Description of the Microbe

Listeria monocytogenes is a widespread foodborne pathogen that has the ability to survive in a variety of different environmental conditions, including high and low temperatures meaning it can be resistant to different forms of pasteurization and cooking. When *L. monocytogenes* transitions from the log to the long-term–survival phase after being exposed to a high-temperature factor, it can increase its resistance to pressure and heat, the cells also change morphology from rod to cocci shape as they move into this phase (Wen et. al, 2009). Even after this kind of exposure to an adverse environment, this bacteria has the ability to re-enter into the log phase when exposed to the right nutrients and still contain the new resistance to heat, also allowing it to increase. When *L. monocytogenes* is exposed to colder temperatures it exhibits the same kind of pattern with the related resistance. When creating and testing six different Genome-scale Metabolic Models (GMM) for this bacteria, it was found that *L. monocytogenes* is more efficient at metabolizing carbon as nutrients as opposed to other sources of nutrients like phosphorus and nitrogen (Metz et. al, 2018). High amounts of carbon in processed meats and ready-to-eat foods make a favorable environment for *L. monocytogenes* to thrive, reproduce, and spread, infecting the population that ingests these products. By using Core Genome Multi-Locus Sequence Typing (cgMLTS) recombination rates can be detected in the four main lineages of *L. monocytogenes*, as well as the differences amongst them which show that these lineages have evolved at different rates. It was also found that genetic lineage III of this bacteria is the most efficient in horizontal gene transfer which can lead to more antibiotic resistance (Zamudio et. al, 2020). Understanding the evolution of this bacteria and how these strains might infect hosts differently, cause different symptoms, and if they differ in mortality rate is important when tracking contamination and using preventative methods to reduce the risk of foodborne illnesses. *Listeria monocytogenes* also contains about 62 different strains of the bacteria. These strains were all found to have different virulence as well as survival mechanisms. Some strains were observed to have been resistant to certian cleaning

chemicals as well as certain stressors in food processing (Muchaamba et. al, 2022). These variations in characteristics are due to small differences in the genes of these bacteria.

Discussion of infection mechanisms

Farm environments including animals like cows, sheep, goats, and chickens are all possible reservoirs of this pathogen. Vegetables can also be contaminated before harvesting due to soil contamination and during retail. Different agricultural practices can also impact the likelihood of *L. monocytogenes* being present in produce. Irrigation, clean water supply, and fertilization as well as other factors can all contribute to the contamination of produce. These practices must be carefully monitored to reduce the risk of *L. monocytogenes* from transferring from manure to the produce. In poultry factors such as temperature, humidity, and even wind speed have shown an influence on *L. monocytogenes* contamination. Transmission of this bacteria between different environments solely depends on the bacteria's ability to adapt to different environments. Regulatory proteins play an important part in this kind of adaptation between environments and hosts, specifically in stress response to different environments (Kallipolitis et. al, 2020). Ultimately transmission of this bacteria relies on both extrinsic factors like the environment and intrinsic factors like metabolism and diversity. This can lead to the contamination of produce or meats through the possibility of malpractice farming techniques and storing methods of food during the retail sale. By ingesting this contaminated produce, the bacteria can adapt to the change in host as well as environment and continue to live, reproduce, and spread inside you which also leads to an impact on the immune system.

Symptoms

Symptoms of being infected with *Listeria monocytogenes* include diarrhea, myalgia, vomiting, abdominal cramps, headache, confusion, arthralgia, fever, and nausea (Awofisayo-Okuyelu et. al, 2016). However, for individuals who are immunocompromised, these symptoms can be more

severe than in healthy individuals. Immunocompromised individuals tend to also have a higher mortality rate from sepsis, rhombencephalitis, and meningitis that may develop because of this initial infection (Dragomir et. al, 2024). Also, the presence of an underlying condition in an individual can impact the time between the onset of symptoms and being able to collect the specimen. However, symptoms may also be masked when an underlying condition is present. Since the diagnosis relies on blood cultures it can be more difficult to suspect when a patient has been infected by this bacteria if they show undifferentiated illnesses (Awofisayo-Okuyelu et. al, 2016). This organism also causes the development of abscesses that have a mortality rate three times higher than other organisms. It is thought that these dangerous abscesses form by entering the central nervous system via infectious macrophages or capillary endothelial cells penetrating the blood-brain barrier. Brain abscesses that have been present in immunocompromised individuals have tended to show stroke-like symptoms, including aphasia and headaches (Dragomir et. al, 2024). Pregnant women also are about 20 times more likely to be infected with *L. monocytogenes* and get Listeriosis which can lead to severe consequences for both the pregnant woman and the baby whether it's unborn or after it's born. In pregnant women, there is also a higher risk once the infection is detected because they often tend to have no symptoms or only mild symptoms. Listeriosis during pregnancy can result in premature delivery, stillbirth, miscarriage, and severe infection in the newborn. About 20% of pregnancies with listeriosis end in either a stillbirth or miscarriage and about two-thirds of babies that survive the pregnancy are likely to develop health problems (Welekidan et. al, 2019). Late onset of this disease in pregnant women also correlates to meningitis in newborns about 2-4 weeks after they have been delivered (Hunjak et. al, 2019).

Epidemiology

Listeria monocytogenes is a gram-positive, facultatively anaerobic coccobacillus bacteria that can inhibit a large range of diverse environments and is responsible for several outbreaks of

foodborne diseases that can have a high mortality rate in immunocompromised individuals and pregnant women (Yamamoto et. al, 2023). Since these bacteria can survive in such a diverse environment, there have been many large foodborne outbreaks in the population that are linked to contaminated food (Schlech et. al, 2019). *L. monocytogenes* also has a high attack rate of up to about 72% among individuals who are exposed to the vehicle of infection, meaning it is highly transmissible and ready to find a host (Schlech et. al, 2019). *Listeria monocytogenes* which causes Listeriosis tends to be found on dairies in different meats like poultry, cows, sheep, goats, and even in animal products like milk and eggs. Hypervirulent strains are also typically found in these areas with animals and their products used for consumption and they can persist for years (Castro et. al, 2021). Surface contamination is also relatively common, up to about 15% of foods harbor *L. monocytogenes*. There have also been specific serotypes of this bacteria that have continued to be consistently found in food and clinical samples in a certain location, emphasizing the prevalence of this bacteria and the perseverance it has through different food processing and safety measures (Paduro et. al, 2020). This disease is also related to febrile gastroenteritis syndrome as well as meningoencephalitis and sepsis. Pregnant women are more likely to develop sepsis from these outbreaks as well which increases mortality rates in this group.

Treatment

Listeriosis is associated with a high mortality rate which makes antibiotic treatment of this infection crucial. Many antibiotics do show activity against *Listeria monocytogenes* however the most effective antibiotic to be discovered against this infection is ampicillin. The use of ampicillin by itself or in combination with an aminoglycoside or gentamicin has been found to be the most efficient treatment for Listeriosis (Schlech et. al, 2019). Listeriosis poses a serious threat to patients undergoing cancer treatment and in others that are immunodeficient. It was found that while testing for the effectiveness of different antibiotics among immunocompromised patients

who have cancer, individuals who possibly got infected by an extremely resistant strain of *Listeria monocytogenes* had resistance found against a specific antibiotic. Clindamycin showed resistance against *Listeria monocytogenes* while the other antibiotics didn't. These included erythromycin, tetracycline, and penicillin, as well as the most effective antibiotics towards this infection, ampicillin and gentamicin showed a susceptibility over 90% (Schlech et. al, 2019). This infection is specifically related to a high mortality rate among immunocompromised hosts due to a delayed diagnosis, often due to the lack of ability to differentiate symptoms and signs from a current disease or infection that they already possess.

Prevention

Listeria monocytogenes tends to be highly transmissible in food processing environments. This occurs by cross-contamination from surfaces and equipment to food in the facility. *L. monocytogenes* tends to be found in dairies that have contaminated water and that also use agricultural techniques that increase the risk of contamination of this bacteria. Once dairy products or meat are taken from a dairy or farm and transferred over to a processing facility, processing methods that do not eliminate bacteria, enable the bacteria the opportunity to find a host. Prevention of Listeriosis is highly correlated with practicing safe food safety techniques to eliminate contamination of vegetables, fruits, ready-to-eat foods, and dairy products. Cleaning protocols should be enhanced in order to eliminate biofilms and ensure that contact surfaces that touch the food being served are properly sanitized. It is also essential that resistant strains are constantly being studied and monitored so the proper treatment options can be made available to the patient (Avila-Novoa et. al, 2023). Overall, the biggest concern when preventing *Listeriosis* is safety measures that need to be implemented in processing facilities of these foods as well as also going directly to the dairies and farms and ensuring they have a clean water source that is not contaminated with this bacteria. With about half a million people dying from foodborne illnesses every year, the U.S Centers for Disease Control and Prevention is

constantly trying to identify and implement standards to achieve safe and healthier foods to prevent this kind of illness (Fouladkhah et. al, 2019). Different techniques are also being developed at different stages of food production to eliminate contamination at varying levels of harvesting and processing.

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