BC Centre for Disease Control
An agency of the Provincial Health Services Authority

Environmental Health Services

Food Issue

Notes from the Field

Tuna loin histamine risks during thawing and sous-vide processes

Request received from:	Multiple Regional Health Authorities
Date of request:	January 28, 2015 (1) / February 25 , 2015 (2)
Issues *(brief description)*:	(1) Is there a histamine risk preparing tuna loins in the sous-vide style? (2) Does overnight thawing of tuna loin at room temperature present a risk?

Disclaimer: The information provided in this document is based on the judgement of BCCDC's Environmental Health Services Food Safety Specialists and represents our knowledge at the time of the request. It has not been peer-reviewed and is not comprehensive.

Summary of search information

1. Internet sources: updated search of HC and CFIA sites; review latest CDC illness statistics
2. PubMed: histamine fish poisoning; biogenic amines; scombroid
3. Consults with Dr. O. Peter Snyder, Dr. Don Schaffner, Dr. Paw Dalgaard (and FSSP modelling)

Background information

Histamine fish poisoning (HFP) is a foodborne chemical intoxication. It occurs when fish with high concentrations of histidine, a naturally occurring physiological amine, is converted to histamine, in the muscle or flesh of the fish.[1]

The histidine to histamine conversion can only occur in the presence of bacteria that (1) possess an enzyme called histidine decarboxylase; and (2) when bacteria have grown to high numbers, usually one million or more bacteria per gram.[2] The best way to prevent histamine formation is to control temperature, and limit the bacterial growth.[3]

In addition to histamine, other biogenic amines associated with decomposition products can also occur, such as tyramine, cadaverine and putrescine, also associated with illness.

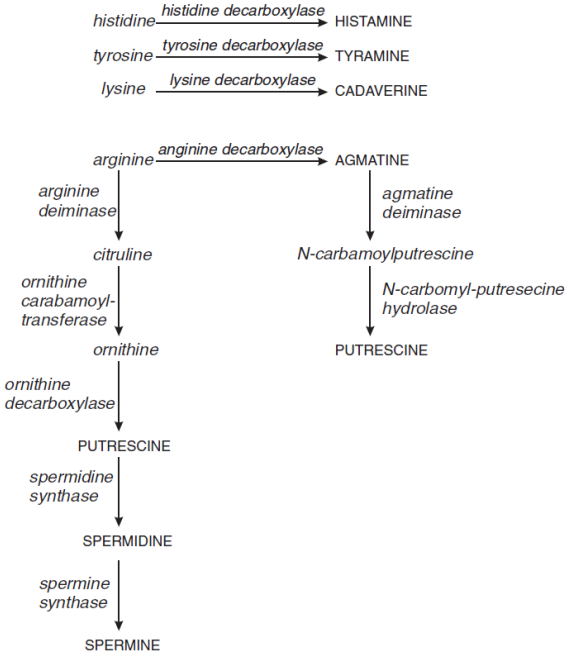

Figure 1. Synthesis of histamine, tyramine and biogenic active polyamines (putrescine, spermidine, and spermine).

Figure 1 – Histamine and biogenic amine formations, copied from Prester (2011)[1]

Fish that contain histamine are often called scombroid fish, from the family Scrombidae, and include tuna and mackerel.[4] However, other species of fish can also contain high levels of histamine, these include mahi-mahi, sardines, pilchards, anchovies, herring, marlin, bluefish, salmon, yellowtail and swordfish.[4] The other biogenic amines formed during temperature abuse of fish appear to increase symptoms, acting as potentiators of histamine, by competing with histamine-metabolizing enzymes in the body once toxin-contaminated fish are ingested.[1,4,5]

The illness associated with HFP occurs very rapidly, from 10 minutes to one hour after eating contaminated fish. The symptoms can include[4]:

- Peppery or metallic taste
- Oral numbness
- Headache
- Dizziness
- Palpitations
- Rapid and weak pulse (low blood pressure)
- Difficulty in swallowing
- Thirst
- Allergy like symptoms, such as hives, rash, flushing, facial swelling

Usually, HFP symptoms are resolved within 24 hours.[4] However, some clinical illnesses can be severe, including tachychardia and respiratory failure, requiring heart monitoring, medications and intubation to improve respiration; and exacerbation of existing asthma conditions.[6,7] Although HFP is relatively common, causing up to 40% of all illnesses related to fish ingestion, outbreak reports that factor time and temperature abuse of the fish are rarer.[6] Attack rates in one outbreak were higher for persons who ate lunch at 12:30pm compared to those who ate lunch 1 to 2 hours earlier, indicating a very rapid rise in toxin levels. This fish – mackerel - was stored at 30°C before cooking.[8]

What are the risks associated with histamine and processes such as sous-vide preparation and thawing?

Questions from the field regarding sous-vide of tuna question whether the time and temperature of some sous-vide cooking styles could result in HFP. Generally the sous-vide temperatures applied have been low, between 40 – 45°C, for very short periods of time, generally less than one hour. Inspectors have also observed thawing of tuna loins for sushi overnight at room temperature. In the morning, tuna loins are still frozen in the centre, but the outer flesh is at ambient temperature. The general process steps for both of these activities are outlined in Figure 2 (next page).

Histamine is heat-stabile, and resistant to freezing, canning and smoking.[8] It will not change the appearance, look or even smell of the fish[8]. In the latest review of foodborne illness (1998-2008) CDC reported scombroid toxin/histamine and fish as the most common pathogen commodity pair, causing 317 outbreaks, exceeding that of *Salmonella*-poultry (145 outbreaks) and norovirus-leafy green vegetables (141 outbreaks).[9] HFP foodborne illnesses, as with most types of foodborne illnesses are likely underreported.[6]

Strict temperature control of susceptible fish is the most important measure to control formation of histamine. This is largely through limiting the growth of bacteria capable of histidine to histamine conversion. Toxic histamine formation can be caused by mesophilic bacteria (growing above 7 to 10°C) and psychrophilic bacteria (growing above 0°C).[2] There are many types of bacteria able to convert histidine, the most common genera is *Morganella*, with species capable of growing and causing histamine formation in cold temperatures at 0°C (*M. psychrotolerans*), and up to temperatures of approximately 45°C (*M. morganii*).[10] Optimal growth temperatures are 15°C (*M. psychrotolerans*) and 26°C (*M. morganii*), with generation times of 2 hours and 54 minutes, respectively.[10] Other species of bacteria associated with HFP include *Klebsiella pneumoniae* and *Hafnia alvei*.[11]

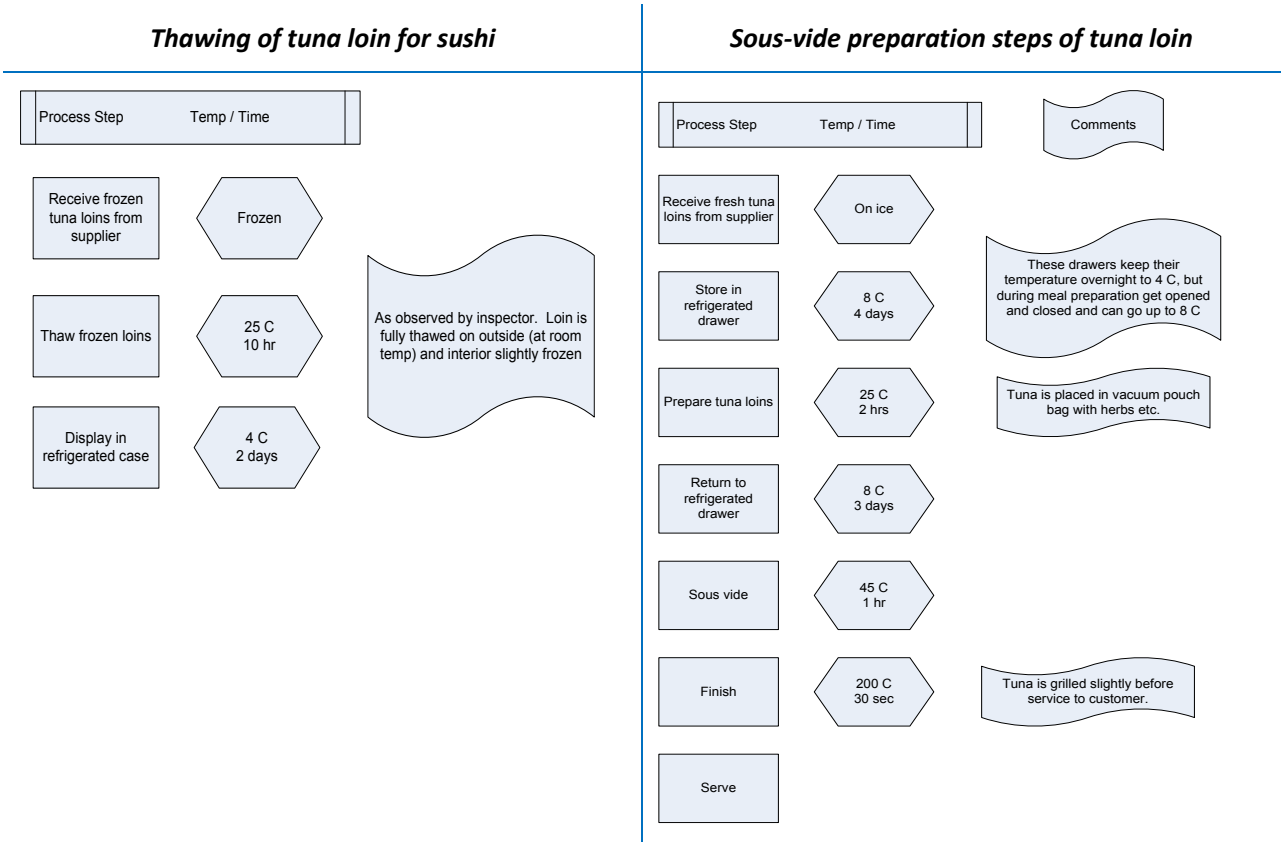

Figure 2 – processes observed in the handling of tuna loin

The situations described in Figure 2 are "worst-case" scenarios. Most often, once sushi tuna is thawed and refrigerated, it is sold within one day. Although unlikely to be stored for prolonged periods in refrigerated drawers, tuna was observed to be stored in this manner and the likely cause of HFP (pers. comm., M. Ritson).

Histamine levels are variable in tuna, ranging from low to high concentrations in the fish muscle.

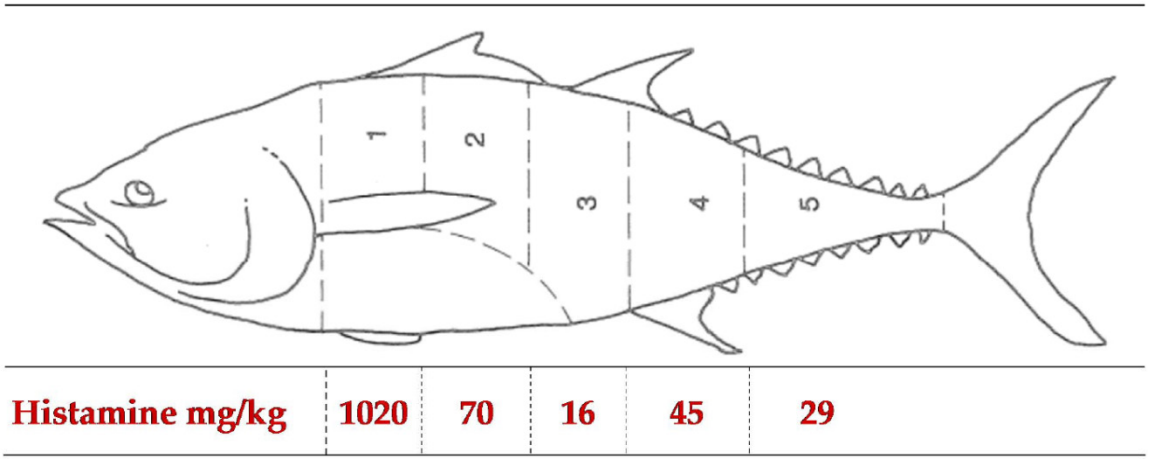

Figure 3 – Variable histamine concentrations in fresh fish, copied from Dalgaard (2014)[2]

To determine if enough bacterial growth will occur to result in histamine formation, a free software modelling program (Food Spoilage and Safety Predictor – FSSP) can be utilized http://fssp.food.dtu.dk , based on research conducted at the Technical University of Denmark.[10,12] Models were run to determine the affect of bacterial growth and histamine formation at several temperatures. Based on the models (shown in **Appendix A**), the following information was determined:

- At 37°C (the highest temperature in the growth model), histamine formation begins in approximately 7 to 8 hours, with maximum histamine formation in 12 hours (when initial counts of *M. morganii* and *M. psychrotolerans* are at 100 CFU/g. (**Figure A**).
- At 22°C (ambient temperature), histamine formation begins after temperature abuse for one day, starting at approximately 22 hours, with maximum histamine formation in ~40 hours (when initial counts of *M. morganii* and *M. psychrotolerans* are at 100 CFU/g. (**Figure B**)
- At 8°C (poorly controlled refrigeration), histamine formation begins in ~4 days (**Figure Ca**), and at 4°C, histamine formation begins in ~9 days (**Figure Cb**); based on initial counts of *M. morganii* and *M. psychrotolerans* (no growth lag) at 100 CFU/g.

Previous guidance on histamine and fish handling processes from British Columbia

A food safety note describing scombroid poisoning advices to control the hazard through refrigerated control.[13]

Previous guidance on histamine from Health Canada and Canadian Food Inspection Agency

Permissible histamine in finished fish products should not exceed 100 mg/kg in fish and other fish products; and 200 mg/kg in fermented fish sauces and pastes.[14] Purchase fish from reputable suppliers, and maintain refrigeration of fish during transportation and storage.[15] Processors must incorporate controls into plans to comply with regulatory standards.[15]

Recommendations from BCCDC

Based on this modelling information and growth requirements for spoilage bacteria we can interpret this data. Sous-vide style cooking temperatures of 45°C or higher will likely reduce numbers of bacteria, and limit formation of histamine in the fish. However, at temperature below 45°C, histamine formation is rapid, within 7 hours at 37°C. Overnight storage of previously frozen tuna, i.e. up to 10 hours, will likely not result in histamine formation. ***However,*** in both of these scenarios, this interpretation is based on no prior temperature abuse, no prior opportunity for bacterial growth, and no prior histamine formation. In one study, tuna was temperature-abused under various conditions to mimic what might occur in a fish-processing facility. The researchers found that when tuna was temperature-abused for 2 hours daily for 7 to 12 days, toxic histamine levels were reached.[11] As depicted in Figure 3, some portions of fish may be more at risk for histamine formation than others.

Failing to control a known hazard, i.e. histamine, with a process that is known to increase risk of the hazard, i.e. sous-vide style cooking at temperatures below 45°C and thawing at ambient temperatures are **AVOIDABLE** situations.

We therefore do not recommend sous-vide style cooking practices for seafoods at risk of histamine formation at temperatures of less than 45°C, even when they are less than one hour; and, we do not recommend thawing these foods at ambient temperatures. We further offer these recommendations:

- All seafoods at risk of histamine formation should be maintained under refrigerated control (i.e. ≤4°C) to limit bacterial growth;
- Thawing of seafoods, or marinating of seafoods, or other processes involving seafoods at risk of histamine formation should occur under refrigerated control, or using a method verified in a food safety plan and approved by the health inspector to control the hazard of histamine formation;
- Sous-vide style cooking of fish species known to be at greatest risk of causing HFP (i.e. tuna, mackerel) are not recommended at temperatures below 45°C.

Additional recommendations for BCCDC

- Update the seafood cooking section of the sous-vide guidelines to include risks of histamine associated with sous-vide style cooking;
- Investigate the occurrence of histamine fish poisoning with polar species of fish, such as salmon, to determine if these fish should also be included in the above recommendations.

References

1. Prester L. Biogenic amines in fish, fish products and shellfish: a review. Food Additives & Contaminants: Part A. 2011 2011/11/01;28(11):1547-60.
2. Dalgaard P. Safety and Health Effects of Aquatic Food Histamine and biogenic amines – formation and importance in marine fish products 2014.
3. Chong C, Abu Bakar F, Russly A, et al. The effects of food processing on biogenic amines formation. Int Food Res J. 2011;18(3):867-76.
4. Hungerford JM. Scombroid poisoning: A review. Toxicon. 2010;56(2):231-43.
5. Taylor SL. Histamine food poisoning: toxicology and clinical aspects. Crit Rev Toxicol. 1986;17(2):91-128.
6. Tortorella V, Masciari P, Pezzi M, et al. Histamine Poisoning from Ingestion of Fish or Scombroid Syndrome. Case Reports in Emergency Medicine. 2014 12/07 09/13/received 11/18/revised 11/18/accepted; 2014:482531.
7. Wilson B, Musto R, Ghali W. A Case of Histamine Fish Poisoning in a Young Atopic Woman. J GEN INTERN MED. 2012 2012/07/01;27(7):878-81.
8. Lehane L, Olley J. Histamine fish poisoning revisited. International Journal of Food Microbiology. 2000;58(1-2):1-37.
9. Centers for Disease C, Prevention. Surveillance for foodborne disease outbreaks--United States, 2008. MMWR Morbidity and mortality weekly report. 2011 Sep 9;60(35):1197-202.
10. Emborg J, Dalgaard P. Growth, inactivation and histamine formation of Morganella psychrotolerans and Morganella morganii - development and evaluation of predictive models. Int J Food Microbiol. 2008 Dec 10;128(2):234-43.
11. Economou V, Brett MM, Papadopoulou C, et al. Changes in histamine and microbiological analyses in fresh and frozen tuna muscle during temperature abuse. Food Additives & Contaminants. 2007 2007/08/01;24(8):820-32.
12. Emborg J, Dalgaard P. Modelling the effect of temperature, carbon dioxide, water activity and pH on growth and histamine formation by Morganella psychrotolerans. Int J Food Microbiol. 2008 Dec 10;128(2):226-33.
13. BC Centre for Disease Control. Fish safety notes: Scombroid fish poisoning. Vancouver, BC: BC Centre for Disease Control; 2008 [updated April 2008; cited 2012 Apr 4]; Available from: http://www.bccdc.ca/NR/rdonlyres/A3933EE5-1E60-4828-AF40-18EF39799775/0/ScombroidFishPoisoning1.pdf.
14. Health Canada. Canadian Standards ("Maximum Limits") for Various Chemical Contaminants in Foods. 2012 [cited 2012 Aug 10]; Available from: http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/contaminants-guidelines-directives-eng.php.
15. Canadian Food Inspection Agency. Food safety facts on scombroid poisoning. 2015 [Mar 27, 2015]; Available from: http://www.inspection.gc.ca/food/information-for-consumers/fact-sheets/food-poisoning/scombroid/eng/1332280657698/1332280735024.

Appendix A – Histamine formation models from the FSSP program (http://fssp.food.dtu.dk)

Figure A. Growth at 37°C over one day

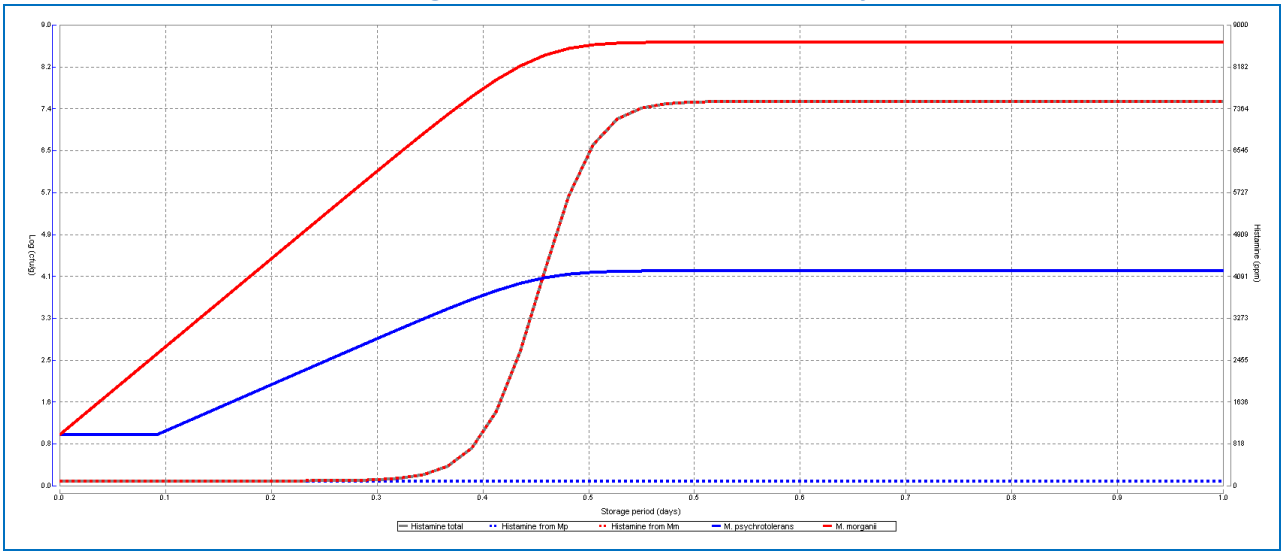

Figure B. Growth at 22°C over two days

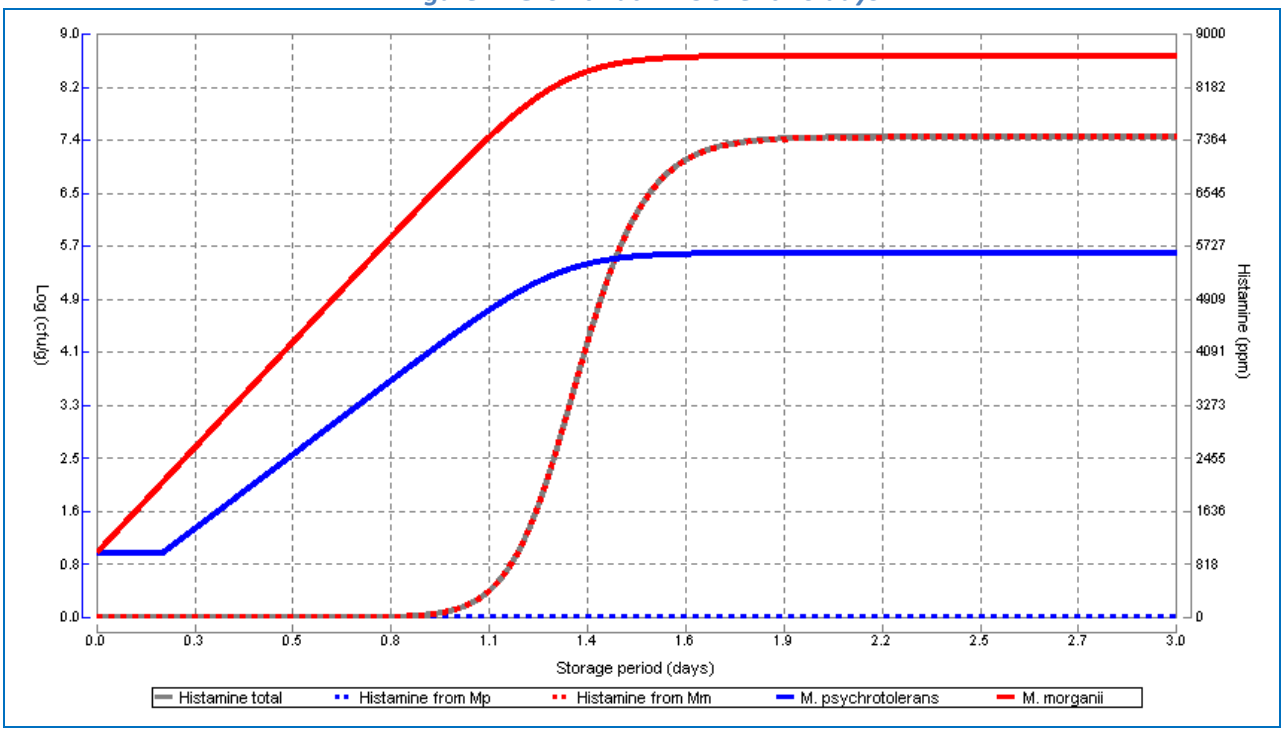

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Figure Ca. 7 days at 8°C

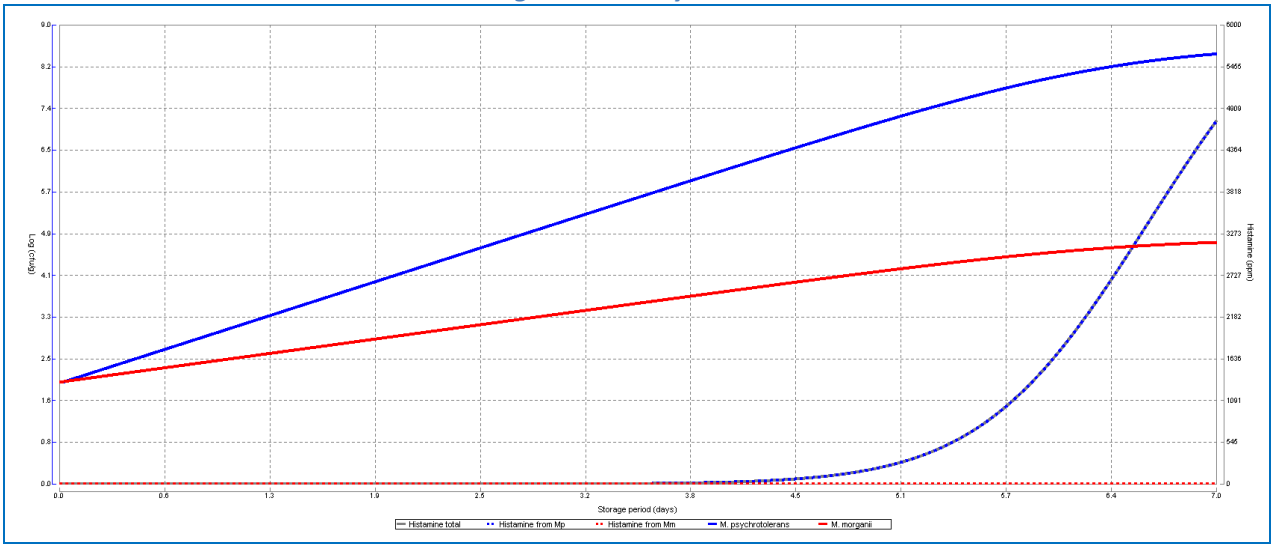

Figure Cb. 14 days at 4°C