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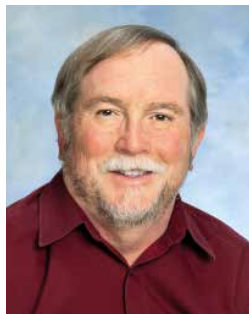
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From The Editors

Thank a Mentor

I used to keep a sign on my desk that read, “The sign of a good boss is that he/she hires people smarter than they are.” One can look at this in different ways, but I like to think of that boss as not being afraid to hire bright, dedicated people who are interested in growing. Having a bright team makes life easier, as the boss should be able to delegate responsibilities, which makes operations more efficient. This also has the potential benefit of boosting staff confidence and putting them in a position where they might think, “The boss has placed his confidence in me, so I don’t want to let him/her down.”



Managers with this attitude also tend to be great mentors. Sit back and think about your life. I’ll wager that you can identify several people who helped your career path and/or helped you grow as a person and as a professional. I can look back and pick several persons who fit that bill, including two very supportive parents. In fact, my mother, Dr. Elizabeth Stier, has a major award offered through the IFT in her name—the only award named after a woman. I can pick people from Rutgers: Roy Morse and Mike Solberg. They focused on teaching problem solving, as opposed to regurgitating every little fact related to an issue. When I was a graduate student at UC Davis, my advisor, Dr. George York, actually sent me out into the field to help processors in need of help. It was sink or swim, and I managed to swim.

But the greatest mentors for me were those from the National Canners Association, later the National Food Processors Association, a trade association that represented the food canning and processing industry. I joined the microbiology section, headed up by Keith Ito, whom I am proud to claim as a friend and mentor. Keith allowed his people to work up to their abilities. It was a real pleasure to watch Keith work with, listen to, and advise people. He had a unique ability to lead the discussion so that by the end of a meeting, the client felt that they themselves had figured things out. Keith would smile and say, “Let me know if you have questions.”

If you have people in your lives who are mentors, consider yourselves fortunate. We at *Food Quality & Safety* hope that you may find one or two pieces in each issue that are added to your reference files. We may not be mentors, but we hope we are a good source.

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NEWS & NOTES

Researchers Discover Five New Species of *Listeria*

While examining the prevalence of *Listeria* in agricultural soil throughout the U.S., scientists at Cornell University in New York City have stumbled upon five previously unknown relatives of the bacteria. The discovery, researchers say, will help food facilities identify potential growth niches that, until now, may have been overlooked, which could improve food safety.

The research was published May 17, 2021 in the *International Journal of Systematic and Evolutionary Microbiology*.

“This research increases the set of *Listeria* species monitored in food production environments,” says lead author Catharine R. Carlin, a doctoral student in food science. “Expanding the knowledge base to understand the diversity of *Listeria* will save the commercial food world confusion and errors, as well as prevent contamination, explain false positives, and thwart foodborne outbreaks.”



One of the novel species, *L. immobilis*, lacked motility. Motility has previously been thought to be common among *Listeria* closely related to *L. monocytogenes* and used as a key test in detection methods. This discovery effectively calls for a rewrite of the standard identification protocols issued by food safety regulators, Carlin says.

As *Listeria* species are often found co-existing in environments that support the growth of *L. monocytogenes*, food facilities will monitor for all *Listeria* species to verify their sanitation practices.

L. monocytogenes can have profound pathogenic influence on food processing plants and those plants must be kept clean.

Listeriosis has a mortality rate of 20% to 30%, even for patients taking antibiotics, according to FDA. The Centers for Disease Control and Prevention estimate that 1,600 people in the U.S. acquire listeriosis annually, and nearly 260 die.

“This paper describes some unique characteristics of *Listeria* species that are closely related to *L. monocytogenes*, which will be important from an evolutionary perspective and from a practical standpoint for the food industry,” says co-author Martin Wiedmann, PhD, a professor in food safety and food science. “Likely, some tests will need to be re-evaluated.”

Understanding the different *Listeria* species is key to comprehending their similarities. “This will help us to get better about identifying *L. monocytogenes*,” Dr. Wiedmann says, “and not misidentifying it as something else.”

Since 2010, Dr. Wiedmann’s research group has discovered 13 of the 26 species classified in the genus *Listeria*. “When you’re inspecting the environments of food processing plants or restaurants, you need to know the pathogenic *Listeria* from the non-pathogenic species,” he says. “You need to tell the good guys from the bad guys.”

Group Launches Food Safety Standard for Indoor-Grown Leafy Greens

The CEA Food Safety Coalition (FSC), a group composed of leaders in the controlled environment agriculture (CEA) industry, has announced the first-ever food safety certification program specifically for CEA-grown leafy greens.

Members of the coalition can now choose to be assessed for the CEA Leafy Greens Module and, upon successful completion, will be allowed to use the CEA food-safe seal on certified product packaging. The module is measured against science-based criteria and is an add-on to existing compliance with an underlying Global Food Safety Initiative (GFSI)-recognized food safety standard.

“Current food safety standards were written for the field, and many do not ad-

dress the unique attributes of controlled, indoor environments,” says Marni Karlin, executive director of the coalition. “This new certification process and the accompanying on-pack seal help to unify CEA growers while also differentiating them from traditional field agriculture.”

CEA takes a technology-based approach to produce optimal growing conditions inside controlled environments such as greenhouses and indoor vertical farms. Plants are typically grown year-round using hydroponic, aeroponic, or aquaponic methods, without the need for pesticides and unaffected by climate or weather.

“The CEA industry is rapidly expanding and predicted to support more than 10% of U.S. vegetable and herb production by 2025,” says Rebecca Anderson, technical key account manager for GLOBALG.A.P. North America. “The CEA FSC Leafy Green Module will set a new industry standard for CEA-grown produce while driving consumer awareness of the innovations happening in indoor agriculture today.”

The certification program is available to all coalition members for a nominal cost and must be completed on an annual basis. CEA growers can be assessed at multiple sites across four key areas:

- **Hazard analysis:** use of water, nutrients, growing media, seeds, inputs, site control and other relevant factors.
- **Water:** all contact with the plant and with food contact surfaces. The use of recirculating water will require a continuing hazard analysis. Will also require zone-based environmental monitoring based on company-specific risk assessment.



- **Site control/infrastructure system design:** all food contact surfaces and adjacent food contact surfaces, including plant containers; will also assess associated farm physical hazards, including lighting, robotics, sensors, equipment, and utensils.

- **Pesticide use/testing:** the use of pesticides or herbicides during the plant life cycle.

The coalition was founded in 2019 to represent the interests of CEA leafy greens growers in developing credible and appropriate food safety standards while educating consumers and regulators alike on the value of controlled environment agriculture.

Irrigation Water Likely Cause of 2020 *Salmonella* Outbreak in Red Onions

In May 2021, FDA released a report on its investigation of the *Salmonella* Newport outbreak that caused more than 1,600 reported illnesses in the U.S. and Canada between June and October 2020. The agency worked with the U.S. Centers for Disease Control and Prevention, state partners, and Canadian officials (the Public Health Agency of Canada and the Canadian Food Inspection Agency) to investigate the outbreak, which was linked through epidemiology and traceback to whole red onions supplied by Thomson International, Inc., headquartered in Bakersfield, Calif., with an additional location in Holtville, Calif.

The outbreak is the largest *Salmonella* foodborne illness outbreak in more than a decade. The FDA report includes an overview of the traceback investigation, subsequent on-site interviews, visual observations of the growing fields, environmental sampling, and various factors that potentially contributed to the contamination.

The report identified several potential contributing factors to the outbreak in red onions:

- Potentially contaminated sources of irrigation water;
- Sheep grazing on adjacent land;
- Signs of animal intrusion, including scat (fecal droppings), and large flocks of birds that may spread contamination; and
- Food contact surfaces that had not been inspected, maintained, or cleaned as frequently as necessary to protect against the contamination of produce.

In sampling conducted in Holtville, FDA found *Salmonella* Newport in 10 water (irri-



gation, seepage, and drainage) subsamples and in one sediment subsample; however, the whole genome sequencing of these samples did not match the outbreak strain.

Although a conclusive root cause could not be identified, one leading hypothesis is that contaminated irrigation water used in a growing field in Holtville may have led to contamination of the onions.

Thomson International, Inc. cooperated with FDA throughout the investigation and is continuing to engage with the agency regarding its findings and recommendations.

Study: Many Consumers Confused about Food Date Labels

BY KEITH LORIA

Although most consumers rely on “Best If Used By” and “Use By” notations on date labels to make decisions about food, believing they know what these phrases mean, new research shows that consumers commonly misunderstand this system. A new study published in the *Journal of Nutrition Education and Behavior*, examined consumer understanding of the U.S. food industry’s labeling system and the relative effectiveness of messages in increasing understanding.

“The majority of people use date labels to make decisions about food,” says Catherine Turvey, MPH, a public health specialist in the department of exercise and nutrition sciences at the Milken Institute School of Public Health at The George Washington University in Washington, D.C., and lead author of the study. “Misunderstanding food date labels is a problem because it can lead people to eat food that is no longer safe or waste food that is still good to eat. Reducing confusion around food date labeling is an important strategy for reducing waste of food.”

Americans throw out about a third of all food purchased, representing more than \$161 billion in wasted food each year, she says.

The study polled 2,607 U.S. adults, and 64% correctly explained what the “Best If Used By” label meant, while just 44.8%

were able to describe what the “Use By” label meant. It’s easy to understand why these labels are confusing. The “Use By” date indicates when a food item may no longer be safe to consume. According to USDA, you shouldn’t eat, cook or freeze any items if this date has passed. The “Best If Used By” date is when the food will be at its optimum flavor and/or quality. USDA notes that this isn’t a “must purchase by” date, but merely a suggestion of when you should eat it. If a food looks and smells fresh a few days after this date, it’s still safe to consume.

“Educational messages are needed to improve understanding of the food industry’s date labeling system,” Turvey adds. “The messages we tested significantly improved understanding, but even after reading an educational message, misunder-



standing was still common. The familiarity of food date labels and consumers’ overconfidence in their own understanding of the labels may be a barrier to reaching consumers with educational messaging about what the labels mean.”

Once the researchers provided a brief explanation on what the two food label terms meant, the level of understanding increased, with 82% of participants describing “Best If Used By” correctly and 82.4% explaining the “Use By” label correctly.

The researchers believe that standardizing labels and reducing the variety of labels on products could help lower confusion. “The food industry took an important step by creating a voluntary standardized system with just two labels,” Turvey says. “As this system becomes more widely adopted, engaging educational messaging is needed to help people realize they may misunderstand date labels and teach them the label meanings.”

FDA has recently championed the conversion to just the “Best If Used By” label in an effort to standardize labeling and help to reduce food waste, but the agency hasn’t yet mandated any specific language.

Washington Report



The Challenge with Leafy Greens

FDA issues a report on recurring *E. coli* outbreaks and calls for more collaboration among growers, government, and academia to mitigate the problem

BY KAREN APPOLD

E. *coli* outbreaks linked to leafy greens grown in the California Central Coastal region have plagued the area since 2017, despite efforts to stop them. The most recent outbreak, in the fall of 2020, prompted an FDA investigation; the agency published its findings in April 2021.

The investigation found that samples collected in response to leafy greens outbreaks in 2019 and 2020 contained the same strain of Shiga toxin-producing *E. coli* (STEC) O157:H7. In light of this finding, FDA analyzed trends across outbreaks that had occurred each fall since 2017 and found three key trends in the contamination of leafy greens by *E. coli* O157:H7 in recent

years: a reoccurring strain, a reoccurring region, and reoccurring concerns with the potential impacts of adjacent lands.

According to Jim Gorny, PhD, senior science advisor for produce safety at FDA's Center for Food Safety and Applied Nutrition in College Park, Md., the reoccurring pathogenic *E. coli* strain appears to be a reasonably foreseeable hazard, specifically in the South Monterey County area of the Salinas Valley and Santa Maria Valley growing regions.

FDA's report recommended that agricultural communities in the affected areas work to identify where the reoccurring strain of pathogenic *E. coli* is persisting in the environment and the likely routes of

lettuce contamination with the strains of STEC. Furthermore, FDA encouraged producers in the Central Coast of California growing region to participate in the California Longitudinal Study, an initiative launched in November 2020 to improve food safety after continued *E. coli* outbreaks, and in a locally led, locally convened workgroup organized by the California Department of Food and Agriculture and the Monterey County Farm Bureau to identify what actions can be taken to reduce contamination.

When pathogens are identified through microbiological surveys or pre-harvest or post-harvest testing, FDA recommends that growers implement industry-led root cause analyses to determine how the contamination likely occurred and then implement appropriate prevention and verification measures, Dr. Gorny says.

Another Step: Updating the Leafy Greens Action Plan

In addition to its investigation, FDA has updated its Leafy Greens STEC Action Plan (LGAP), originally released in 2020, for 2021. The new plan includes steps the agency will take in collaboration with leafy green stakeholders to advance lettuce safety.

The update is informed by work and knowledge gained over the past year. "New actions have been added based on information collected and lessons learned, including those from the 2020 investigative report," Dr. Gorny says. "The updated plan includes a renewed emphasis on actions to prevent contamination stemming from activities on adjacent land, announces new actions that build on the accomplishments and learnings from the 2020 plan, and renews FDA's commitment to complete certain actions that were difficult to accomplish in 2020 due to challenges presented by the COVID-19 pandemic."

In commenting on the updated LGAP, Ben Miller, MPH, PhD, senior director of scientific and regulatory affairs at The

Acheson Group, a global food safety consulting group based in Bigfork, Mont., says, “These approaches have been updated for 2021 to better understand how STEC can move from the surrounding environment and contaminate produce grown in California and Arizona. Based on investigations in 2019 and 2020, addressing risks from nearby cattle operations form the basis of many updates in the 2021 plan.”

The updated LGAP includes 33 specific action items.

A Closer Look at LGAP

The updated LGAP emphasizes three components:

- Enhancing prevention strategies;
- Improving response activities by FDA and other entities; and
- Identifying and addressing knowledge gaps that exist around STEC contamination of leafy greens.

Regarding prevention strategies, Dr. Miller says the new approaches are largely focused on irrigation water and adjacent land use; however, the close proximity of cattle to these growing areas and unknown routes of contamination from the environment to leafy greens makes developing and validating effective mitigation and control measures difficult.

Ensuring that outbreak response activities are conducted as quickly and thoroughly as possible is essential for preventing illnesses, Dr. Gorny says. In addition, it is critical that FDA and stakeholders share lessons learned to inform future prevention efforts.

“Much of the 2021 focus is on improving information sharing between FDA and the industry and improving the rapidity and accuracy of traceback investigations,” Dr. Miller says. “Sharing learnings from past outbreaks can help the FDA and industry better understand potential sources of contamination. Traceback investigations have demonstrated their usefulness in helping determine the cause of outbreaks and point investigators to suspect growing fields to narrow the scope of field investigations and sampling. Improving traceability can also limit the impact and scope of consumer advisories when the next outbreak occurs if the source of an outbreak can be quickly identified.”

While FDA and stakeholders have greatly expanded what is known about

leafy greens safety, knowledge gaps still exist, which can be explored in new ways through the use of emerging technologies, Dr. Gorny says. Addressing these knowledge gaps is critical to advancing future prevention activities.

It’s also important to recognize that these are not siloed areas of focus, but rather numerous points of intersection and mutual reinforcement, Dr. Gorny adds.

Each of these three approaches acknowledges a current lack of data or consensus in a particular area. “By collecting more data, FDA hopes to create a more objective assessment of contributing risk factors and preventive measures for leafy greens grown in the Yuma and Salinas regions,” Dr. Miller says.

Outlook

FDA and the leafy greens industry have been working to reduce *E. coli* contamination in leafy greens since 2006. “A lot of progress has been made and, while the risk is less today than it was in 2006, the ongoing outbreaks show that risks still exist,” says David Acheson, MD, CEO, and president of The Acheson Group.

Obviously, the problem has not been resolved despite the California Leafy Greens Marketing Agreement, a program implemented in 2007 to ensure safe leafy greens and a much greater use of testing than in the past, Dr. Acheson says. “Part of the problem links back to gaining a better understanding of the root cause, for example, the movement of *E. coli* in dust and driven by the wind—which is hard to control,” he says.

Dr. Acheson says situations still exist in which growers are not fully leveraging what is known around risk: Some still grow lettuce at the bottom of a hill on which cattle are grazing. While there are many more controls in place today, along with regulatory requirements in the form of the FSMA Final Rule on Produce Safety, the risks remain and the ultimate controls are elusive. “As long as both live animals and leafy greens are raised in the same broader environment, this problem is not likely to totally go away,” he says.

Mitigating the Issue

In order to resolve the issue of *E. coli* contaminating leafy greens, Dr. Miller

says it’s important to understand how STEC from the environment makes its way onto leafy greens. “Monitoring and treating irrigation water is common sense and an achievable control compared to controlling by windborne contamination,” he says. “Seasonal climate patterns may contribute to windborne contamination in the Salinas Valley; more research is needed in this area to understand the role that weather, climate, and cattle proximity play in field-level contamination.”

A root cause analysis will seek to eliminate the hazard at its source, as cattle are a known and well-documented reservoir for STEC, Dr. Miller says. Cattle vaccines against *E. coli* O157:H7 are commercially available, although their uptake has been limited. Cattle may not be the only source of environmental STEC where lettuce is grown, although FDA investigations in 2019 and 2020 identified the outbreak strain in cattle feces surrounding growing fields identified in traceback investigations.

While more research is needed to understand how STEC moves from cattle to leafy greens, testing technology can also play a role in detecting contamination events. “With COVID-19, we’ve seen that rapid testing platforms can be quickly developed and in-line harvesting sampling with rapid turnaround times could allow the industry to more quickly detect field-level contamination at harvest time,” Dr. Miller says.

“If we continue to see outbreaks associated with animal agricultural operations, policy makers may decide that additional regulations on this industry are needed to help manage these risks through prioritizing land use or other regulatory changes,” Dr. Miller adds. “Produce growers are growing a ready-to-eat food product outdoors, and there are probably limits on what they can independently do to detect and prevent sporadic contamination events that may still lead to an outbreak. Success in reducing these risks will require multiple stakeholders to come together and identify how they can minimize the risk of STEC in the environment in these growing regions.” ■

Appold is a writer in Lehigh Valley, Pa. Reach her at kappold@msn.com.

Legal Update



In Search of the Meaning of “Milk”

The courts and legislators debate whether the term can be applied to plant-based products

BY JOEL S. CHAPPELLE, ESQ., AND SHAWN K. STEVENS, ESQ.

Attempts to legislatively constrain the English language are rarely successful. There are many reasons for this, both legal and practical. Yet, the appetite for such efforts, especially in the food industry, seems to be all but insatiable. This article explores ongoing attempts to constrain the use of the term “milk,” and the legal battles being waged in furtherance of that pursuit.

The online Merriam Webster dictionary offers several definitions of “milk.” The first is “an opaque white fluid rich in fat and protein, secreted by female mammals for the nourishment of their young.” Another is to exploit or defraud someone. FDA’s standard of identity for milk provides that “milk is the lacteal secretion, practically free from colostrum, obtained

by the complete milking of one or more healthy cows.” The FDA’s standard of identity of course excludes the milk from goats and other mammals. One final definition from Merriam Webster is “a liquid resembling milk in appearance, such as the latex of a plant or the contents of an unripe kernel of grain.”

In recent years, significant acrimony has arisen over which types of products may be called “milk.” Throughout the country, laws are being enacted and battles are being waged—both in the court of public opinion and the actual courts—over what types of products may be called milk. The increasing popularity of plant-based milk alternatives is largely attributable to shifting views about the health benefits of cow’s milk and the moral implications of animal agriculture, which include con-

cerns about animal welfare, environmental impacts, and perceptions about the nutritional value of plant-based products.

In response to the explosive growth of plant-based dairy alternatives, i.e., almond milk and oat milk, the dairy industry has vociferously argued that using the term “milk” in the names of these products should be prohibited. According to the National Milk Producers Federation, “Dairy farmers take great pride in their high-quality, nutritious dairy products and have spent many decades building consumer confidence in them. Imitations should not be allowed to unfairly capitalize on these associations, especially in ways that encourage inadequate nutrition and consumer confusion.” The organization further advocates for efforts to end the “continued proliferation and marketing of mislabeled non-dairy substitutes for standardized dairy foods misrepresented as ‘milk,’ ‘cheese,’ ‘butter,’ ‘yogurt,’ ‘ice cream,’ or other dairy foods.”

Conversely, the Good Food Institute (GFI), an organization that advocates on behalf of plant-based products, contends that consumers are not fooled by plant-based dairy alternatives. The GFI asserts itself as a proponent of protecting plant-based companies’ first amendment rights to label their products using words that consumers understand. Echoing recent court holdings, GFI argues that no reasonable consumers are misled by the term “almond milk,” which any consumer instantly understands is not cow’s milk.

Legislation and Regulation

Politically, the campaign for and against plant-based dairy alternatives has been bipartisan. In April 2021, U.S. Senator Tammy Baldwin (D-Wisc.), who is the chair of the Senate Agriculture Appropriations Subcommittee, and U.S. Senator Jim Risch (R-Idaho) reintroduced the Dairy Pride Act, a piece of federal legislation that seeks to force FDA to take punitive measures against food producers that use dairy terms, such as “milk,” “cheese,” and “yogurt,” to describe plant-based dairy alternatives. The act previously stalled in the legislature, and it is unclear whether it will pass this time around.

From a regulatory standpoint, the debate hinges on whether these products are misleading or misbranded. The Food,

Drug, and Cosmetic Act (FDCA) prohibits the introduction or delivery into interstate commerce of any misbranded foods. A food is misbranded if it violates any of the voluminous and arguably arcane labeling regulations intended to prevent manufacturers from misleading consumers about the make-up or nutritional value of foods. Under these regulations, a food is misbranded “if it purports to be or is represented as a food for which a definition and standard of identity has been prescribed by regulations.”

FDA has historically posited that the standard of identity for “milk” only applies to the use of the unqualified term. As such, if a producer of almond milk simply labeled their product as “milk,” it would be mislabeled. Indeed, when the regulation establishing the identity standard for “milk,” was promulgated, FDA stated the standard would not preclude the use of the term “milk” for qualified products like chocolate milk. By way of comparison, there are other similarly situated foods, such as corn bread and rice noodles, which are not bread or noodles in the traditional sense. According to GFI, it’s equally clear that almond milk and other plant-based milks do not purport to be “milk.”

For several years, FDA has been reviewing whether these terms are likely to mislead or confuse consumers. In a July 2018 statement, Scott Gottlieb, MD, then-FDA Commissioner, stated that, “Because these dairy alternative products are often popularly referred to as ‘milk,’ we intend to look at whether parents may erroneously assume that plant-based beverages’ nutritional contents are similar to those of cow’s milk, despite the fact that some of these products contain only a fraction of the protein or other nutrients found in cow’s milk.” It is unclear at this point what that review has found or whether it remains ongoing.

Case Law

The cases that have been decided to date have been largely unfavorable to opponents of plant-based dairy alternatives.

In *Gitson v. Trader Joe’s Co.*, the plaintiffs sued to enjoin the sale of soy milk, arguing they were misled to believe that organic soy milk complied with FDA’s standard of identity for milk and that organic

On the one hand, it’s critically important to maintain prohibitions against deliberately misleading or deceiving consumers. On the other hand, society must take great care not to enact linguistic prescriptions, especially for the purpose of granting a commercial advantage to one industry over another.

soy milk provided quality, taste, and nutritional benefits comparable to cow’s milk.

The court disagreed with the plaintiffs and held that the standard of identity regulation “simply means that a company cannot pass off a product as ‘milk’ if it does not meet the regulatory definition of milk.” The court ascertained that it was implausible to believe that a reasonable consumer would believe soy milk is cow’s milk and has the same qualities as cow’s milk. In granting the extraordinary relief of dismissing the case, the court reasoned that *Gitson* was “one of those rare cases where the accused label itself makes it impossible for the plaintiff to prove that a reasonable consumer is likely to be deceived.”

Ang v. Whitewave Food Co. resulted in a similar outcome. In this case, the plaintiffs alleged that the defendants had misbranded Silk products by using names like “soymilk,” “almond milk,” and “coconut milk,” since the Silk products are plant-based, and FDA defines “milk” as a substance coming from lactating cows (the “milk claims”). The court forcefully rejected the plaintiffs’ argument. In its decision, the court asserted that the names “soymilk,” “almond milk,” and “coconut milk” accurately describe Defendants’ products.

Further, the court noted that the name “almond milk” clearly conveyed the basic nature and content of the beverages, while simultaneously distinguishing them from cow’s milk. “Moreover, it is simply implausible that a reasonable consumer would mistake a product like soymilk or almond milk with dairy milk from a cow. The first words in the products’ names should be obvious enough to even the least discerning of consumers,” the court concluded. Of particular import, the court reasoned that adopting the plaintiffs’ position could increase confusion, “especially with respect to other non-dairy alternatives such as goat milk or sheep milk.”

The court went so far as to compare the plaintiffs’ claims in *Ang* to those in another case, *Werbel ex rel. v. Pepsico, Inc.* In *Werbel*, in which the plaintiff claimed to have believed “Cap’n Crunch’s Crunch Berry” cereal derived its nutrition from actual fruit because of its label’s reference to berries and because the “crunch berries” resembled real berries. The court derided the allegations as “nonsense,” observing that the word “berries” was always preceded by the word “crunch” and that the crunch berries depicted on the label did not remotely resemble any naturally occurring fruit.

These disputes highlight an important area of tension in the law. On the one hand, it’s critically important to maintain prohibitions against deliberately misleading or deceiving consumers. On the other hand, society must take great care not to enact linguistic prescriptions, especially for the purpose of granting a commercial advantage to one industry over another. Banning the use of descriptive terms, even if they might conceivably be misconstrued by some consumers, is a very slippery slope and one that can have far-reaching and devastating implications. As for the use of dairy terms to describe plant-based products, it’s fair to say there are reasonable arguments on both sides. However, to the extent a manufacturer goes too far, marketing a product that is in fact misleading, there are many remedies available to address that situation under the current civil and regulatory framework. As such, the courts will likely continue to reject further restraints. What state and federal legislators and regulators may do, however, is uncertain.

The only thing that is certain is that the lawyers will continue to milk this issue for all it’s worth. ■

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Cannabis Corner



Nanoemulsions in Foods and Beverages

Experts debate the safety of this technology for use in cannabis-infused products | BY JESSE STANIFORTH

Visitors to cannabis trade shows in recent years may have noticed the increasing number of companies touting some of the most advanced technology to be applied to the consumption of cannabis: food-grade nanoemulsions. Such nanoemulsions encapsulate a bioactive substance in a tiny particle that can more easily be absorbed by the body and combined with water or other ingredients.

In the cannabis-infused food and beverage industry, nanoemulsions are used to make active cannabinoids, such as tetrahydrocannabinol, cannabidiol, cannabigerol, and cannabinol, both water soluble and bioavailable. These paired factors make nanoemulsions a popular technology in developing cannabis-infused beverages, as well as other infused foods.

In Canada in particular, where major beverage manufacturers own large stakes among licensed cannabis producers, there is a drive to deliver cannabis beverages as a product that competes with alcoholic drinks. For such producers, nanoemulsions are one of the most effective methods not just to make cannabinoids water soluble, but also to make them metabolize more quickly. While traditional edible cannabis products normally have an onset time of more than one hour, products infused with cannabinoid nanoemulsions may take effect within as few as 15 minutes—a huge gain for beverage producers hoping to make infused drinks as attractive to consumers as hard seltzer and other market-leading alcohol products.

Yet, some in the cannabis industry have concerns about the safety of these

cannabinoid nanoemulsions in food and beverages.

The Debate

“I have concerns about nanoemulsions in general,” says Rebecca White, PhD, chief technology officer for New Mexico-based Trait Biosciences, which employs glycosylation to offer a cannabinoid-infusion technology that is an alternative to nanoemulsions. Dr. White says there hasn’t been enough study of nanoparticles in food and beverages and, accordingly, food nanoparticles are inadequately regulated.

“This suite of ingredients may have unintended effects on cells and organs, particularly the digestive tract,” says Dr. White. “There are also indications that nanoparticles may enter the bloodstream and accumulate elsewhere in the body. They have been linked to inflammation, liver and kidney damage, and even heart and brain damage.”

Brad Douglass, PhD, is vice president of intellectual property and regulatory affairs for Monrovia, Calif.-based cannabis biotechnology lab the Werc Shop. He offers a largely opposing position, arguing that if all ingredients used in the creation of a nanoemulsion are classified as generally recognized as safe (GRAS) for food use and are being used within acceptable concentration limits, the nanoemulsion itself should be safe.

“If you’re using GRAS ingredients in the quantities and specifications that are permitted, that’s very unlikely to cause serious issues,” he tells *Food Quality & Safety*. “The term ‘nanoemulsion’ tends to throw people off, particularly the ‘nano’ prefix. When I see ‘nanoemulsion,’ I just see ‘emulsion,’ and emulsions are emulsions—you just have smaller vesicles and a more stable emulsion that permeates.”

David Julian McClements, PhD, distinguished professor in the department of food science at the University of Massachusetts Amherst, essentially concurs. Dr. McClements has published widely on the subject of nanoemulsion safety and edited

a book on the science of nanoemulsions. He says, “We already consume nanoemulsions in some foods (for example, homogenized milk or soft drinks often contain nano-sized lipid droplets). If they are made from digestible oils, which they typically are, then they should be fully digested in the gastrointestinal tract, then behave like normal fat.”

Likewise, Touseef Ahmed Wani, a senior researcher at the University of Kashmir’s Department of Food Science and Technology, was the lead author (along with Dr. McClements) of a 2018 book chapter entitled “Safety of Nanoemulsions and their Regulatory Status.” He tells *Food Quality & Safety*, “The analysis performed regarding the safety of nanoemulsions reveals their use as safe at low concentrations. So, the use of nanoemulsions in different foods is promising.”

Yet, Wani is not categorical in his support for nanoemulsions. He explains, “It is a matter of great concern to substantiate the safety of nanoparticles before commercializing them on the world food market.”

Wani lists four significant questions regarding the consumption of nanoemulsions:

- Do nanoparticles have free access to cells, or are they controlled in some way?
- How long do nanoparticles remain inside the body?
- How are they excreted?
- Do they have toxic effects?

“These questions are yet to be answered, [primarily] because the research on the safety and toxicity of nanoparticles is still in infancy,” Wani says.

Where There’s Agreement

If it seems as though there are two camps of diametrically opposed scientists debating the issue, there is much about nanoemulsions on which all parties essentially agree. The first factor everyone agrees on is that nanoemulsions and nanoparticles are an emerging technology we do not yet fully understand. This lack of a complete understanding opens up serious questions about nanoemulsion safety, to which even an enthusiastic nanoemulsion supporter like Dr. Douglass yields.

In particular, Dr. Douglass identifies the issue of surfactant ingredients, which lower surface tension, as a source of con-

cern. “When it comes to food, there are fewer surfactants that have been judged to be GRAS for food use. There are so many types of surfactants—for example, polysorbate, polysorbate 80 tween—these were developed for the pharmaceutical industry. Some have applicability for food use, but some people have concerns. Are they [too effective as] surfactants, where they start to bypass the intestinal barrier?”

At this point, Dr. Douglass’ position begins to align with that of Dr. White, who highlights the lack of understanding of how nanoparticles are digested.

“For organic nanoemulsions like those that are used for delivering cannabinoids,” says Dr. White, “the concern is that little is known about the absorption or toxicity of the nanoparticles themselves. Cannabinoids, including CBD, are pharmacologically active ingredients. There is no way to know the health risks or effects of combining nanotechnology and cannabinoids unless diligent toxicology study is conducted.”

The possibility remains that nanoparticles could be absorbed into different regions of the gastrointestinal tract, says Dr. McClements, though he adds that he doesn’t believe there is evidence to support this theory.

“A particle that’s small enough can go around your cells—paracellular transport. That’s somewhat of a concern, at least a conceptual concern, with nanoparticles,” Dr. Douglass says. “With emulsions, the idea is that you can disrupt that bilayer of the cells and make it more permeable to things it would normally keep out.”

Yet, Dr. Douglass sees this concern as “mainly theoretical” in situations where all ingredients are designated GRAS for food use. Like Dr. McClements, he says there has been no “demonstrable concern from data sampling.”

Lack of Evidence

This doesn’t mean that Dr. Douglass presumes the safety of GRAS nanoemulsions to be settled. He notes that GRAS designations change, and some ingredients designated as GRAS have been removed from the list after they have become better understood. “But, generally there’s a pretty good foundation to say there’s probably an acceptable hazard or risk profile in using these ingredients,” he adds.

Dr. Douglass, like Dr. White, stresses the gaps in understanding that surround the emerging technology of nanoemulsions.

“Lack of evidence isn’t evidence of lack,” Dr. Douglass says. “I tend to give some credence to anecdotal reports if they happen over and over again. That window of uncertainty between what we know and what we don’t know, there’s probably some important effect.”

Wani notes that there are still questions surrounding how, for example, nanoparticles are excreted. “Because nanoemulsions are fabricated from food-grade materials, the materials should normally be excreted in urine,” he says. “However, because of their extremely small size, they could evade the xenobiotic pathways and could be accumulated in various tissues or organs. Besides, they could find a way across the blood–brain barrier and cause effects that are still a mystery.”

All four scientists stress the importance of continuing to develop new information to better understand nanoemulsion safety. Dr. McClements says, “It is important to carry out toxicity studies,” as with any new food.

As the most skeptical of the technology, Dr. White goes furthest, saying “I think it is important to have rigorous standards for safety testing given how little we know about nanoemulsions in general, and products using nanoemulsions should be subject to additional testing. It is not sufficient to test the nanoemulsion without active ingredient and test the active ingredient without the nanoemulsion; you have to test them separately and together.”

Yet, she concludes on the note with which Dr. Douglass most agrees, saying, “From a consumer transparency perspective, I think that products using nanoparticles should include that on the label so that consumers may make informed choices.”

“If I do have concerns about the use of emulsions in cannabis beverages,” says Dr. Douglass, “it’s the lack of transparency in labelling. That’s a lot easier to enforce when you have an experienced regulator like Health Canada overseeing things, rather than [U.S.] state-based regulators.” ■

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FOOD SAFETY IN DRY, LOW-MOISTURE, AND LOW-WATER-ACTIVITY FOODS

Part 1: Emerging pathogens

BY PURNENDU C. VASAVADA, PHD,
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Editors' note: This is part 1 of a two-part series on emerging pathogens in dry, low-moisture, and low-water-activity foods. Part 1 looks at what pathogens pose the most risk. Part 2, which will publish in the August/September 2021 issue of Food Quality & Safety, will focus on technologies and strategies for their control.

Dried foods, low-moisture foods (LMFs), and low-water-activity foods ($L_{a_w}F$) are those foods and ingredients that have been dried to lower their moisture content or/and reduce their water activity in order to preserve the food. The moisture content and water activity (a_w) of dried foods are generally less than 25% (3% to 12%) and below 0.85, respectively. Dried and LMFs are characterized by low a_w , ranging from 0.03 to 0.7.

Because moisture content is an important characteristic required for the growth and activity of microorganisms and enzymes in food, lowering the moisture content by drying and controlling the availability of water by reducing a_w are among the most common ways of preserving food.

Some common examples and categories of dried foods and LMFs include dried milk, egg powder, cocoa powder, flour, cereals, pasta, dried fruits and vegetables, dried meats, meal, grits, herbs, condiments and spices, honey, hydrolyzed vegetable protein powder, peanut butter, tree nuts and peanuts, powdered infant formula, and seeds and grains.

Drying is a very common and ancient method of food preservation. In LMFs, the moisture content and a_w are reduced to a point at which spoilage and pathogenic organisms are inhibited, resulting in an increased shelf life for the foods. However, the drying process is not typically designed to inactivate microorganisms; therefore, dried foods and LMFs are not sterile foods. Dried foods may become contaminated with pathogens during harvest and storage, through processing equipment and the processing environment,

and during post-processing handling and storage. Pathogens and spore-forming organisms can survive during the extended storage of dried foods and ingredients, and some pathogens are able to survive in a dehydrated state for long periods of time. Drying can inhibit the growth of microorganisms, but vegetative cells and spores can remain viable for months. Additionally, conditions during dehydration of dry foods may increase the thermal resistance of the pathogens, protecting them from heat.

Many dried foods and ingredients are considered ready-to-eat (RTE) and are not cooked prior to consumption. Thus, in spite of a significant barrier to the growth of pathogenic microorganisms provided by low a_w or low moisture content, dried, LMFs and $L_{a_w}F$ are not inherently safe from pathogenic bacteria, as evidenced by the fact that dried foods and ingredients have been increasingly involved in foodborne illness outbreaks and recalls due to contamination by emerging pathogens such as *Salmonella* spp., *Bacillus cereus*, *Clostridium botulinum*, *E. coli* O157:H7, and *Listeria monocytogenes*.

In this article, we will discuss the emerging pathogens associated with dried foods, LMFs, and $L_{a_w}F$. We'll also give examples of outbreaks and recalls, and discuss novel methods for dehydration and strategies and approaches for controlling these pathogens in the dry foods and processing environment.

Emerging Pathogens of Concern

The Centers for Disease Control defines an emerging pathogen as an infectious agent whose incidence in humans has increased dramatically within the past two decades, or one that has the probability of increasing in future. The agency includes new foodborne pathogens or those that have been newly recognized as predominantly foodborne in the last 20 years. Many outbreaks of foodborne illnesses and widespread recalls caused by dried, LMF, or low a_w food /ingredients contam-

Despite the common misconception that bacteria aren't able to survive and grow in dry, low-moisture, and low-water-activity foods, managing the production of dry foods and controlling pathogenic bacteria poses a significant challenge.

inated with emerging pathogens such as *Salmonella* spp., *Cronobacter sakazakii*, *B. cereus*, *Clostridium perfringens* and *C. botulinum*, *E. coli* O157:H7, and *Staphylococcus aureus* have been reported.

Among these pathogens, *Salmonella* spp. are the most important, as they are implicated in outbreaks associated with a wide variety of food products and ingredients, including peanut butter, chocolate, powdered infant formula, almonds, spices, and pet foods and treats. Some of these pathogens exhibit increased tolerance to heat, can survive for several months, and are found in dry foods and dry food ingredient processing and preparation environments. Major foodborne pathogens associated with dried, LMF, and $L_{a_w}F$ and ingredients are listed in Table 1 (see p. 20), along with their key characteristics.

The following is a brief description of emerging pathogens associated with dried foods:

***Salmonella* species:** *Salmonella enterica* serovars have been the most commonly implicated bacteria in foodborne illness outbreaks and recalls associated with contaminated dried, LMF, and $L_{a_w}F$ and ingredients. *Salmonella* are Gram-negative, facultative anaerobic, non-spore forming rods. There are more than 2,400 known strains of *Salmonella*. Foodborne illness outbreaks and recalls associated

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with *Salmonella*-contaminated milk products and powdered infant formula have been reported worldwide since the 1950s, when *Salmonella* strains such as *Salmonella* Derby, *Salmonella* Agona, or *Salmonella* Worthington were implicated. More recently, in 2018, a dairy manufacturer recalled dry whey powder due to potential *Salmonella* contamination. Several secondary recalls have since been issued by companies who sourced the powdered milk and whey as an ingredient in their own products.

Salmonella can contaminate manufacturing equipment and the processing environment and can survive in dry environments for long periods of time. In 2015, an outbreak of *Salmonella* Worthington infection in elderly people caused by contaminated milk powder was reported in France. Follow-up investigations showed the presence of *Salmonella* Worthington in environmental samples taken at the manufacturing plant, milk powder from one of the hospitals, and a sample of milk powder that was stored in the manufacturing plant. More recently, in 2017, an outbreak of *Salmonella* Agona among infants was identified in France. Five different infant milk products manufactured at one facility were implicated, and the company recalled all products that had been processed at the facility since February 2017.

Salmonella contamination in dry milk, dry buttermilk, and dry whey have resulted in large recalls in the U.S. For example, in 2016, the FDA seized nearly four million pounds of dry nonfat and buttermilk powders from a dairy manufacturing facility. The presence of *Salmonella* was detected in the plant's internal environmental and finished product samples. In addition, environmental swabs collected during the inspection confirmed the presence of *Salmonella* Meleagridis on surfaces with which the food had come into contact after being pasteurized.

Other *Salmonella enterica* serovars implicated in dried foods include *Salmonella* Agona, *Salmonella* Agona PT15, *Salmonella* Anatum, *Salmonella* Durham, *Salmonella* Ealing, *Salmonella* Eastbourne, *Salmonella* Enteritidis, *Salmonella* Enteritidis PT30 and 9C, *Salmonella* Java PT, *Salmonella* Javiana, *Salmonella* Manchester, *Salmonella* Mbandaka, *Salmonella*

Montevideo, *Salmonella* Seftenburg, *Salmonella* St. Paul, *Salmonella* Tennessee, *Salmonella* Typhimurium, and *Salmonella* Wandsworth.

It should be noted that *Salmonella* is considered a zero-tolerance organism (i.e., <1 organism/25 g of sample) in some jurisdictions. Many *Salmonella* strains are multi-drug resistant and relatively heat tolerant, particularly in LMFs, and some strains may survive cooking or baking processes that would typically inactivate other non-spore-forming pathogens. Also, *Salmonella* can form a biofilm.

***Cronobacter sakazakii*:** *C. sakazakii* is an emerging pathogen associated with powdered infant formulas. It is an opportunistic pathogen, primarily associated with life-threatening infections in neonates, including necrotizing enterocolitis, bacteremia, and meningitis, with fatality rates of 50% to 80%. *C. sakazakii* is a Gram-negative, non-spore-forming bacterium. It has been isolated from a wide variety of sources, including water, sediment, soil, plant material, and foods such as cheese products, meat, rice and other grains, vegetables, herbs and spices, fermented breads, poul-

try, ultra-heat-treated milk, spoiled tofu, and kefir. More importantly, it has been isolated from milk powder manufacturing facilities and household vacuum cleaners.

Cronobacter strains show high tolerance to elevated temperatures and osmotic stress and are generally considered a thermotolerant organism. Many *C. sakazakii* strains show resistance to antibiotics such as ampicillin and ciprofloxacin. *C. sakazakii* is recognized as a significant emerging pathogen associated with powdered infant formula. However, the threat of foodborne illness associated with *Cronobacter* spp. in healthy adults and children is exceptionally small, and it is not regarded to be as much of a threat as *Salmonella* spp.

***Bacillus cereus*:** *B. cereus* is a Gram-positive, facultatively anaerobic, spore-forming rod. *Bacillus* spp. are ubiquitous in raw milk and the milking environment, and are commonly isolated from soil, air, water, plants, and animals. The occurrence of *B. cereus* in dried milk products and infant food, as well as food poisoning outbreaks attributed to the pathogen, have

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Poultry

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been reported. The majority of *Bacillus* species are rarely associated with foodborne illness; however, *B. cereus* and *B. licheniformis* have been known to cause outbreaks of foodborne illness. *Bacillus* spores can form biofilm, survive in powders for at least six months, and cause outbreaks of *Bacillus*-related foodborne illness associated with milk powder and infant formula.

***Clostridium* spp.:** *C. botulinum* and *C. perfringens* are Gram-positive, anaerobic, spore-forming bacteria found in many environmental sources, including soil, dust, water, sediments, sewage, vegetation, feeds, and silage. *C. botulinum* has been found in foods such as honey, vegetables, smoked fish and seafoods, and meat. Outbreaks have been reported with cheese and yogurt due to the addition of contaminated ingredients. *C. botulinum* intoxication is rare; however, a possible link to infant formula milk powder has been indicated in one such case in the U.K. *C. botulinum* type B was isolated from an opened container of infant formula from the patient's home and an unopened container of the same batch obtained prior to distribution and retail sale. *C. perfringens* can grow in conditions with very little or no oxygen and, under ideal conditions, can multiply very rapidly. Some strains of *C. perfringens* produce a toxin in the intestine that causes illness.

In 1983, a report of presumptive *C. botulinum* spores in whey protein concentrate produced in New Zealand caused a large recall and generated questions about potential risks and strategies for control of spores in dried dairy products. However, the original reports that the isolate was toxigenic were false positive, and further additional independent testing showed that the isolate was a closely related species, nontoxigenic *C. sporogenes*, and not pathogenic *C. botulinum*.

It is important to note that spores of *Clostridium* spp. are ubiquitous in the environment and in foods, and consuming the spores of *C. botulinum* alone poses no health risk to children older than 1 year of age or to adults with normal microflora. Spores are known to survive milk pasteurization and other similar thermal processes. Therefore, the use of good quality milk, temperature control, and sanitation

Table 1. Characteristics of Foodborne Pathogens Associated with Dried, Low-Moisture, and Low-Water-Activity Foods and Ingredients

Pathogen	Key Characteristics	Heat Resistance
<i>Salmonella</i> spp.	Gram-negative, facultative anaerobe non-spore-forming	Some strains are heat resistant, surviving for weeks, months, or years in low a_w foods (up to a_w 0.30); requires minimum a_w 0.94 for growth.
<i>C. sakazakii</i>	Gram-negative, facultative anaerobe non-spore-forming	Ability to survive in dry foods—up to two years in powdered infant formula; can survive at a_w 0.2; minimum a_w for growth not known.
<i>E. coli</i> O157:H7	Gram-negative, facultative anaerobe non-spore-forming	Ability to survive in dry foods; requires minimum a_w 0.95 for growth.
<i>L. monocytogenes</i>	Gram-positive, facultative anaerobe, psychrotrophic, non-spore-forming	Ability to survive in dry food ($a_w < 0.83$), e.g., peanut butter (a_w 0.33); requires minimum a_w of 0.90–0.93 for growth.
<i>B. cereus</i>	Gram-positive, facultative anaerobe, psychrotrophic, spore-forming	Spores can survive in dry environments, growth and emetic toxin formation at a_w of 0.92–0.93
<i>C. botulinum</i>	Gram-positive, anaerobe, psychrotrophic, spore-forming	Spores can survive in dusty, dry environments, minimum a_w for psychrotrophic: 0.97
<i>C. perfringens</i>	Gram-positive, anaerobe, psychrotrophic, spore-forming	Spores can survive in dry environments, requires minimum a_w of 0.93 for growth
<i>S. aureus</i>	Gram-positive, facultative anaerobe non-spore-forming	Can survive for months in dry foods; minimum a_w of 0.83–0.85 for growth; a_w 0.87 for toxin formation

a_w , water activity; $L_{a_w}F$, low-water-activity foods; LMFs, low-moisture foods.

of equipment and processing plants, along with similar precautions, are recommended to minimize spores in dried milk products.

Listeria monocytogenes: *L. monocytogenes* is a Gram-positive, non-spore-forming facultative anaerobic rod bacteria that grows between -0.4°C and 50°C. It has been isolated from a variety of sources, including plant; soil and surface water samples; silage; sewage; milk and milk products, such as ice cream and soft and semi-soft cheeses; and RTE meats. It is one of the most virulent foodborne pathogens, with mortality rates of 20% to 30%. It causes meningitis and septicemia, particularly in pregnant women and immunocompromised patients.

L. monocytogenes is truly an emerging pathogen because, although it was known as an animal and human pathogen for more than 50 years, it has not been recognized as a significant public health problem until recently. Outbreaks of listeriosis have been associated with cheese, coleslaw, meat, vegetables, and fish, as well as with several other dairy products such as raw and pasteurized milk, fresh Swiss- and Mexican-style cheese, chocolate milk, and butter.

Nonfat dry milk (NFDM) can serve as a vehicle for foodborne illness; for example, several outbreaks of salmonellosis have been traced to the product and other dry dairy ingredients. A study designed to determine the presence of *Listeria* spp.

in imported dry milk samples in Mexico showed that 53.5% of *Listeria* isolates were identified as *L. monocytogenes*. Another study showed that *L. monocytogenes* in NFDM survived during extended storage, and the thermal stability of *L. monocytogenes* in a_w 0.25 NFDM after six-month or 12-month storage under refrigerated or ambient temperature did not deviate much from that found in NFDM prior to the storage.

L. monocytogenes is considered an environmental pathogen that should be controlled in the dairy processing environment through an environmental pathogen monitoring program.

Staphylococcus aureus: *S. aureus* is a Gram-positive, facultative anaerobe non-spore-forming organism that causes food poisoning worldwide. It is found in air, dust, water, milk, and dairy products, and on the skin and in the noses of people and animals. *S. aureus* is sensitive to heat treatment and sanitizing agents but tolerates salty and dry conditions. Therefore, the presence of this organism in foods generally indicates poor sanitation and unhygienic conditions. The microorganism is readily destroyed by heat, but, under certain conditions, it can grow and produce enterotoxins. Staphylococcal enterotoxins are highly stable, heat resistant, resistant to freezing, drying, and low pH, and can survive heat treatments involved in cooking. Milk and dairy products, such as dry milk, butter, and cheese, have been associated with several rather large outbreaks of foodborne illness caused by staphylococcal enterotoxins.

The incidence of foodborne outbreaks and recalls associated with dried foods, LMFs and low water activity $L_{a_w}F$ contaminated with pathogens have been increasing in recent years. Table 2 (see p. 22) lists some examples of these foods that have been implicated in outbreaks and recalls.

The Effect of Drying on Microorganisms

The drying process is designed to remove water and reduce water activity. Microorganisms require moisture and a_w to grow. So, methods designed to reduce water by dehydration and/or reduce a_w by removal of water or through the addition of solutes (e.g., salts and sugars) are among the most efficient food preservation methods.

Drying and dehydration are complex processes involving simultaneous heat and mass transfer to remove moisture from wet or high-moisture materials. In conventional food dehydration, air is used to supply heat to the food and to carry moisture vapor away from the material subjected to drying. The effect of drying on microorganisms involves several physiological, metabolic, and genetic changes. The removal of water during drying can induce DNA and RNA breakdown, protein denaturation, cytoplasmic membrane alteration, and cell wall damage. In dried conditions, microbial growth is inhibited, but spores and vegetative cells can remain viable for months.

Dry heat is less effective than moist heat because the cell proteins, an important component in maintaining cell viability, are more stable in a dry state. Drying also involves environmental stresses including oxidative and osmotic stress. Bacteria subjected to osmotic stress during dehydration can show changes in cell morphology, such as swelling or shrinking, depending on osmotic changes.

In some bacteria, dehydration can lead to formation of filaments, e.g., *Salmonella* can form filaments due to the inhibition of cell division proteins as a result of osmotic stress. The formation of filaments leads to an increase in overall biomass without any increase in cell numbers, resulting in an underestimation of bacteria present in dry products. The formation of filaments prior to a dried state may lead to increased desiccation tolerance, increased survival, and persistence of bacteria within a factory.

Removal of a substantial fraction of the bulk water during drying results in desiccation and an increase in intracellular salt concentrations and macromolecules due to a decrease in cell volume. Other effects of drying include changes in biophysical properties (such as surface tension), reduced fluidity of membrane lipids, and damage to proteins and DNA, as well as free radical attacks to phospholipids, DNA, and proteins.

Drying can also influence the cultivability of microorganisms. Numerous pathogenic bacteria, including *Salmo-*

(Continued on p. 22)



(Continued from p. 21)

Table 2. Some Dried, Low-Moisture, and Low-Water-Activity Foods Associated with Foodborne Bacterial Pathogen Contamination

Pathogen	Foods
<i>Salmonella</i> spp.	Almonds, pecans, pistachios, classic hummus, dog and cat food, spices and blends, cinnamon apple chips, raw macadamia nuts, curry powder, organic coconut flour, potato slices, carrot slices, pet food, chews and pig ear pet treats, crackers, flour, unbleached flour, cake mixes, skim milk powder, onion soup mix, gelatin-based desserts, ground malabar pepper, taco seasoning products, dry whey powder, powdered kratom products, chili kit, shredded coconut, ginger powder, dried fungus, powdered whey protein mix/supplement, whey protein isolate, herbal tea, jalapeño-flavored kettle cooked potato chips, beef jerky, dried fish, egg powder.
<i>Cronobacter</i> spp.	Powdered infant formula, infant cereal.
<i>E. coli</i> O157:H7	Hazelnuts and mixed nut products, macadamia nuts, flour, apple powder, buttermilk powder, cheddar cheese seasoning, powdered chicken, sour cream powder, biscuit (cookie) cream, cereal (rice), infant cereal.
<i>B. cereus</i>	Cookies, infant cereal.
<i>C. botulinum</i>	Dried fish, dried seafood products, salted fish, black bean tortillas, whole capelin fish pet treats.
<i>L. monocytogenes</i>	Walnuts, dog and cat food, peanut butter, popcorn, pumpkin seeds, pet food, organic almond butter, organic peanut butter, organic tahini butter, chocolate-peanut butter spread, nutritional yeast.
<i>S. aureus</i>	Gingerbread houses, cake mix, skim milk powder, onion soup mix, gelatin-based desserts, pasta.

Sources: FDA; Gurtler, JB, Doyle MP, Kornacki JL. The Microbiological Safety of Spices and Low-Water Activity Foods: Correcting Historic Misassumptions. Gurtler JB, et al. (eds.), *The Microbiological Safety of Low Water Activity Foods and Spices*, *Food Microbiology and Food Safety*. Springer. New York. 2014. pp. 3-13.

nella and *L. monocytogenes*, transition to a viable-but-nonculturable (VBNC) state. Bacteria in the VBNC state cannot form colonies on normal microbiological media, which results in lower numbers of bacteria detectable in dry and LMFs. It is important to note, however, that cells resuscitated from a VBNC state can retain their pathogenic capacity and remain infectious.

In a dry food environment, stressed bacterial cells form biofilm by attaching to a surface and producing glycocalyx layers, which consist of extracellular polysaccharides (EPS), proteins, and nucleic acids. *Salmonella* biofilms consist of a matrix composed of curli fimbriae and cellulose and the cell surface protein Bap A. The pro-

duction of curli fimbriae, one of the main components of biofilms, and cellulose have both been shown to enhance long-term desiccation survival. Other organisms, such as *C. sakazakii*, may survive in dry environments by encapsulation and forming biofilm. The biofilms are known to provide desiccation tolerance and protection against normal cleaning and sanitation protocols.

While it's known that the drying process results in low moisture content and a_w , inhibiting the growth of pathogenic as well as spoilage microorganisms, the effect of the drying process and the response of pathogens to low a_w is very complex. Gram-negative bacteria are much more

susceptible to drying than are Gram-positive bacteria. The higher resistance of Gram-positive bacteria is thought to be related to their smoother surfaces, the thicker peptidoglycan layer, and the lack of lipopolysaccharides.

Microorganisms subjected to environmental stress during the drying process develop mechanisms for withstanding heat and oxidative stresses and for surviving in dry foods and dry food processing plant environments. In dried foods, microbial growth is inhibited, but spores and vegetative cells can remain viable for extended periods. Additionally, microorganisms use sophisticated genetic, metabolic, and physiological mechanisms to adapt to and survive in the conditions of the drying process and the dry food plant environment.

While much research has been done to understand mechanisms used by microorganisms to survive in dry environments, the effects of drying stress on pathogenic bacteria are only partially understood. Despite the common misconception that bacteria aren't able to survive and grow in dry, low-moisture, and low-water-activity foods, managing the production of dry foods and controlling pathogenic bacteria poses a significant challenge. There has been an increased awareness of the survival and cross-contamination routes of pathogens such as *Salmonella* and *Cronobacter* during processing. In recent years, various pre-drying treatments and novel and hybrid drying technologies have been developed. In addition, novel approaches to controlling pathogenic bacterial contamination—including implementation of GMPs and HACCP, the hygienic design of facilities and equipment, and the application of zoning and dry cleaning to avoid the growth of bacteria in the processing environment—have been implemented in manufacturing facilities.

Part 2 of this article will discuss novel methods and technologies for the production and control of pathogens in dry, low-moisture and low-water-activity foods. ■

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Safety & Sanitation

How to Control Food Dusts in Your Processing Facility

Dusts can be combustible hazards and cause cross-contamination

BY ANDY THOMASON

When food products are manufactured indoors, small particles often become airborne and have the potential to do serious harm to people, products, equipment, and facilities. Dusts that are combustible can cause fires and explosions. Other dusts can contain ingredients that are harmful when swallowed, inhaled, or come into contact with skin. Dust also can cross-contaminate other products that are manufactured in the same facility. When combustible dusts are collected from the air into a dust collection system, the system itself can be a source of combustible dust explosions if not properly protected.

Here are frequently asked questions about controlling food dusts in order to maintain a safe work environment.

Q. What are common dust hazards in the food processing industry?

The biggest threats are occupational exposure and combustible dust explosions. Dust can cause dermatitis and allergic reactions. More seriously, dust particles can become embedded in the lungs and can cause respiratory problems like asthma—and even cancer. In addition, many solid

food ingredients are combustible, including sugar, starch, spices, proteins, and flour.

Airborne dust particles also can damage other food products. For example, particles that contain gluten or peanuts could cross-contaminate products that are supposed to be free from these foods, causing severe allergic reactions for customers who trust those product labels.

Q. Which agencies regulate dangerous dusts?

The Occupational Safety and Health Administration (OSHA) is ultimately responsible for protecting employees from dangerous dusts. OSHA requires companies to control dust emissions in indoor workplaces and to comply with legal limits set for each ingredient and material. If no legal limits are applicable, the company must define in writing and implement and measure its own environmental safety plan. FDA's Food Safety Modernization Act requires food processing facilities to implement measures to prevent or minimize contamination hazards.

In addition, the National Fire Protection Association (NFPA) plays a major role

in recommending standards and guidelines for managing combustible dusts. If manufacturers do not follow these guidelines, they can be fined by OSHA, face legal scrutiny, and risk a damaged reputation—not to mention harm their employees.

Q. What equipment is used to capture hazardous food dusts?

Industrial dust collectors are used to capture and contain dust and other harmful particles from the air in plants, factories, and other processing facilities. Much of this airborne dust is too small to be seen with the naked eye. Collectors capture dust by continually cycling the dust-laden airstream through a series of filter cartridges. The dust remains on the cartridges, and the clean air is returned to the work environment.

Systems for high-volume dust collection capture food dust at the source using stainless steel pickup hoods at each production station. Whether attached directly to batch mixers or high-velocity slot hoods behind weigh stations, ducting pulls airborne particulates into the dust collector. Ideally, dust collectors are placed in a location where dust can be effectively and safely discarded. Several other design features are used to control cross-contamination from food dust, including filter orientation, filter media, and filter design.

Industrial dust collectors can be placed inside or outside the manufacturing facility. If processing combustible dust, placing the dust collector outdoors is the safest option to vent away from buildings and populated areas in case of an explosion. However, it is not always feasible to place them outside. Dust collectors placed indoors must have the appropriate explosion protection system if they will be handling any combustible dusts.

Q. How does an explosion occur in a dust collector?

A dust collector is a closed vessel, and any closed vessel that is full of dry particles is ripe for an explosion. An explosion usu-

Combustible Food Dust

If your facility processes any of these products or materials in powdered form, there is potential for a combustible dust explosion.

Alfalfa	Malt	Spice powder
Apple	Milk, nonfat, dry	Starch, corn
Beet root	Milk, powdered	Starch, rice
Carageenan	Oat flour	Starch, wheat
Carrot	Oat grain dust	Sugar
Cocoa bean dust	Olive pellets	Sugar (10x)
Cocoa powder	Onion powder	Sugar, beet
Coconut shell dust	Parsley (dehydrated)	Sugar, milk
Coffee dust	Peach	Sunflower
Cornmeal	Peanut meal & skins	Sunflower seed dust
Cornstarch	Peat	Tapioca
Cottonseed	Potato	Tea
Egg white	Potato flour	Tobacco blend
Garlic powder	Potato starch	Tomato
Gluten	Rice dust	Walnut dust
Grass dust	Rice flour	Wheat flour
Green coffee	Rice starch	Wheat grain dust
Hops (malted)	Rye flour	Wheat starch
Lemon peel dust	Semolina	Whey
Lemon pulp	Soybean dust	Xanthan gum
Linseed	Soy flour	Yucca seed dust, raw
Locust bean gum	Spice dust	

Source: <https://www.osha.gov/Publications/combustibleposters.pdf>

OSHA list of combustible food materials (this list is not inclusive)

ally begins when a suspended cloud of combustible dust is present in high concentration inside the collector. As the fan draws in large volumes of air, an outside spark or ember can be sucked into the collector and collide with the dust cloud under pressure, triggering an explosion. The source of the spark may be a production process, an ignition source drawn into a dust capture hood, or a static electricity discharge from improperly grounded equipment nearby.

Q. How do you protect a dust collector from a combustible dust explosion?

First, it is important to have all collectors sized properly for the facility they will be handling. Second, it is important to understand that combustible dust explosions cannot always be prevented from occurring in the dust collector; however, systems can be put in place to lessen potential harm from an explosion. There are a variety of explosion protection options.

The most common is explosion venting because it is the most cost effective, but some facilities may also be required to have explosion isolation valves or integrated safety monitoring filters. All of these mitigate incidents and prevent the

flame front and pressure from traveling to process areas. The NFPA provides guidelines to design, locate, install, and maintain these explosion protection devices to minimize harm to personnel as well as structural and mechanical damage. It is important to note that if the dust collector is protected properly, an explosion inside the unit is much safer than having it occur in an open facility or around employees.

Q. What does explosion venting do?

A well-designed explosion vent functions as a weak element in the dust collector's pressure envelope. It relieves internal combustion pressure (back pressure) to keep the collector from blowing up into pieces.

Typically, the collector is located outside so that it vents away from buildings and populated areas to a safe location. If it is properly equipped and located indoors, standards mandate designating a safe area around the collector. While explosion venting will usually save the dust collector from being a total loss, the collector can sustain major internal damage. Nonetheless, if personnel remain safe and facility structural damage is minimized, the explosion venting equipment has done its job.

(Continued on p. 38)

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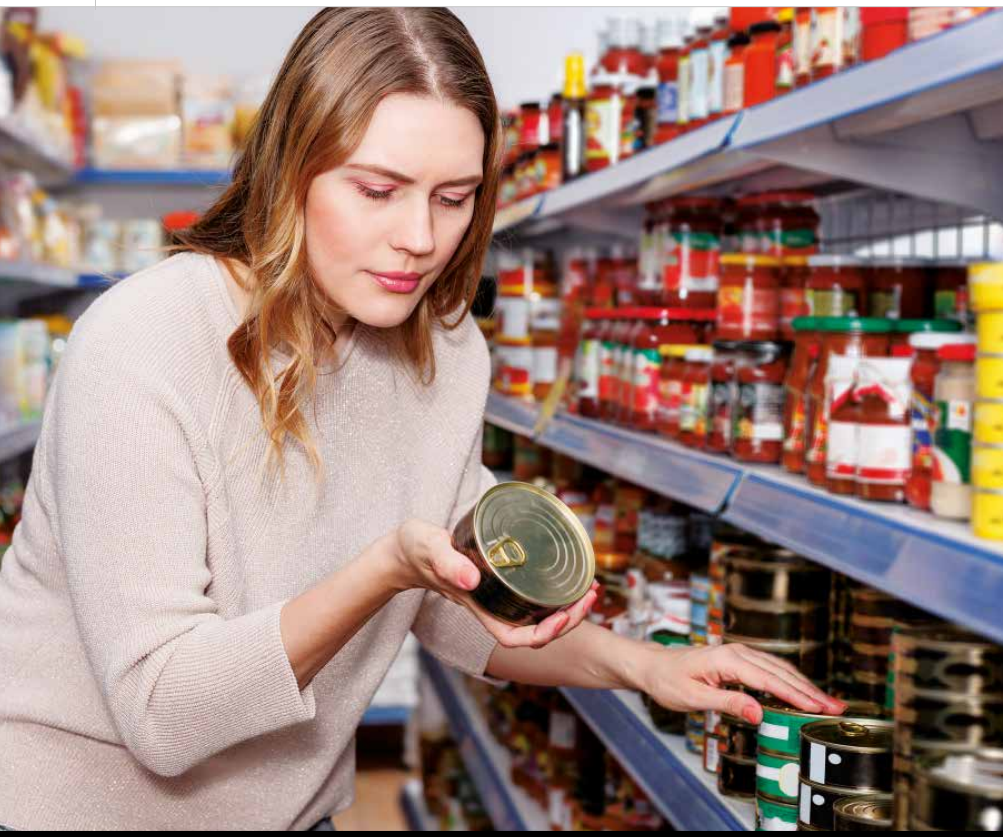
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Quality



Shelf Life and the Clean Label Movement

As consumers demand more “natural” ingredients in their food and beverages, manufacturers take steps to keep up with clean label preservative technology

BY ANDREA TOLU

The “clean label” movement has grown steadily for years and has reached all aisles of the supermarket. At its center is the ingredients list. Before deciding to buy a food product, more and more consumers pay particular attention to the number of ingredients listed, and whether the list includes familiar names.

Of the two components—length and familiarity—the latter is the more import-

ant to consumers, according to research from InsightsNow, a behavioral research consultancy firm based in Corvallis, Ore. “Our data shows that the length of the ingredients list is only about half as important [to consumers] as having recognizable names. A short list with artificial ingredients is more likely to be rejected [by the consumer] than a long list with no artificial ingredients,” says Greg Stucky, chief research officer at InsightsNow.

At the heart of clean label formulations is the replacement of artificial, “chemical-sounding” ingredients with natural ones. That goal, however, forces food companies to reassess the shelf life of products. It’s not just that changing ingredients will create different food safety and quality issues; replacing well-known synthetic antimicrobials and antioxidants with natural ones won’t necessarily guarantee the same shelf-life duration.

The Go-To Antioxidant

When it comes to clean label antioxidants, the go-to ingredient is rosemary extract. Technology has come a long way in this area: “Today it’s a lot easier to replace synthetics, whether it’s a single antioxidant or a combination. An effective strategy is to use rosemary extract alone or with other natural compounds, like mixed tocopherols, acerola cherry, or green tea, depending on the matrix. With meat products, for example, rosemary extract would be enough. But with frying oil, we would use a combination of different ones,” says David Johnson, senior product manager at Kalsec, a natural ingredients supplier based in Kalamazoo, Mich.

“With clean label antioxidants, challenges come from regulations, labeling requirements, and the claims that brands want to make on the label,” says Jane Quartel, executive director of product management at Kalsec. “For example, rosemary as an antioxidant is not allowed in India. In Europe it’s a well-established additive, but it cannot appear on the label as a natural flavor; its antioxidative purpose must be explicit. The alternative would be to use its e-number E392, which is definitely not clean label.”

Off Colors and Off Flavors

Rosemary extract is also proving to have good antimicrobial properties, although a few issues remain. “The problem with rosemary extract and with a lot of clean label antimicrobials is that, in order to get the activity you want, you have to add a lot of the base ingredient, which comes with other components that can give an off color or off flavor. That limits how much of an ingredient you can add,” says Kathleen Glass, PhD, associate director of the Food Research Institute at the University of Wisconsin in Madison. “For example,

when we tried benzoic acid—a common preservative obtained from cranberry extract—with chicken, we had to use such a large amount for antimicrobial activity that it gave the meat a sickly grey color. It doesn't matter if it's safe if nobody wants to buy it."

According to Dr. Glass, as research into extraction and fermentation continues, we'll be able to obtain higher concentrations of active components.

Another issue that comes with natural antimicrobials is variability: "There can be a lot of variation in the concentration of active compounds between suppliers or even between lots of a specific ingredient. The problem is, there are already enough variables when working with natural ingredients that I don't want to necessarily add the concentration of active compounds as another," says Dr. Glass.

Fermentation is also becoming more popular for developing clean label preservatives. Cultured vegetables are widely used in cured meats: "A lot of vegetables have naturally occurring nitrate. During fermentation, it loses one atom of oxygen and converts to nitrite, which can replace sodium nitrite," says Dr. Glass. Other fermentable options with antimicrobial properties are sugar, wheat, and dairy. "Through fermentation, it's possible to obtain the same types of organic acids as the synthetic ones used to control *Listeria*, *Clostridium*, or molds in dairy or bakery products."

A category apart is clean label plant-based meat. Here, says Quartel, shelf-life issues are more related to spoilage organisms than to oxidation. However, she adds, "We come across off flavors throughout their shelf life. It probably has to do with protein degradation, although that's still an active area of research."

"Plant-based and animal proteins have different microbiomes," says Dr. Glass. "The basics of microbial control, such as water content or acidity level, will be the same, but some microbes in plant-based clean label meat may be more tolerant to the usual formulation strategies used for animal protein."

Beyond Formulation

Working on formulations is not the only way to ensure the shelf life of clean label products. There are other factors food

manufacturers can consider. One of them is packaging. "For products with a long shelf life, using heat treatment with a specifically designed package is an excellent way to keep the product safe without preservatives," says Josefine Wegelid, a food technologist at Tetra Pak, a food packaging and processing company.

When heat treatment is too aggressive, however, it could be perceived as a way to produce "ultraprocessed" food, which is something clean label proponents tend to avoid. "Traditional thermal processing or nonthermal methods like pulsed electric fields, cold plasma, electron-beam irradiation (EBI), or ultraviolet (UV) light may not always be accepted by consumers in clean label products," says Sadhana Ravishankar, PhD, associate professor of animal and comparative biomedical sciences and nutritional sciences at the University of Arizona in Tucson. "You may have to reduce the heat and combine it with natural antimicrobials or find alternative methods. One of them is high-pressure processing (HPP), which uses high pressure instead of heat and works really well with sauces, guacamole, jellies, and ready-to-eat meats. Ozone is another effective clean label processing technology, especially for water and fresh produce. It works better than chlorine against foodborne pathogens and leaves no residue," says Dr. Ravishankar.

Beyond formulations, maintaining shelf life in clean label products has an impact at all levels of food production.

"Before reformulating a product, it's very important to do a new risk assessment based on the new conditions to understand what microorganisms can grow," says Ulrika Brintje, a food technology specialist at Tetra Pak. This, in turn, will influence what critical points need to be controlled in the facility."

"Clean label reformulations cost more and require time, not only to find the right concentration and flavor profile but also to test shelf life properly," says Quartel. "We have customers that take as long as a full year to do a shelf-life study."

Being Strategic about Reformulations

Clean label reformulations can be lengthy and costly, and an adequate shelf life is

not always guaranteed. Wouldn't it be better just to explain to consumers that a chemical is a chemical, whether it comes from a natural source or not, and that natural ingredients are not necessarily good for our health, while artificial ones are not necessarily bad?

Education may not be the best strategy right now: 77% of surveyed consumers are aware that some natural ingredients can be bad for their health, says Dave Lundahl, PhD, CEO of InsightsNow. The problem is that people today always don't trust large food companies, he adds. "Just because an ingredient is GRAS or a marketer says it's healthy, they will not [necessarily] believe it."

The clean label trend cannot be ignored either. It's showing no signs of relenting, not even during the pandemic: The movement was already focused on health, so it aligned very well with what people are concerned about now, says Stucky.

A better strategy is to look closely at the data and find areas where consumers are open to trade-offs. For example, for certain products, such as yogurts, achieving the same shelf life may not be necessary. "When we asked our cohort to choose between a food with natural ingredients that only lasts a short time and food with preservatives that will last longer, 87% chose the former," says Dr. Lundahl. "If it's a natural product kept in a refrigerator, a shorter shelf life will be accepted more easily [by the consumer]."

Also, data shows that consumers don't look for clean label products all the time, which means that reformulating may not always be necessary. In fact, some categories of food products have been less permeable to the trend: "Sauces and dips is the sector that is trailing behind the most in the clean label category, as they're considered a small enhancement to foods, and people don't usually consume much of them," says Stucky.

"It depends on the context," says Dr. Lundahl. "Breakfast, for example, is when clean label is more important because people are more concerned about health and wellness. But if it's an indulgent moment, it will be less important." ■

Tolu is a freelance writer who specializes in covering the food industry. Reach him at andrea@andreatolu.com.

In The Lab



Using Direct Mass Spectrometry to Verify Product Authenticity

The technology allows for rapid classification to quickly screen for food fraud

BY SIMON HIRD, PHD

Food fraud has become a topic of major concern over the past decade, primarily due to major incidents, such as the 2008 Chinese melamine scandal and the 2013 European horse meat scandal, and subsequent increased customer awareness and media coverage.

The cost of food crime is considerable. This expense has helped refocus attention on developing measures to ensure the integrity of the food supply chain, with an increase in demand for food fraud detection to be proactive, rapid, and reliable to maintain the security of the food chain while also acting as a deterrent.

There are many types of food fraud, including:

- Substitution of part or all of the food with a lower value commodity;
- Addition of a component to increase the value of the overall product; and
- False claims on product labels that increase their value, such as “organic,” “welfare friendly,” “fair trade,” or “country of origin.”

Direct Analysis Using Mass Spectrometry (Direct MS)

The primary objective of authenticity testing is rapid verification, from raw ingredients through to finished (processed)

products, to support traceability systems. Development of technologies that can be used to rapidly differentiate authentic products from fraudulent ones represents a significant challenge. One approach is the direct analysis of samples using mass spectrometry (MS) without any pre-treatment (e.g., extraction or chromatography). MS-generated images using various types of ambient ionization are used to create multivariate statistical models. Most applications have used linear discriminant analysis on principal component analysis (PCA-LDA) reduced data for the generation of predictive models, but others have explored machine learning approaches.

The result of the subsequent sample classification is presented and refreshed in real time. In all cases, validation is essential to evaluate the accuracy of the models. Analysis of a sample and the generation of results takes only a few seconds, enabling faster decisions and support for next steps. Let's look at a few examples.

Rapid Evaporative Ionization Mass Spectrometry (REIMS)

REIMS allows for the collection of mass spectrometric data directly from the surface of biological samples, without any sample preparation. The technique was originally demonstrated to show promise for detection of cancerous tissues during surgery but has subsequently been used for investigation into food and beverage fraud, especially in the seafood and meat sectors. This work is conducted on a high-resolution instrument, the quadrupole time-of-flight (Q-TOF) mass spectrometer, to ensure enough selectivity to differentiate components and increase the specificity of the statistical model. REIMS typically uses a surgical diathermy sampling device, the iKnife, but there is growing interest in alternative means to generate the aerosol from the sample, such as other designs of monopolar probes, bipolar forceps, and use of lasers.

When it comes to fish and shellfish, we often don't get what we ask for. Fraud is common. For example, one can get high-quality salmon substituted with lower quality salmon species, wild is swapped for farmed, and, in some countries, rainbow trout is often mislabelled and sold as salmon. Typically, polymerase chain reaction (PCR) methods are used,

which exploit minor differences in DNA sequence between different fish species. A small piece of fish DNA is copied many times using PCR and compared with a large, authenticated database of fish species using matcher software to ensure accurate fish species identification.

However, such techniques comprise multiple steps and can take hours. REIMS offers an accurate, high-throughput, cost-effective alternative to screen large numbers of samples for discrimination among fish species. After construction and validation of well-established models, the identity of blind fish fillets can be given in real time without any sample preparation. It has been demonstrated that REIMS can be applied as a rapid screening technique to detect various species of white fish, salmon, tuna, and other sea creatures, to complement existing DNA methods. In addition, there is some evidence that the same approach can be used to monitor the quality of products, such as shelf life and degree of lipid oxidation of fish oils during storage and in real time during cooking.

Since high quality meat demands premium prices, producers of meat-based products might be tempted to blend these products with lower cost meat, cuts from the same animal, or other bulking agents. Moreover, the labelled meat contents may no longer be met. All three types of adulteration are difficult to detect in processed products and lead to deterioration of product quality. REIMS has successfully been used to measure meat quality, fraud, and safety, including determination of species,

country of origin, and substitution with cheaper cuts of meat.

Although REIMS is rapid and simple to use, the technology is coupled to a high-resolution mass spectrometer (HRMS), which may prove prohibitive for most point-of-control testing. REIMS has been installed and used effectively in an abattoir to detect boar taint, demonstrating that this is a technology that has practical potential to be used closer to the points of production and control if the costs can be reduced. However, there are innovative solutions being explored on the potential of other ambient ionization techniques, but fitted to a compact, easy-to-use nominal mass detector, which has greater potential for deployment away from the research laboratory environment.

Atmospheric Solids Analysis Probe (ASAP)

There are other types of ambient ionization, for example, ASAP, which has recently been interfaced to a much simpler mass detector to provide a new, low-cost, dedicated direct analysis MS system. The sample or a related solution is simply applied to the glass capillary probe of the ASAP under controlled heating without any significant sample preparation. Upon thermal desorption at high temperatures, the vaporized molecules are ionized at ambient pressure before entering the mass spectrometer.

Although the MS-generated results from the ASAP are not the same as REIMS and comprise ions from a lower molecular

mass range, there remains enough information to generate reliable models. As a proof of concept, the system has been used to generate multivariate statistical models for the detection of substitution

Direct MS enables rapid discrimination and classification of different raw ingredients and foods or feed using multivariate statistical reference models to quickly screen samples for signs of fraud.

fraud in dried oregano. The results from the validation study demonstrate the capability of the solution as an accurate, robust, and routine screening tool for the real-time recognition of adulteration in herbs. There are also investigations underway looking at the performance of this dedicated, compact, direct MS platform for other applications, including cocoa butter quality control, detection of fraud in edible oils, and mislabelling of honey. The data from this simple mass detector, when combined with multivariate statistics, proved able to rapidly differentiate sample types with good accuracy.

Direct MS enables rapid discrimination and classification of different raw ingredients and foods or feed using multivariate statistical reference models to quickly screen samples for signs of fraud. The absence of any sample preparation of chromatography steps when combined with a simple results dashboard makes results possible in seconds, thus speeding up decision making. It can be used for classification, to give immediate yes/no decision making, so the technique is of interest for point-of-control testing, bringing the analysis closer to the point of production, or at critical points in supply chain. There is a growing range of applications across food, meat, and crop sciences. ■

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Manufacturing & Distribution

FOREIGN OBJECT CONTROL

Vision-Based Detection Systems for Food Processing

Recent advances in computing have made it possible for hyperspectral systems to operate on the line, in real time

BY OLGA PAWLUCZYK

Preventing foreign object contamination is a growing priority for food processors. According to USDA, it accounted for more than 75% of the total volume of food recalled by the Food Safety and Inspection Service in 2019. Contamination isn't a novel issue, however, and many processors are looking for new and innovative solutions to help automate detection and increase the likelihood of finding foreign materials. One reason for this trend is that materials such as plastics and rubber are showing up with greater frequency, and these materials are often missed by metal detectors and X-rays.

Improved detection of foreign contaminants will help reduce food waste as well as lower costs and the risk of recalls. Many processors look to identify contaminants early so they can address an issue quickly and minimize the impact on production.

The good news is that detection technology is evolving quickly. Vision-based systems are a good example of growing innovation in the processing sector. But

what exactly do we mean when we talk about vision systems for food processing?

While X-rays and metal detectors are commonplace in processing, vision systems are relatively new. "Vision system" is an umbrella term for a number of different systems with widely varying capabilities and characteristics. In this article, we will compare different vision systems in terms of how they function, their specific attributes, and how they may benefit food processors.

The Science of Seeing

To understand the differences among types of vision systems, it's useful to remember how light works—the science behind how we see things.

Our eyes are only able to see three color bands: red, green, and blue, otherwise known as the visible spectrum. However, light is actually made up of thousands of different wavelengths. Each wavelength behaves differently and interacts differently with various materials. We can use these diverse wavelengths of light, both inside and outside of the visible spectrum,

to gather information about different materials or objects.

When it comes to comparing vision systems, there are three main differences to consider:

- The number of light bands, i.e., the number of colors that a system is able to see (otherwise known as wavelengths);
- The spectral resolution—the higher the resolution, the smaller the 'gaps' between each color or wavelength; and
- The amount of information a vision system is able to see per pixel of an image. A pixel is the smallest unit of information that makes up a picture.

Together, these three characteristics define the level of detail a vision system is able to consider, the ability of that system to detect a variety of different materials, and how "trainable" a system is, i.e., whether it can learn from the information it's gathering.

The Art of Looking

The original vision systems are our eyes. Human inspectors are frequently brought

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in or added when there has been a contamination event. Studies from other industries have shown, however, that after just 15 minutes on an inspection task, human performance drops dramatically. After 30 minutes on a task, the probability of detection falls by more than 50% on average, meaning that inspectors have a one in two chance of missing the materials they've been hired to find.

This can be due to multiple factors, including line speed, levels of training or experience, fatigue or illness, and even external factors such as background noise or lighting conditions. Studies in other industries have shown that simply adding more inspectors does not necessarily increase detection rates.

Automation of repetitive tasks—such as inspection—delivers better and more consistent outcomes. It also frees up valuable staff for more important and, often, safer tasks that require human expertise.

Camera-Based Inspection Systems

Camera-based systems are the most well-understood type of vision system. Cameras have been around for more than a century, and most of us carry one in our pocket at all times. Camera-based inspection systems are the closest in performance to the human eye, which means that they will only see objects within the three colors of the visible spectrum. Their advantage over human inspectors can be greater consistency; they don't get tired or lose concentration. However, cameras are not effective in detecting contaminants when there is little contrast between the object being inspected and the material they are looking for—for example, white plastic on a fatty piece of chicken or on ground pork trim.

When it comes to detecting contaminants, cameras will likely miss items such as clear plastics or any objects similar in color to the product. Line speed and lighting conditions can also affect camera performance, because cameras have trouble seeing objects on a messy or variable background, such as meat on a line. Figure 1 shows how a camera can more easily see objects when the background is plain.

Camera-based systems are ideal for assessing size and shape, such as with nuggets or patties.

Beyond the Visible Spectrum

Multi-spectral systems are different from camera-based systems. Instead of being limited to three colors, as in a camera-based system, multispectral systems are able to see between three and 15 spectral bands, and can see colors outside the visible spectrum. This enables them to see some chemical properties of the inspected object.

Multi-spectral systems were used in early space-based imaging to map landscape details on Earth. Detection in these systems is based on the materials the system expects to see. In the case of space-based imaging, the systems were set to detect water versus land versus vegetation. In food processing, these systems can be useful when contaminants are consistently

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MORE INFO



(Continued from p. 31)

Complex background

Simple background



Figure 1: Objects on a busy background (left) and on a plain background (right).

made of the same materials; however, new or previously unknown contaminants will be missed, even if this “new” contaminant reappears multiple times.

Because these types of systems use a set number of spectral bands, they have a limited capacity to learn from what they see over time. And, like camera-based systems, multispectral systems aren’t able to assess quality measures.

From Multispectral to Hyperspectral

As the name suggests, hyperspectral systems collect information across the electromagnetic spectrum. They measure continuous bands through both the visible and invisible spectra, which means they see hundreds or thousands of essentially continuous light bands. This means that hyperspectral systems gather very robust data about the materials being inspected, down to a chemical level.

Hyperspectral imaging systems produce incredibly rich data on every piece of product they inspect. In a food processing plant, that means you can not only find, but identify, foreign materials based on their chemical signature, reducing your time to resolve issues by pointing the way to the likely source of the contaminant.

Hyperspectral imaging systems can go beyond just finding foreign materials. Unlike multispectral or camera-based systems, hyperspectral systems can assess quality measures such as steak tenderness or fat/lean ratios in sausages and can find myopathies like woody breast or spaghetti breast in poultry.

Hyperspectral systems are also exceptional in another way: These systems can

use artificial intelligence (AI) to learn from the chemical data they collect over time. This makes these systems highly effective at identifying new or unexpected contaminants. It also means these systems can grow and change over time as the needs of a processing plant change, without the need for new capital equipment.

Recent advances in computing and computer processing have made it possible

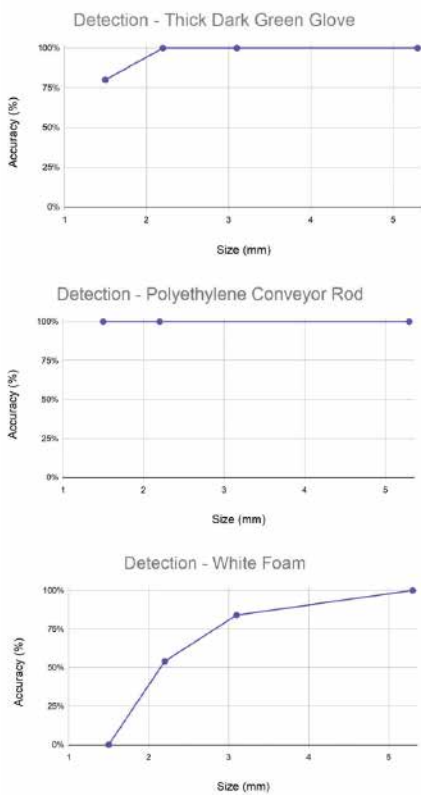


Figure 2: Examples of detection curves for a hyperspectral imaging system.

for these hyperspectral systems to operate on the line in real time.

How to Choose a Vision-Based System

Vision systems have tremendous advantages for food processing, but it’s important to know which system is the right one for your plant. Asking the right questions will help guide your selection process.

First, ask to see a detection curve for the system. A detection curve, a chart that shows object size plotted against probability of detection, will give you a very clear indication of how successful a system will be in detecting objects of any size. Figure 2 shows examples of detection curves for different materials identified by a hyperspectral imaging system.

A detection curve provides much more useful insight than simply asking about the smallest size of object a system can detect. A system that claims to find microscopic objects, for example, might only find them in very rare instances.

Second, ask about false positive rates. Using the same example, a system might claim to find a very high number of tiny objects. But what if many of these detections are false positives, meaning that there is no contaminant actually present? A lot of valuable product may be unnecessarily discarded.

Finally, ask if the system is future-proof. Will it be able to expand to detect new types of contaminants over time? Might you need to evaluate quality metrics in the future? Plants are constantly evolving, and new processing techniques or types of products bring in new forms of contaminants and evolving quality issues. Will the system be able to adapt to these changes?

The food processing sector is embracing innovation at a faster pace than ever before. But, as with any evolving technology, the key is understanding the differences among available detection systems. The right approach for your business may even be a combination of different systems—a multi-hurdled approach.

Asking the right questions will guide you in your selection and help drive efficiency and safety in the plant, while reducing food waste and costs in the long term. ■

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How Remote Monitoring Can Improve Water Treatment Management

These systems can help keep watch on water conditions at your food processing facility

BY **ROB FUSCO**

Food processing plants use millions of gallons of water every day, and water treatment and wastewater management are important components of the operation. Processes that consume vast amounts of water include washing, rinsing, cooking, butchering, cleaning, disinfecting, bottling, canning, and packaging. Incoming water must be treated to ensure safety and quality before it can contact food products, and wastewater must be treated before it is reused or discharged because it contains processing debris.

The type of food product, such as meat, poultry, fish, fruits, vegetables, oils, and

dairy, determines the methods the facility uses to treat the wastewater. But they all have one thing in common: Federal, state, and local regulations require food processing facilities to properly treat wastewater before it is discharged. No matter the size of the water treatment system, food processors cannot afford a malfunction, which could result in releasing untreated water, contaminating the environment, paying fines and citations, and suffering public contempt.

Remote monitoring systems are an affordable way to keep watch on water treatment conditions. They send immediate notification when a sensor reading moves

outside of preset parameters. The systems integrate seamlessly into floats, pump alarm outputs, level transducers, and other equipment. Operators can check the status of the sensor readings at any time by logging into a website, calling the device, or checking an app, depending on how advanced the system is.

Here are four ways to improve water treatment management using a remote monitoring system.

1. Receive Early Notification and Conduct Predictive Maintenance

Using a remote monitoring system with water treatment and wastewater pro-



Remote monitoring base unit.

cessing equipment is a low-cost way to receive immediate notification of potential malfunctions that can lead to breakdowns. Modern pumping systems typically include alarms that alert operators when a malfunction occurs. However, by integrating a remote monitoring system with the right sensors and using data logging functionality, operators can perform predictive maintenance, prevent unscheduled shutdowns, and optimize the best efficiency point of the pumps and components.

For example, many different operating conditions reduce the lifespan of a pump. A clogged intake, suction loss, or cavitation can stress components of the pump and cause it to fail prematurely. Bearing wear, deadheading, dry pumps, and impeller jams can cause early motor and pump failure. If a pump stops and no one notices right away, the malfunction can damage other equipment and send untreated water into the facility and the surrounding environment. Receiving an alert from a monitoring system as soon as possible can save a lot of time and money in clean-up costs, production downtime, and possible fines.

Advanced monitoring systems for wastewater plants can easily interface with any equipment that uses a programmable logic controller (PLC) with Modbus communications. The monitoring system

directly interfaces to the PLC over Modbus, providing sensor status data on demand. It also alerts designated personnel when sensor readings move out of the normal parameters, signaling that preventive maintenance is required.

Cloud-based technology lets users check conditions from anywhere in real time from a mobile device, tablet, or computer. They can view the state of multiple water and wastewater locations, access pump run-time and flow reports, check specific equipment status and review alarm history without having to install any software. Monitoring systems also log data automatically, which enables operators to analyze trends and improve performance system-wide.

Providers of advanced monitoring systems use private cloud services that are not shared with the public. These providers monitor the cloud platform around the clock and have multiple backup server sites across the country to ensure the system is never down.

2. Select and Place Sensors

The ideal remote monitoring systems for water treatment operations should monitor Modbus data registers as well as support several digital or analog sensor inputs. This enables operators to cast a wide monitoring safety net. The selected sensors depend upon the conditions the

user wants to monitor, how many base units are in use, and how many sensors each unit can handle. Typical conditions to monitor include tank levels, pump status, flow rate, turbidity, temperature, humidity, water leaks, vibration, pressure, run times, power, and voltage.

Key monitoring points and sensors for water treatment and wastewater processing systems include:

- Disinfectant (alkalinity sensor, pH sensor, turbidity sensor);
- Clarifier (sludge-level sensor, chlorine sensor, oxidation-reduction potential sensor);
- Pumps (vibration sensor, pressure sensor, current amperage, run times); and
- Motor/generators (voltage sensor, flow rate sensor, vibration sensor).

3. Evaluate Relevant Types of Condition Monitoring

Let's take a closer look at a few examples of condition monitoring important for water treatment systems.

Vibration. Every rotating machine has its own vibration characteristics, and when a part starts going bad, those characteristics change. For example, if the seals or bearings on a pump begin to fail or if an impeller breaks, vibrating increases. Although this change would not be noticeable to the human eye or ear, it is easily detected by a vibration sensor installed on the pump. The sensor reads the pump's acoustics to detect imbalances, providing early warning of issues arising within the pump.

Each vibration sensor communicates its frequency readings in real time to the remote monitoring system, which sends



Thermal flow rate sensor with digital display.

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an alert when an out-of-limit value is detected. This gives operators time to take the action required to prevent catastrophic failure, secondary damage, and operational downtime.

When vibration sensors are integrated into the monitoring system, they capture vibration readings at set time intervals, which users can view in real time and/or analyze over a longer period to identify trends that indicate a failure is imminent.

Pressure. Monitoring pressure is a way to understand the characteristics of the pump and increase its life cycle. The greater the flow, the less pressure there will be on the discharge. Low flow will show a higher pressure on the discharge. Pressure sensors help to identify key problems that can prevent the pump from running within its best efficiency point. Ideally, a pump should not operate at flows plus or minus 10% of its efficiency point.

When a pump is not running at its best efficiency point, the motor temperature rises, placing stress on bearings, seals, and impellers, which reduces their service life. All this can lead to premature failure of the pumping system. A pressure sensor on the suction side, where the difference in pressure is proportional to the total head, as well as pressure sensors on both sides of the pump, are recommended.

In addition, pressure sensors monitor pump discharge, so they can alert if a pump shuts down for a long period of time or pressure drops from lack of suction. Pressure alarms let personnel take action to prevent the pumps from running dry if they lose suction for any reason.

In wastewater applications, submersible pumps are typically placed at the bottom of lift station storage tanks to pump suspended solids, sewage, and refuse. Pressure sensors can identify blockages and flooding so that operators can turn on additional pumps during flooding, equalize wear on pumps, and turn pumps off when tanks are low.

Current amperage and voltage. Remote monitoring systems can easily monitor for power failures, which obviously stop pumps and other equipment from running altogether. Taking this a step further by continually monitoring the pump's motor current can help to determine if there is a hidden problem. A pump running at over-

current for a long period of time, even by small amounts of 5% to 10% of its rating, will ultimately overheat, damaging internal components and causing the pump to prematurely fail. Bad or failing bearings, clogged lines, or material jammed within the pump can also cause an overcurrent problem.

Reduced flow caused by a blockage can cause an undercurrent situation. In an overvoltage situation, the current can increase and cause motor temperatures to run higher when the load decreases, causing a surge in voltage to the pump's motor. Similarly, if the voltage sags under heavier loads, the motor can suffer from a low-voltage state, which will increase the motor's current.

In any pump installation, the amount of current (amperage) the motor draws correlates directly to the size of the load. Adding a current transformer (CT) on the pump's incoming power will monitor the

pump's current draw. A severe increase or decrease as described above indicates a pump problem that requires immediate attention.

In pump installations, problems like suction loss and jams can cause serious damage to the motor or pump long before the thermal overloads trip. These problems can be detected within milliseconds of the occurrence by monitoring the drive motor current with a current transformer.

4. Acquire and Review Data

As noted above, advanced remote monitoring systems are equipped with data acquisition capabilities that automatically provide real-time and historical operating information on pump and equipment performance. This lets employees collect and record precise data, including flow rates, run times, and all of the operational principles involved in pump monitoring. Because the system automates the record-keeping, personnel can easily generate accurate information required for regulatory reports and internal review.

Operators can also configure flow meters with multipliers to determine how much flow a station is outputting. These values can be recorded and archived, so operators can create monthly and yearly reports. Important run times to include for data measurements include total hours a pump has worked, how much accumulated time it has operated per day, and work cycles on pumps.

Other reports such as alarm logs can be crucial tools to determine how much time the system was offline and when it came back online.

Clearly, it is vital for food processing facilities to keep water treatment and wastewater processing operations running as efficiently as possible. A remote monitoring system with integrated and external sensors is a low-cost way to provide early warning of malfunctions. These alerts enable operators to conduct predictive maintenance and automate data acquisition and reporting. Monitoring systems provide an extra layer of protection to make sure equipment is running properly to keep the pumps working and water flowing. ■

By integrating a remote monitoring system with the right sensors and using data logging functionality, operators can perform predictive maintenance, prevent unscheduled shutdowns, and optimize the best efficiency point of the pumps and components.



Fusco is the director of business development at Sensaphone and has been working in the remote monitoring industry for nearly 25 years. Reach him at fuscoco@sensaphone.com.

Food Service & Retail



Industry Standards and the “Last Mile”

How standards can help keep temperature-sensitive products safe during food delivery | BY NEIL COOLE

Looking back pre-pandemic, it's safe to say that the e-commerce food and retail delivery industry was growing at an impressive rate, with consumers ordering meals and groceries online for the sake of comfort and convenience through apps such as GrubHub, Uber Eats, and others. However, with consumers sheltering in place as a result of COVID-19 and generally spending more time at home amidst varying levels of lockdown restrictions around the world, it's no surprise that the resulting effects on consumer buying habits have increased e-commerce by an incredible 44% in 2020, as highlighted in a recent report by Digital Commerce 360. It's also no surprise that this placed a significant demand on the food and retail supply chain to keep up with the spike in consumer demand.

The numbers are quite telling from a commercial performance perspective, considering that in-store retail sales grew from \$3.7 billion in 2019 to \$4.04 billion in 2020, representing a 6.9% increase. At the

same time, e-commerce sales jumped from \$598 billion in 2019 to \$861 billion in 2020, a staggering 44% increase that Digital Commerce 360's report attributes directly to the pandemic.

Growth is a positive thing for the food and retail industry. The e-commerce effect of the pandemic has given organizations the ideal situation to embrace new and innovative ways of fulfilling the growing demand for online orders from more discerning consumers who expect high quality and safe goods in shorter times. However, this dramatic increase in the demand for e-commerce, specifically for food and groceries, has presented the food industry with specific and important challenges, from the health, safety, and well-being of essential workers in distribution centers and behind the wheel of the delivery vehicles delivering parcels and packages every minute of every day worldwide to the safe and sanitary transportation of temperature-sensitive grocery items and prepared meals.

The Last Mile

What does this increase in consumer demand for e-commerce food and groceries mean for the “last mile” industry? First, we need to define the “last mile” industry. It is those essential organizations that operate throughout the supply chain process—everything from the ordering of the goods online to resource planning, warehouse staff, fulfillment centers, packaging, and transportation partners, from trucks to drones, on down to the “last mile” of each product's final destination.

We know that the logistics of transporting and storing refrigerated groceries involves an intricate process to confirm that precise hygiene and safety conditions are met throughout every step of the supply chain, from receipt to delivery at the designated destination.

To highlight the importance of food safety in the last mile industry, Frank Yiannas, FDA's deputy commissioner for food policy and response, conducted an insightful interview last year on the impact of the pandemic on consumer buying habits. Yiannas said that part of the work involved with FDA's “New Era of Smarter Food Safety,” an initiative designed to create a more digital, more traceable, and safer food system, involves dealing with the reality of e-commerce as more and more consumers order foods online that are delivered right to their door. “We have been considering what steps we need to take to ensure the safety of those foods in how they are produced, packaged, and transported,” he added. “When we first started talking about this, we were anticipating that 20% of groceries would be ordered online by 2023. That benchmark may have been blown out of the water by consumers sheltering in place. I don't see that trend reversing when the crisis has passed.”

The Importance of Standards

This insight highlights the need for more to be done to support organizations operating throughout this last mile industry,

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especially for refrigerated delivery service providers. These providers have a clearly defined business risk management framework that specifies the provisions and operations for all stages, from acceptance of a chilled or frozen parcel to its delivery at the final destination.

The industry highlighted the need for this best practice framework in 2017 with the publication of the publicly available specification PAS 1018:2017—“Specification for indirect, temperature-controlled refrigerated delivery services. Land transport of refrigerated parcels with intermediate transfer.” Since its publication, the standard has been adopted by the International Organization for Standardization (ISO) and incorporated into a new standard published last year, ISO 23412:2020: Indirect, temperature-controlled refrigerated delivery services — Land transport of parcels with intermediate transfer.

This standard provides organizations within the global last mile industry an internationally recognized and harmonized framework that demonstrates industry best practices to ensure that temperature-sensitive products are stored and distributed safely in order to protect the end consumer. The standard provides a practical breakdown of the essential elements of process management and risk

control of temperature-sensitive products for last mile businesses by clearly articulating terms and definitions, refrigerated delivery attributes, acceptable conditions for operating sites, refrigerated enclosures, cold stores and cooling materials, transportation networks, geographical routing systems through to information exchange, the acceptance and transfer of chilled or frozen parcels, up to the final delivery of the parcel to its final destination.

An example of how industry sectors have leveraged and benefited from the use of ISO standards in the past would be cargo or freight containers that industries rely on to transport their goods around the globe. When containers were initially adopted as a means for shipping, there were many different sizes, types, and corner fittings used. This presented a variety of risks and challenges to the transport industry; the various types of containers, all with different dimensions and design specifications, being loaded onto cargo ships, railcars, and truck beds, caused a high number of cargo containers to become loose and fall off.

As a result, in August 1989, British Standards Institution (BSI) published BS (British Standard) 3951-1-1: Freight containers, General, specification for Series 1 freight containers: Classification, dimensions and ratings, which was adopted

by ISO in April 1996 as ISO 668: “Series 1 freight containers—Classification, dimensions, and ratings.” This standard has been updated over the years and is still used to ensure that all cargo and freight containers meet the internationally adopted classification, dimensions, and ratings, so now the various types of containers are all manufactured to the same specifications and fit on cargo ships, railcars, and truck beds like Lego pieces.

Continued Protection

The e-commerce and last mile industries are growing at an exciting pace. And, throughout the last mile industry, those risks that are present today related to the safe and hygienic distribution of temperature-sensitive groceries can be managed through the use of standards to better protect the products and consumers for tomorrow. Consider standards as a method that describes the best way of doing something, such as manufacturing a product, supplying materials, and managing a process or behavior. Voluntary and consensus-based standards are the distilled wisdom of people with expertise in their subject matter, experts who know the needs of the industries and organizations they represent. ■

Cooler is director of food and retail supply chain at BSI Americas. Reach him at neil.cooler@bsigroup.com.

How to Control Food Dusts ... (Continued from p. 25)

Q. Which facilities are required to have their dust tested?

NFPA standards require a dust hazard analysis (DHA) for any facilities that generate, handle, or store potentially explosive dust. The burden of proof is on manufacturers to demonstrate that their dust is not combustible, so it is important for them to have their process dust tested by a valid third-party testing lab and keep records on file proving that it is not combustible.

If tests show that the facility has combustible dust, NFPA Standard 652 requires the completion of a DHA of the dust collection system. Operators also need to keep this report on file to show when requested by the local fire marshal or any other authority with jurisdiction. In addition, explosion venting equipment must be

inspected at least annually based on the documented operating experience.

Q. How are explosion vents and discharge ducts sized to make sure they are right for a dust collector?

Chapters 7 through 9 of NFPA 68 provide the calculations to use for properly sizing explosion vents, vent discharge ducts (also called vent ducts), and other components. A reputable dust collector supplier will follow the vent sizing equations in chapter 8 (Venting of Deflagrations of Dusts and Hybrid Mixtures). The supplier can also provide a calculations sheet that becomes part of the documentation manufacturers keep on file to demonstrate the plant's compliance. An experienced dust collector supplier may also have performance-based solutions for this type of equipment, which is also allowed by the NFPA standards.

Q. Is it safe to recirculate the air from your dust collector back into the work environment?

Recirculating heated or cooled air back into the workspace can provide significant energy savings and eliminate the cost of replacing that conditioned air. Containing the air indoors also avoids the time-consuming permitting involved when contaminated air is exhausted outside. Recirculating the air can be done safely, even if the facility handles explosive dust, by outfitting the dust collector with a safety monitoring filter. This helps isolate the downstream equipment from the progression of a flame front during an explosion. ■

Thomason is the senior applications specialist at Camfil Air Pollution Control and has served in the dust collection industry for 35 years. Reach him at filterman@camfil.com.



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Environmental Scrub Sampler

The 3M environmental scrub sampler with 10 mL wide spectrum neutralizer is a solution for environmental microbial sampling applications. Designed for use with downstream detection methods such as 3M Petrifilm Plates and the 3M Molecular Detection System, this new technology offers the food manufacturing industry a broad solution for proactive, integrated environmental monitoring and food microbiological testing. The scrub sampler is an environmental microbial sampling device used to collect samples from surfaces within food processing environments and is designed with acrylic scrub dot technology to disrupt biofilm and enhance sample collection, comes with or without a stick to access hard-to-reach spaces, and is hydrated with a wide spectrum neutralizer for effective neutralization of sanitizers commonly used in the food industry. **3M, 800-328-6553, 3m.com/environmentalscrubsamplerinnovative.**

Foam Cleaner for Poultry Processing

Chlorinated foam cleaner PoulChlor, for the poultry processing industry and beyond, is an all-in-one solution that contains detergents, chlorine, and alkaline caustic for hard-to-clean areas. The liquid, self-foaming formula can be used as a chlorinated cleaner for all equipment. After diluting two to 12 ounces of the solution in a gallon of water and applying the foam, the user should rinse the equipment thoroughly with potable water. **Birko, birkocorp.com.**



Interior Roll Up Door

The new RR200 UltraSeal interior roll-up door from Albany has a slim design and tight seal that make it useful for applications where space is limited. The door's opening and closing speeds and patented low-friction, gravity-driven technology can help optimize production processes. The door's patented bead design also creates a superior seal that minimizes levels of dirt



Food Conveyor

This conveyor from Fortress Technology features a quick release and disassembly of the deck, belt, motor, and rollers. During the sanitization process, machine operators simply unclip and disconnect the conveyor motor and lift out the entire assembly. In seconds, the conveyor belt can be removed, along with its individual components, such as rollers and bearings. The belt tension and alignment are instantly restored when clipped back into place after maintenance and cleaning, which can improve line efficiencies. To further advance inspection efficiency, the enhanced belt design also eliminates noise, which can cause unwanted vibration, which affects metal detection sensitivity and check-weighing accuracy. **Fortress Technology Ltd., fortresstechnology.com.**



and contaminants in interior areas, while also providing improved climate control. For safety, the curtain will automatically reinsert itself into the side guides if the door is ever hit, an infrared photo-eye will reverse the door if an obstruction is detected, and a soft bottom door curtain protects both people and products. The door is also available in a stainless steel version. **Albany, 800-252-2691, albanydoors.us.**

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19-21
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15-20
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 Virtual Event
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24-26
NAMI Meat Industry Food Safety Conference
 Chicago, Ill.
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August 27-September 2
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 Boston, Mass.
 Visit aoac.org
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28-29
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5-9
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SCIENTIFIC FINDINGS

For access to complete journal articles mentioned below, go to “Food Science Research” in the June/July 2021 issue at foodqualityandsafety.com, or type the headline of the requested article in the website’s search box.

Salmonella in Eggs: Risk Factors from Shopping to Consumption

Nontyphoidal salmonellae are among the most prevalent foodborne pathogens worldwide. A high number of cases and outbreaks of salmonellosis are associated with the consumption of eggs and egg products, and several of these occur at the household level. The aim of this study was to critically evaluate the current status of knowledge regarding *Salmonella* in eggs from a consumer perspective, analyzing the hazard occurrence and the good practices that should be applied to reduce salmonellosis risk. The authors followed a HACCP-based approach, and some steps along the food journey were identified as steps in which consumers can significantly reduce the level of *Salmonella* in these products. From shopping and collecting to consumption, each of these steps is discussed in this review to provide an evidence-based overview of risk factors of human salmonellosis related to egg consumption. The main message to consumers is to choose *Salmonella*-free eggs when available, especially for dishes that are not fully heat treated. Additionally, because guaranteed *Salmonella*-free eggs are only available in a few countries, refrigerated storage from the point of collection and proper cooking will significantly reduce the risk of salmonellosis. This will require a revision of the actual



recommendations/regulations, because not all ensure that eggs are maintained at temperatures that prevent growth of *Salmonella*. **Comprehensive Reviews in Food Science and Food Safety. 2021;20:2716–2741.**

Aflatoxin Contamination of Agricultural Products and Foods

Aflatoxins represent a global public health and economic concern, because they are responsible for significant adverse health and economic issues affecting consumers and farmers worldwide. Countries with warmer climates and staple foods that are aflatoxin-susceptible shoulder a substantial portion of the global aflatoxins burden. Enactment of regulations, prevention of pre- and postharvest contamination, decontamination, and detoxification have been used to prevent human dietary exposure to aflatoxin. Means that exploit the chemical and structural properties of aflatoxins are devised to detect and quantify their presence in foods. In this article, recent developments in several important aspects impacting aflatoxin contamination of the food supply, including



fungal producers of the toxin, occurrence in food, worldwide regulations, detection methods, preventive strategies, and removal and degradation methods, are reviewed and presented. Knowledge gaps and current challenges in each discussed aspect are identified, and new solutions are proposed. **Comprehensive Reviews in Food Science and Food Safety. 2021;20:2332–2381.**

Predicting Salmonella in Agricultural Surface Water



This paper aims to create a new hybrid ensemble data mining model to predict the presence of *Salmonella* in agricultural surface waters based on the combination of a heterogeneous ensemble approach for feature selection, clustering, regression, and classification algorithms. The data set for this study was collected from six agricultural ponds in central Florida consisting of 23 features with 540 instances (26 *Salmonella* positive and 514 *Salmonella* negative). The model consisted of three stages. Initially, a heterogeneous ensemble feature selection approach was applied to select top features. Then, the k-means clustering algorithm was

implemented to remove misclassified cases from the data set. Finally, classification and regression algorithms, including support vector machine, naïve Bayes, artificial neural network (ANN), and random forest (RF) with a soft voting approach were applied to the preprocessed data set to predict the *Salmonella* presence in agricultural surface waters with the amount of test set. These algorithms were combined in 10 different ensemble models through the soft voting approach. The performance of these hybrid ensemble models was also evaluated. The ensemble ANN+RF model achieved the highest performance and outperformed all other single and ensemble models based on area under the ROC curve and prediction accuracy. The findings emphasize the validity of the authors’ hybrid ensemble model, which encourages researchers to predict *Salmonella* presence in agricultural surface waters. **Journal of Food Safety. Published April 11, 2021; doi:10.1111/jfs.12903.**



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