

Fruit Jam Safety Explained: Microbial Risks and Polyphenol Benefits for Processors

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Introduction

Fruit jams are made from crushed fruits with the addition of sugar, acid, and sometimes pectin. These ingredients determine the safety and stability of jams. Acid lowers the pH of the jam, which slows microbial growth. Pectin, a complex starch, helps jam maintain its thick texture without separating. Because fruits have a wide range of pH and pectin content, different fruits may require varying amounts of acid and pectin to be added to the recipe to produce a safe jam that does not separate (Figure 1).

Low pH & High Pectin 	Low pH & Low Pectin 
High pH & High Pectin 	High pH & Low Pectin 

Figure 1: Fruits grouped by their pectin and acidity levels (Source: Molly Caron, Department of Food Science and Technology, Virginia Tech).

Fruits are cooked down with sugar, pectin, and acid to release the juices and develop a thick texture. A shelf-stable jam is one that can safely be stored at room temperature.

Health Benefits of Fruit Jams

Raw fruits contain many beneficial nutrients, including minerals, vitamins, fiber, and polyphenols. Berries, specifically, are an excellent fruit to make jams with due to their beneficial nutrients, low pH, and high polyphenol content.

Polyphenols are phytochemicals that have been shown to offer numerous health benefits, including reducing inflammation and enhancing heart and brain health (X et al., 2022). After being processed into a jam, many of these health benefits are likely to remain (De Moura et al. 2012).

Anthocyanins, the polyphenol found in the highest amounts in berries, are responsible for their bright red and purple colors. Anthocyanins have also been shown to possess antimicrobial properties (Cisowska et al., 2011), which could contribute to making a safer jam by inhibiting foodborne pathogens.

Factors that Impact Pathogen Growth in Jams

Foodborne pathogens are microorganisms that can make people sick after consumption, so it is crucial to ensure that the food product and the environment in which it is produced can prevent those microorganisms from growing. Six primary factors can impact whether a pathogen will grow in a food product.

Food

This component includes the amount of nutrients in a product that are available for pathogens to use to grow. Pathogens prefer a high-carbohydrate environment. Fruit jams often contain many carbohydrates in the form of fruit sugars that can impact nutrient availability for pathogens.

Acidity

Most pathogens grow well in environments with low acidity (high pH). Generally, lowering the pH of a product below 4.6 can prevent microbial growth. The types of fruit used in a jam (Figure 1) can raise or lower the pH of the final jam. Additional acids or acid ingredients may be used to acidify the jam (lower the pH below 4.6).

Time

Pathogens need time to reproduce (grow). Examples of “time” with food products include time for preparation (preparation time), time to make the food (processing time), time the food is held/served at a particular temperature (holding time), and time in storage (storage time or shelf-life). The preparation method and how long its unopened shelf-life are both related to this component.

Temperature

Foodborne pathogens grow best at human body temperature (98.6°F) or in the range of 41-140°F, which is how they can make humans sick. Because these organisms can multiply in this range, it is referred to as the Temperature Danger Zone. Fruit jams stored in the refrigerator are outside of this range.

Oxygen

Some pathogens require oxygen to grow (obligate aerobes), while others cannot survive in the presence of oxygen (obligate anaerobes). Most foodborne pathogens can grow with or without oxygen (facultative anaerobes). The type of packaging you use will impact the availability of oxygen to pathogens. Properly processed fruit jams result in an anaerobic environment.

Moisture

Pathogens require water to grow. The more available water (water activity) in a product that pathogens

can use, the easier it is for pathogens to grow. The thickening process used in jam production can reduce water activity below what foodborne pathogens can use to grow.

Generally, the more factors that are controlled to prevent pathogen growth, the safer a food product is considered to be. Every pathogen has different conditions under which it can grow quickly; therefore, it is essential to identify the pathogens that are at risk of being present in the product (Table 1).

Canning Risk Factors

The microorganism that poses the greatest health concern in canned goods is *Clostridium botulinum*, also known as *C. bot.* *C. bot* produces a neurotoxin that causes botulism (USDA FSIS, n.d.). This microorganism can only grow in oxygen-free (anaerobic) environments, which is why it is a threat to canned goods.

This toxin is also flavorless and scentless, so it can go undetected. To kill the pathogen that makes the toxin, the temperature needs to reach 240-250°F, so a pressure cooker (retort) is required to achieve those temperatures. The spore produced by the pathogen cannot germinate at a pH < 4.6, so the pathogen cannot grow and produce a toxin in those types of products (such as some fruit jams). This is why high-acid (low pH) foods can be canned at a lower temperature and still achieve a safe, shelf-stable product. It is recommended to discard any canned goods with dents or imperfections, as they may have been (or could become) contaminated (Sunarti, 2024).

Pathogenic *Escherichia coli*, *Listeria monocytogenes*, and *Salmonella enterica* can also pose a risk of being present in canned goods. However, these microbes are inactivated or killed at lower temperatures than those commonly used in canning activities (Table 1).

Proper Processing Techniques for Jam Manufacturers

In addition to the acid component and thickening (water activity reduction) provided by pectin, heat processing can further remove water (through evaporation) and produce an oxygen-free

(anaerobic) environment to prolong the product's shelf-life. However, some foodborne pathogens, *C. bot*, can grow well in oxygen-free environments when the pH is above 4.6. At a pH below 4.6, the spores produced by *C. bot* cannot germinate, which means the pathogen cannot grow and produce the toxin that makes humans sick. However, heat is still required to kill any vegetative cells.

Properly processing a jam can kill *C. bot* and prevent its spores from germinating, but it requires a precise combination of time and temperature control during processing. Common methods used in large-scale jam production include two in-container processing methods: the hot-fill-hold method and the pressure canning procedure.

Table 1. Common canning microbes and the temperatures at which they are killed.

Pathogen	Killed At (°F)	Notes
<i>E. coli</i> (Barlaam et al. 2019)	≥ 158°F (70°C)	Common contaminant, especially in produce
<i>Listeria</i> (Kathariou 2002)	≥ 165°F (74°C)	Can grow at refrigeration temperatures
<i>Salmonella</i> (Ehuwa et al. 2021)	≥ 158°F (70°C)	May be a contaminant in some fruit ingredients
<i>C. botulinum</i> USDA FSIS, n.d.)	≥ 250°F (121°C)	Requires pressure canning for low-acid foods, but can be controlled with lower temperature/higher acid products

Hot-Fill-Hold

This process consists of filling a jar with the hot product, securely tightening the lid, and inverting it for a predetermined amount of time to sterilize the interior of the jar. As the product cools, a vacuum forms, which aids in the development and maintenance of a hermetic (airtight) seal. This prevents the product from leaking out of the container and contaminants from entering the container after processing.

Pressure Canning

This process involves filling a jar with the product, securely tightening the lid, and placing it in a

pressure cooker (retort) to raise the boiling point of water above its standard boiling point (212°F). This allows the product to be heated at a higher temperature, killing vegetative pathogens and their spores. This technique must be used on low-acid foods, but it is not commonly used with fruit jams, which naturally have a lower pH.

Who Should I Contact If I Have Questions?

Please reach out to the following authors if you have questions regarding any of the following topics addressed in this fact sheet:

- Polyphenols and health benefits of fruit jams: Dr. Dennis Cladis (dcladis@vt.edu)
- Ingredients in fruit jams for proper preservation (and acid and acidified foods): Melissa Wright (foodbiz@vt.edu)
- Factors that impact microbial growth and canning risk factors: Dr. Alexis Hamilton (ahamilton@vt.edu)

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