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# Food Safety Basics: Application to a Listeriosis Outbreak Linked to Caramel Apples

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## Overview of the Outbreak

Improperly prepared food can lead to the growth and survival of spoilage and pathogenic microorganisms. Spoilage microorganisms can affect food by causing undesirable changes in appearance, texture, taste, and smell. Pathogenic microorganisms, however, can cause foodborne illness in humans while also being undetected in food, as they do not cause physical changes in foods (like spoilage organisms do). Reducing the ability of pathogenic microorganisms to grow in the food is an important way to keep food safety risks low.

There are six primary growth factors that are considered first when assessing the capability of microorganisms to grow in a food product, abbreviated as "FATTOM" (Figure 1): food (nutrients), acid (pH), temperature, time, oxygen (atmosphere), and moisture (water activity). Understanding the properties of the food and the environment in which you are producing food can help identify the microorganisms of concern that producers should focus on minimizing the growth of.

If left uncontrolled, growth of pathogenic microorganisms in a food product can cause foodborne illness or outbreaks (where 2 or more individuals get sick by the same pathogenic microorganism). One example of this is the 2014 listeriosis outbreak linked to caramel apples. This was a multistate outbreak that occurred from October 2014 through January 2015. During this timeframe, 35 people across the U.S. became sick listeriosis (a foodborne illness caused by the pathogenic microorganisms *Listeria monocytogenes*; Figure 2). A traceback investigation found the pathogenic microorganism, *L. monocytogenes*, caused the illness is a specific packinghouse that packed whole apples, which were sold to producers that made the caramel apple product.

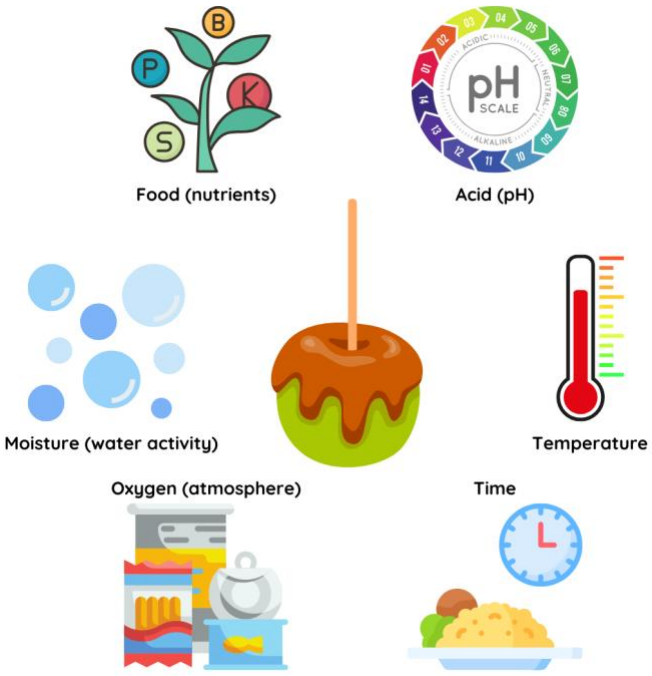


Figure 1. Visual representation of the six primary growth factors.

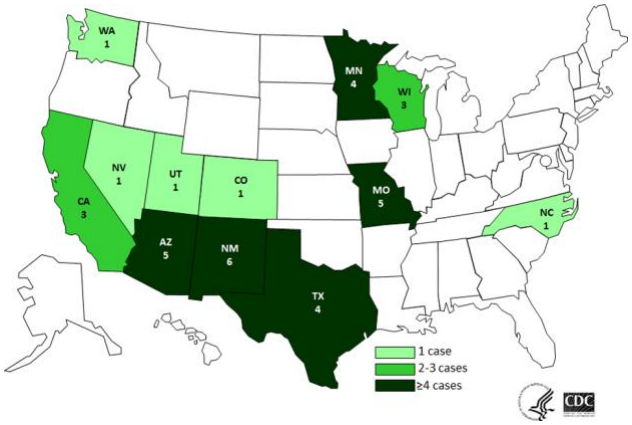


Figure 2. Case count map illustrating the locations of ill individuals across the United States from the U.S. Centers for Disease Control and Prevention (CDC).

# How Microbial Growth Factors Impacted the Outbreak

The 2014 listeriosis outbreak linked to caramel apples occurred because of uncontrolled growth of a pathogenic microorganism in a food product. This uncontrolled growth was able to happen because of the combined effects of mismanaged microbial growth factors.

## Food (Nutrients)

Caramel apples are typically made by washing and sanitizing the apple, inserting a stick through the stem bowl and into the core, dipping the apple in hot caramel, then cooling and packaging the product. When the stick was inserted into the apple, apple juice from the apple interior mixed with the caramel coating to provide free carbohydrates that *L. monocytogenes* was able to consume.

## Acidity (pH)

The pH of apple juice is typically less than 4.0, which can inhibit the growth of *L. monocytogenes*, but the pH was neutralized by the caramel sauce once the stick was inserted. The increase in pH resulted in the removal of acidity as a barrier to pathogen growth, which made a more favorable environment for *L. monocytogenes* to grow.

## Temperature

The caramel apple products were stored at room temperature (68-72°F), which was within the temperature range that *L. monocytogenes* can grow.

Additionally, the stem bowl area (Figure 3) protected *L. monocytogenes* from the typically lethal effect of the hot caramel sauce.

Figure 3. Apple stem bowl. This Photo by Unknown Author is licensed under CC BY-SA-NC.

## Time

The shelf-life of the caramel apple product was multiple weeks, which allowed *L. monocytogenes* time to grow. Combining the time at which the product was held and the temperature at which the product was held (room temperature) also increased the ability of *L. monocytogenes* to grow.

## Oxygen (Atmosphere)

*L. monocytogenes* is a facultative anaerobe, meaning it can grow well in environments with or without oxygen. The stem bowl area where the stick, caramel sauce, and apple juice intersected provided appropriate oxygen conditions for growth.

## Moisture (Water Activity)

When the stick was inserted, some of the apple juice inside the apple leaked into the space in between the stem bowl and the caramel coating. This caused increased water availability that *L. monocytogenes* could use to grow.

# Key Learnings

Controlling any one or more of the six primary growth factors discussed may limit the ability for pathogenic microorganisms to grow in food products or the environments in which they are produced, which may reduce the risk of a foodborne outbreak occurring in a food product.

Some examples of ways the six primary growth factors could have been controlled to prevent pathogenic microorganism growth in a caramel apple product include:

- Time and temperature control: store stem-in caramel apples in the refrigerator to slow the growth of pathogenic microorganisms and consume within four days.
- Time control: wait to insert the stick into the caramel apple until right before consumption.
- Temperature and moisture control: partially dip stick-in apples so that the caramel sauce is not present near the stick insertion point.

There are many ways to reduce the food safety risks associated with the production and processing of a food product. While there are other factors that can impact the growth of microorganisms in food (such as through proper cleaning and sanitizing or antimicrobial substances), keeping in mind the principles of FATTOM are one way to identify realistic, actionable steps that could be used to reduce food safety risks.

# References


Angelo, K.M., A.R. Conrad, A. Saupe, *et al.* 2017. Multistate outbreak of *Listeria monocytogenes* infections linked to whole apples used in commercially produced, prepackaged caramel apples: United States, 2014-2015. *Epidemiology and Infection* 145(5), 848-856. https://doi.org/10.1017/S0950268816003083

Boyer, R.R. 2001. How do you know if your food is safe to sell? Virginia Cooperative Extension. http://hdl.handle.net/10919/50788

Glass, K.A., M.C. Golden, B.J. Wanless, *et al.* 2015. Growth of *Listeria monocytogenes* within a Caramel-Coated Apple Microenvironment. *mBio* 6(5). https://doi.org/10.1128/mbio.01232-15

Linton, R. 1996. Food Safety Hazards in Foodservice and Food Retail Establishments. Purdue Cooperative Extension FS-2. https://www.extension.purdue.edu/extmedia/FS/FS-2.pdf

National Research Council (US) Subcommittee on Microbiological Criteria. 1985. An Evaluation of the Role of Microbiological Criteria for Foods and Food Ingredients. Washington (DC): National Academies Press (US); 1, Introduction. https://www.ncbi.nlm.nih.gov/books/NBK216688/

U.S. Centers for Disease Control and Prevention (CDC). 2015. 2014 Outbreak of Listeria Infections Linked to Commercially Produced, Prepackaged Caramel Apples Made from Bidart Bros. Apples. https://archive.cdc.gov/www_cdc_gov/listeria/outbreaks/caramel-apples-12-14/index.html

Ward, S., Bedale, W., & Glass, K. A. 2022. *Listeria monocytogenes* Outbreaks Related to Commercially Produced Caramel Apples: Developments in Sanitation, Product Formulation, and Packaging: A Review. *Journal of Food Protection*, 85(9), 1287–1299. https://doi.org/10.4315/jfp-22-069



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2025 FST-504NP