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RAPID REVIEW

# Thermal Inactivation of Influenza A (H5N1) in Meat

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## Highlights

- Currently the Canadian Food Inspection Agency (CFIA) indicates there is no evidence to suggest that avian influenza A(H5N1) could be transmitted from eating thoroughly cooked beef or poultry, and cooking to recommended cooking temperatures should inactivate the virus, if present.[1–4]
- The United States Department of Agriculture's (USDA) Food Safety and Inspection Service (FSIS) recently reported that samples of raw ground beef collected from retail outlets in states with dairy cattle herds positive for influenza A(H5N1) were all negative for the virus.[5]
- The FSIS recently conducted testing on beef burgers that found cooking the burgers to 63°C and 71°C inactivated the H5N1 virus.[5]
- While no published literature was identified that specifically assessed thermal inactivation (the minimum temperature required to inactivate the virus) of influenza A(H5N1) in beef, other studies have shown that the temperatures required to inactivate the virus in poultry meat are in the range of temperatures recommended for cooking beef.[6–9] However, there is variation in these meat products and beef may not always be consumed fully cooked. Further research would help clarify requirements for influenza A(H5N1) inactivation in beef.
- To date, there have been no detections of the virus in commercial beef cattle in the United States, and no evidence to suggest that Canadian cattle have been affected.[10,11]

## Scope

This rapid review aimed to assess the time and temperature for inactivation of influenza A(H5N1) in meat, including poultry and beef.

## Background

Highly Pathogenic Avian Influenza (HPAI) A(H5N1) is a viral infection that predominantly infects birds, including wild birds and commercial or domestic poultry.[12] The virus causes severe illness in birds and is rapidly transmitted between susceptible avian species, resulting in high fatality rates.[12] While most influenza viruses that circulate in birds are not zoonotic, some HPAI strains, including influenza A(H5N1) have the ability to infect susceptible mammals, including people, resulting in a risk to public health.[12]

The avian influenza A(H5N1) clade 2.3.4.4b virus first emerged in 2020, and spread globally, leading to a high number of deaths in wild birds and poultry in Africa, Asia and Europe. The virus was first detected in Canada in December 2021 and is now widespread throughout North and South America.[13] Detections have also occurred in numerous mammalian species, including raccoons, bears, polar bears, coyotes and seals, with exposure believed to have occurred through direct or indirect exposure with infected wild birds, including through predation.[14] As migratory wild birds begin their spring migration, there is a risk of exposure to Ontario cattle via direct or indirect contact with the feces, saliva or nasal secretions of infected wild birds.[15]

While influenza A(H5N1) clade 2.3.4.4b infections have been sporadically reported in humans, infections are rare, with only 15 confirmed human infections reported globally from December 2021 to April 11, 2024.[13] The most recent human case was reported in the United States (US) in April 2024 and had a mild infection following contact with dairy cattle presumed to be infected with HPAI A(H5N1) viruses and their environment.[16] Clinical severity in infected humans has varied from asymptomatic or mild infection (Europe, North America) to severe or fatal (Asia, South America).[13] No human to human transmission has been reported to date and all cases reported close contact with infected birds or cattle or their environment.[13,17] Per the Public Health Agency of Canada there have been rare reports of human infection with influenza A(H5N1) following consumption of contaminated raw or undercooked products, including raw duck organs and duck blood, however there is no evidence to suggest that the virus can be transmitted through consumption of fully cooked poultry, game meat or eggs.[2]

In March of 2024, the World Organization for Animal Health (WOAH) reported detections of influenza A(H5N1) clade 2.3.4.4b in neonatal goat kids and in dairy cattle in the US, marking the first detections in US livestock and the first in ruminants.[18–21] The virus was subsequently detected in unpasteurized samples of milk, nasal swabs and tissue samples collected from infected dairy cattle in the US.[22] On April 24, 2024 it was reported that the US FDA had detected remnants of the virus in pasteurized milk using PCR testing.[23] The FDA noted that the detection of the virus did not necessarily imply infectivity and is currently conducting studies in collaboration with the US Department of Agriculture (USDA) to explore the effectiveness of different pasteurization parameters utilized by the Canadian and US dairy industry in inactivating influenza A(H5N1) in milk and milk products.[24] The recent detection of HPAI A(H5N1) clade 2.3.4.4b in cattle appears to provide some evidence of tropism for mammary tissue in lactating dairy cattle.[25] Prior to the recent detections of influenza A(H5N1) in dairy cattle in the United States (US), cattle were not believed to be susceptible hosts for influenza A infection.[26]

To date there have been no detections of the virus in commercial beef cattle, and no evidence to suggest that Canadian cattle have been affected.[10,11] Currently the CFIA indicates there is no evidence to suggest that the virus could be transmitted from eating thoroughly cooked beef or poultry, and cooking to recommended cooking temperatures should inactivate the virus, if present.[1–3] On May 1, 2024 the USDA FSIS reported that they collected 30 samples of ground beef from retail outlets in states with dairy cattle herds that had tested positive for influenza A(H5N1) at the time of collection.[5] All samples tested negative for the virus, indicating that the US meat supply continues to be unaffected.[5] On May 16, 2024 the USDA FSIS reported results from a ground beef cooking study conducted to determine the effectiveness of cooking temperatures on H5N1 in beef. Beef patties were inoculated with a high level of an H5N1 virus surrogate and cooked to different temperatures (49°C, 63°C and 71°C).[5] No virus remained in burgers cooked to 63°C and 71°C, and cooking to 49°C also substantially inactivated the virus.[5] As a precautionary measure, the USDA continues to recommend that consumers properly handle raw meats and cook to recommended internal temperatures.[5]

# Methods

We conducted a rapid environmental scan of relevant publicly available online information and guidance from national public health organizations in Canada and the United States.

Information was collected by scanning key government websites, and public health organization websites, as well as Google searches for items related to thermal inactivation of influenza A(H5N1), specifically in meat. This search was limited to English-only resources. Additionally, we performed a search focused on relevant English scientific publications through Google Scholar, using the following search terms: “influenza A” AND “inactivation” AND “heat” OR “temperature” OR “H5N1” AND “thermal” AND “inactivation” AND “meat” OR “poultry” OR “beef”.

# Results

While no published literature was identified that specifically assessed thermal inactivation of influenza A(H5N1) in beef, several articles were identified that explored the heat tolerance of influenza A(H5N1), influenza A(H5N2), influenza A(H1N1) or influenza A(H7N7) in poultry meat or eggs.

Doyle *et al.* (2007) with the Food Research Institute provide a briefing including a review of thermal inactivation of influenza A(H5N1) in meat.[27] They include research by Swayne (2006) who conducted an investigation on thermal inactivation in naturally infected poultry and found influenza A(H5N1) was inactivated after exposure at 70°C for 1 second in breast meat and 70°C for 5 seconds in thigh meat.[6,27]

Isbarn *et al.* (2007) explored the inactivation of influenza A(H7N7) in a chicken meat suspension by heat and high hydrostatic pressure, and found that at 63°C, influenza A(H7N7) virus in the suspension was inactivated after 90 seconds and at 65°C, the virus was no longer detectable after 30 seconds.[7]

Thomas *et al.* (2008) compared thermal inactivation of influenza A(H5N1) in naturally infected chickens to artificially infected chickens. The authors reported that while inactivation took longer in naturally infected meat (when both had a similar virus titre), modelling predicted that temperatures recommended by the USDA FSIS for cooking chicken products would effectively inactivate any virus that may be present.[9,28] The study also found that the influenza A(H5N1) strain used in the study was effectively inactivated in chicken breast meat held at 70°C or 73.9°C for less than 1 second.[9]

To explore the ability of heat to inactivate influenza A(H5N1) in naturally infected chicken meat, Thomas & Swayne (2007) measured viral titers in raw thigh and breast meat harvested from infected chickens at 1°C intervals for temperatures from 57°C to 61°C.[8] The authors found that as temperature increased, titers decreased. Their calculations predicted that cooking poultry to recommended internal temperatures as per current food safety guidelines (cooking to an internal temperature of 74°C for 15 seconds for ground poultry, poultry products and poultry pieces, and to 82°C for 15 seconds for whole poultry)[3,4] would inactivate influenza A(H5N1) in heavily contaminated meat, with a large margin of safety.[8] Specifically, survival curves were constructed for strains of influenza A(H5N1) in chicken thigh and breast meat at 1°C intervals for temperatures of 57˚C to 61˚C. From experimental data, the following estimated predictive values of inactivated were provided:

- At 61°C 90% of viable virus was inactivated within 33.1 to 44.0 seconds
- At 70°C 90% of viable virus was inactivated within 0.28 to 0.50 seconds
- At 73.9°C 90% of viable virus was inactivated within 0.041 and 0.073 seconds

# Conclusion

Although there is a lack of published literature specifically assessing the inactivation of influenza A(H5N1) in beef, studies have explored thermal inactivation of various avian influenza A subtypes in poultry meat.[6–8] These studies have found that in poultry meat the virus is inactivated in the range of temperatures recommended by Health Canada for cooking pieces and whole cuts of beef.[3] The recent ground beef cooking study results reported by the USDA FSIS indicates cooking ground beef patties to recommended temperatures will effectively inactivate the virus.[5] Health Canada recommends a minimum cooking temperature of 63°C for medium-rare and 71°C for medium pieces and whole cuts of beef and ground beef.[3] Overall, studies also indicate the importance of cooking time as well as temperature as a key component of inactivating the virus.

Currently there is no evidence to suggest influenza A(H5N1) has affected beef cattle and no retail samples of beef in the US have tested positive for the virus. In addition, the CFIA indicates there is currently no evidence to suggest that the virus could be transmitted from eating thoroughly cooked beef or poultry, and that cooking to recommended cooking temperatures should inactivate the virus, if present.[1–3] However, further research on the time and temperature required to inactivate influenza A(H5N1) in beef would help clarify this question.

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