Food scientists develop framework to improve food quality and still kill pathogens

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Arshpreet Khattra was the lead author of a study that developed a framework for food processors to preserve quality and maintain food safety. Credit: University of Arkansas System Division of Agriculture

Sometimes the processing that makes food safe can compromise flavor and nutrients, but food scientist Jennifer Acuff is looking for a way to make food safe and minimize loss of quality.

Food processors often use heat for pasteurization or sterilization to make food products safe by killing pathogens like salmonella and listeria, but high temperatures can degrade food quality. To ensure food safety, the industry sometimes relies on overly stringent standards that unnecessarily reduce food quality, said Jennifer Acuff, assistant professor of food microbiology and safety for the Arkansas Agricultural Experiment Station, the research arm of the University of Arkansas System Division of Agriculture.

Focusing on low-moisture food products like powdered milk, Acuff and her team performed a study seeking a method that guarantees food safety while retaining the most vitamins, minerals and flavor depending on the food.

"This collaborative approach encompassed microbiology, engineering, and statistics to provide the food industry with what we believe will be a tool to improve safety without compromising quality of their dried food products," Acuff said.

The process is not limited to low-moisture foods and may extend to other foods and processes, Acuff added.

Using data from a study on a harmless "surrogate" microorganism and a statistical technique called "bootstrapping," the researchers developed a framework to provide food processors options within U.S. Food and Drug Administration guidelines.

"We have proposed a methodology to pick a value between the most liberal and most conservative food processing approaches based on risk tolerances," said Jeyam Subbiah, head of the food science department. "The industry can use this methodology to pick a value and petition the FDA for approval."

While there is no specific FDA rule, the government currently asks the food processing industry to make a petition for a case-by-case review.

The study, "Bootstrapping for Estimating the Conservative Kill Ratio of the Surrogate to the Pathogen for Use in Thermal Process Validation at the Industrial Scale," was published online by the *Journal of Food Production* in March.

"Surrogates are like dummies used in crash testing to validate car safety," Subbiah said. "They are non-pathogenic microorganisms, which should have similar or higher heat resistance than the actual pathogen. Often, they are a lot more resistant."

Scientists use a "log cycle reduction," or LCR for short, to calculate how effectively a process kills harmful microorganisms. "Log" refers to the logarithm scale, and 1-log represents a 10-fold reduction equivalent to a 90% reduction in bacteria. A 2-log reduction would be a 99% reduction, 3-log 99.9%, and so on. A 6-log reduction is a 99.9999% reduction.

When surrogate microorganisms are used for food safety challenge studies for sterilization of canned foods, the Institute of Food Thermal Processing Specialists recommends a "simple mean," or average, kill ratio to validate food safety at an industrial scale. For example, Subbiah said if sterilization called for a "12-log" reduction of the pathogen and the surrogate was twice as resistant, a processor could show a "6-log" kill of the surrogate, and the FDA would accept it as equivalent.

However, the drawback of that method is that it does not consider the variability of microorganisms, both the pathogen and the surrogate, Subbiah noted.

Although less prone to foodborne pathogens than fresh meats and dairy, low-moisture foods are not immune. Various types of salmonella have been implicated in 15 deaths, thousands of illnesses, and hundreds of hospitalizations over the past 20 years due to infected low-moisture foods like dried fruits and vegetables, nuts, herbs, flour and spices.

After those food safety outbreaks, the food industry "swung to the conservative mode" in food safety challenge studies, Subbiah said, by requiring the same level of log reduction of the surrogate.

For example, if sterilization of spices calls for a 12-log reduction of salmonella, the industry would show a 12-log reduction of the surrogate even though it can be twice as resistant as the pathogen. While this assures a high level of food safety, nutrients may be degraded due to severe thermal processing, Subbiah explained.

Calculating the risk

As a food science graduate student in the Dale Bumpers College of Agricultural, Food and Life Sciences, Arshpreet Khattra used previously published data from Subbiah's lab involving the surrogate Enterococcus faecium to develop a solution for preserving quality in thermal processing. She applied the bootstrapping technique to estimate the distribution of kill ratio in milk powders rather than calculate the "simple mean," or average, kill ratio.

With bootstrapping, scientists can deal with uncertainty in experimental data by generating many samples instead of assuming a specific distribution. The technique calls for randomly picked data points from the original data to give researchers a good idea of how much the results may vary due to chance. It has been used in various studies to improve food processing methods and assess the food safety risks of different microbes in various foods.

From the estimate of kill ratio distribution, the final kill ratio can be calculated on a sliding scale of risk, Subbiah noted. In a hypothetical example, to have a 1% risk level, a processor may want a 9-log reduction of the surrogate, which is a 99.9999999% reduction. A 5% risk level would call for an 8-log reduction, and a 10% risk would call for a 6.5-log decrease of the surrogate to be equivalent to a 12-log reduction of the pathogen. A 12-log reduction is typically called sterilization and a 4- to 5-log reduction qualifies as pasteurization.

This method strikes a balance between killing harmful bacteria and preserving quality, Subbiah said.

More information: Arshpreet Kaur Khattra et al, Bootstrapping for Estimating the Conservative Kill Ratio of the Surrogate to the Pathogen for Use in Thermal Process Validation at the Industrial Scale, *Journal of Food Protection* (2024). DOI: 10.1016/j.jfp.2024.100264

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