation of H5N1 High Pathogenicity Avian Influenza Virus in Naturally Infected Chicken Meat. J. Food Prot. Vol 70. No. 3. Pg 674-680.

[5] Sonja Isbarn, Roman Buckow, Anke Himmelreich, Anselm Lehmacher, and Volker Heinz. Inactivation of Avian Influenza Virus by Heat and High Hydrostatic Pressure. 2007. J Food Prot. Vol 70. No. 3. Pg 667-673.

In the review of viral inactivation in foods by Hirneisen et al. (2010)[6] a 5 minutes treatment at 450 MPa with a starting temperature of 22°C will deliver a 7 log reduction to Hepatitis A. It is expected that a high pressure process designed to deliver a 5 log reduction in *Listeria*, *E. coli* O157:H7, and Salmonella will destroy Coronaviruses.

Acidity (pH)

Products with a pH of 3.0 – 4.0 and held at room temperature or above will probbably not support the survival of the virus.

There is very little data on the effect of pH on SARS-CoV. Darnell et al. (2004)[2] examined the effect of pH on the virus at pH's of 1, 3, 5, 7, 9, 12, and 14. They found that at room temperature when the pH was <=3 or >=12, there was no detectable virus after 1 hour of exposure. pH values between 5 and 9 had little effect after 1 hour on the virus titers even when held at 37°C. For pH 3, when the temperature was reduced to 4°C there was only a reduction of about 3 logs after 1 hour. Wang et al. (2004)[7] measured the conformational change to the N protein of SARS-CoV (considered a less stable structural protein and related to the infectivity of the virus) with regards to pH. Wang et al. (2004)[7] found that the protein started to unfold near a pH of 5 and was fully denatured near pH 2.7, with a midpoint at a pH of 4.0. Wang et al. (2004)[7] also measured a complete denaturing of the N protein at a temperature of 55°C, which correlates with the thermal stability data presented above. With the pH data from Darnell et al. (2004)[2] and the conformational data from Wang et al. (2004)[7] it would seem that pH's below 4.0 are necessary to inactivate the viruses.

UV treatment

UV dosage in excess of what is needed for foodborne vegetative pathogens may be needed for loss of infectivity.

UV treatment at 254nm is effective at reducing the titer of SARS-CoV (Darnella et al., 2004). However, the amount of reduction will be dependent on the dose of UV and temperature of the product. There is insufficient data to determine recommended critical factors for a UV process. Hirneisen et al. (2010)[6] in their review of inactivation of viruses reported that upwards of 36 mJ/cm^2 in needed for a 4 log reduction of FCV. These researchers also reported that upwards of 75 mJ/cm^2 was needed to deliver a 4 log reduction in Hepatitis A. In the juice industry, for the UV

[6] Kirsten A. Hirneisen, Elaine P. Black, Jennifer L. Cascarino, Viviana R. Fino, Dallas G. Hoover, and Kalmia E. Knie. 2010. Viral Inactivation in Foods: A Review of Traditional and Novel Food-Processing Technologies. Comp Reviews in Food Sci and Food Safety. Vol 9. Pg 3-20.

[7] Yulong Wang, Xiaoyu Wu, Yihua Wang, Bing Li, Hao Zhou, Guiyong Yuan, Yan Fu, and Yongzhang Luo. Low Stability of Nucleocapsid Protein in SARS Virus. Biochemistry. Vol 43. Pg 11103-11108.

treatment of apple juice, a UV dose of 14 mJ/cm^2 is often used. Thus, for UV treatment the doses needed to inactivate viruses may be in excess of that needed to inactivate vegetative pathogens.

Irradiation

Irradiation dosage in excess of what is needed for foodborne vegetative pathogens may be needed for loss of infectivity.

Kumar et al. (2015)[8] found that a 4-5 log reduction of MERS-CoV occurred with 10 kGry radiation with Cobat 60 gamma irradiation. They found at 20 kGry that there were no recoverable cells using a culture with a 10^{10} PFU/ml titer. There is some indication that viruses are slightly more resistant than bacterial pathogens. FDA recommended doses for irradiation to control vegetative pathogens may be insufficient to inactive Coronaviruses. Doses of upwards of 10 kGry will probably be needed to deliver a 5 log reduction in the virus. A summary of some of the reported inactiviation data found within literature is listed in table 1.

Table 1: Summary of Reports for Inactivation of Viruses by Processing Method

Processing Method	Test Organism	Product	Process Condition	Log Reduction	Reference
Thermal	SARS-CoV	media	15 mins at 56°C	Loss of infectivity	Chan et. al. (2011)[1]
	SARS-CoV	media	3 mins at 65°C	> 5 log reduction	Darnell et al. (2004)[2]
	FCV-F9	media	32 mins at 56°C	5 log reduction	Bozkurt et al. (2015)[3]
	FCV-F9 and MNV-1	media	2.05 mins at 65°C	5 log reduction	Bozkurt et al. (2015)[3]
	FCV-F9 and MNV-1	media	0.6 mins at 72°C	5 log reduction	Bozkurt et al. (2015)[3]
	Avian influenza H5N1	Chicken breast meat	2.87 mins at 61°C (z=4.7C)	5 log reduction	Swayne (2007)[4]
	influenza A virus H7N7	media	30 secs at 65°C	> 5 log reduction	Isbarn et al. (2007)[5]
High Pressure	influenza A virus H7N7	Media	90 secs at 500 MPa (IT=15°C)	> 5 log reduction	Isbarn et al. (2007)[5]
	Hepatitis A	Media	5 mins at 450MPa (IT=22C)	7 log reduction	Hirneisen et al. (2010)[6]
UV	FCV	Media	36 mJ/cm^2	4 log reduction	Hirneisen et al. (2010)[6]

[8] Mia Kumar, Steven Mazur, Britini L. Ork, Elena Postnikov, Lisa E. Hensley, Peter B. Jahrling, Reed Johnson, Michael R. Holbrook. 2015. Inactivation and safety testing of Middle East Respiratory Syndrome Coronavirus. J of Virological Methods. Vol 223. Pg 13-18.

	Hepatitis A	Media	75 mJ/cm^2	4 log reduction	Hirneisen et al. (2010)[6]
Irradiation	MERS-CoV	Media	10 kGry	5 log reduction	Kumar et al. (2015)[7]
	MERS-CoV	Media	20 kGry	Loss of infectivity (> 10 logs)	Kumar et al. (2015)[7]
pH	SARS-CoV	Media	pH <= 3.0 (25-37^{o}C)	Loss of infectivity after 1 hour	Darnell et al. (2004)[2]
	SARS-CoV	Media	pH =3.0 (4^{o}C)	3 log reduction after 1 hour	Darnell et al. (2004)[2]

IEH Emergency Response Team: We are facing an unprecedented challenge with COVID-19 and how it will impact the food industry. The food industry is vital to the well-being of the nation and we must maintain our food supply during an epidemic. IEH has worked with industry as well as the federal, state, and local health agencies in responding to crises for over 20 years. Call us if you have questions and learn how we can help your business be ready for COVID-19. Our emergency response team is available 24/7 for IEH clients.

IEH Coronavirus COVID-19 Test: IEH is in the process of validating it's COVID-19 test. It will be available to the industry, should there be a need, by March 20, 2020.

IEH Coronavirus challenge studies and validation studies: We will be able to offer these services by March 27, 2020.