



Enoki-Where to Hide: *Listeria monocytogenes* in LFFM Samples Results in Investigation at United States’ Only Enoki Mushroom Grower



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Abstract

“The Laboratory Flexible Funding Model (LFFM) is a cooperative agreement intended to enhance the capacity and capabilities of state human and animal food testing laboratories in support of an integrated food safety system. 1st In the 2023-2024 Sampling year, 255 enoki product samples were collected from retail locations in six states under the LFFM. Of these, 13 samples (5%) tested positive for *Listeria monocytogenes* (LM). These products traced back to six United States sources. One supplier was the only known U.S. Grower of enoki Mushrooms (Company A). On 11/5/24, the California Department of Public Health (CDPH) and the California Department of Food and Agriculture (CDFA) initiated a joint inspection at the facility in Ventura. Sixty-seven product and environmental samples were collected during the investigation. WGS analysis revealed that the LM strains found in both environmental and product samples were limited in diversity. The predominant strain, PDS000025311.379, has been strongly associated with samples originating from China. These positive findings show enoki mushrooms remain a commodity of concern for LM. This is likely to continue due to persistent strains and consumption of raw or undercooked product.

https://www.fda.gov/media/178947/download&ved=2ahUKEwjFtMDn2-q0AxX-ETQIHLEFjsOFnoECD0QAQ&usq=nA0vVaw05Uz-X-tbgPBRyCoAQASI

Background

Enoki mushrooms are identified as a source of LM in several outbreaks and many product samples. Most recently, in March 2020 and November 2022, FDA and state partners investigated separate outbreaks of LM associated with enoki mushroom consumption. In 2023, enoki mushrooms were included in routine surveillance sampling at retail locations.

In 2023-2024 (LFFM Year 4), 255 enoki mushrooms were collected at retail locations in six states under the LFFM grant. Thirteen (5%) were confirmed positive for LM. These samples were collected from California, Maryland, and West Virginia. Additionally, 27 samples (11%) tested positive for other *Listeria* spp, indicating high levels of contamination and conditions that could allow for LM to persist and propagate.

For the LM positive samples , traceback was conducted due to the health risk of LM contaminated products. Ten of the thirteen samples (77%) were referred to CalFERT for follow up because they were imported by or produced by California companies.

Nearly all the enoki mushrooms sold in the United States were imported from China, Korea, Taiwan, or Japan. Since the product was imported, traceback information was shared with FDA partners for follow up. Starting in early 2024, surveillance sampling identified a U.S.-based company (Company A) selling enoki mushrooms under a single brand. In August and September 2024, three samples from Company A (two from CA and one from MD) were positive for LM. As this is the only known U.S. supplier for enoki mushrooms and they have produced contaminated product in several batches, CalFERT conducted an on-site investigation at the growing operation in California to assess potential sources of contamination.

Summary of LM Positive Enoki Mushrooms Collected Under the LFFM Grant 2023-2024

Collection Date	Coll. By	Brand	WGS Cluster ID	Country
(Sept/Oct. 2023)	WV	Qilu Enterprises*	PDS000025311.379	China
(Sept/Oct. 2023)	WV	Qilu Enterprises*	PDS000025311.379	China
5/16/24	CA	Enotan (4 samples)	PDS000024856.240	Japan
5/16/24	CA	Green Farm (4 samples)	PDS000025311.379	Taiwan
6/3/24	WV	More	PDS000187488.1	China
6/10/24	MD	K-Mush	PDS000024856.240	Korea
6/12/24	WV	Green Farm	PDS00052895.10 PDS000025311.379	Taiwan
8/14/24	MD	Global Fresh Marketing	PDS000199029.1	USA
8/28/24	MD	Global Fresh Marketing	PDS000199965.1	USA
9/9/24	WV	Green Farm	PDS000025311.379	Taiwan
9/18/24	MD	Global Fresh Marketing	PDS000025311.379	USA
10/29/24	WV	Enotan	PDS000025311.379	Japan

* Samples of Qilu brand enoki mushrooms were imported by a NY-based importer. Investigations were completed by New York State Department of Agriculture and Markets (NYSDAM)

Mushroom Growing Operation—As Observed by CalFERT

1. Substrate

- Imported from China
- Inoculated with growing enoki mycelium



2. Scraping

- Surface of soil is scraped off to allow mushroom growth



3. Growing

- Grown in humidity, temperature, and light controlled rooms in trays on shelves



4. Harvest

- After 5-7 days, mushrooms pulled from substrate and placed in RPCs



5. Packaging

- Product trimmed even and packed into plastic trays and sealed



6. Finished Product

- Lot code and Best By applied



WGS Tree Visualization

On-Site Investigation

After finding several LM positives in products grown by this company, CalFERT partners CDPH and CDFA conducted an investigation at Company A on 11/5/24. The team observed mushroom growing, harvesting, and packing activities (see photos) and collected samples for LM analysis. The team collected 52 environmental and 15 product samples. During this investigation, no significant concerns related to the growing operation were noted.

The CDPH Food and Drug Laboratory Branch (FDLB) analyzed the product and environmental samples for LM and detected LM in two of the environmental swabs. One of those was in the hallway in front of the growing rooms and the other was in the packaging room. Additionally, two samples (one from the floor of a growing room and one from the conveyor for the finished product sealer) were positive for non-pathogenic *L. grayi*. WGS analysis of the two LM positives indicated that the one from the floor drain in front of the growing room was also part of cluster PDS000025311.379. In fact, when analyzed using whole genome multilocus sequence typing (wgMLST), the sample was indistinguishable (0 SNP difference). These findings were communicated to Company A and they provided corrective actions including enhanced sanitation and retraining of employees. No product action was taken since the pathogenic findings were on zone 3, non-food contact, surfaces.

Summary and Conclusions

Due to the continued LM positives in products and apparent persistent strains, enoki mushrooms continue to be a product of concern. Regardless of where the product is grown, there is a pervasive issue with LM contamination. The WGS analysis indicates that there may be only a few strains that are present, regardless of country of origin. The largest cluster containing a majority of the product samples, PDS000025311.379, also contains environmental, product, and clinical samples from China, among other isolates (QR code above). The U.S. supplier obtains inoculated media from China, and there are other enoki samples in this cluster. This indicates there may be a common spawn supplier or some other commonality that has yet to be discovered.

Moving forward, inherent challenges in the wet, cool growing conditions are likely to continue contributing to contaminated products. Additionally, there is an expectation from Asian and U.S. producers that the product will be fully cooked in accordance with the labeling on the product packaging. However, in the United States, it is common for enoki mushrooms to be consumed raw or only lightly cooked. This disconnect between producer expectations and consumer practices, combined with the persistence of LM in the production environment, makes effective control of LM in this commodity especially difficult. CalFERT will continue to work with the U.S. grower, partner agencies, and importers to control this issue.

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