7 WAYS

ANTIMICROBIAL LIGHT DELIVERS

A CLEANER BOTTOM LINE

THE FOOD & BEVERAGE MANUFACTURERS' ROI GUIDE TO SAVING TIME AND MONEY

vyv

The Contamination Challenge

Maintaining clean production lines is one of the most critical challenges facing food and beverage manufacturers. Tight regulations ensure that production processes and manufacturing environments meet stringent safety guidelines. If products or equipment are found to be contaminated, lines are shut down while everything is thoroughly cleaned. The impact to the bottom line can be significant in some very direct ways:

- Specialized contamination clean-up is very costly (chemicals plus labor).
- The financial opportunity cost of a temporary shut-down increases by the minute.
- Already-processed goods must be discarded at a total loss, while raw materials are discarded or safely stored for future use.
- The sum of these and other associated costs can be staggering and deeply regrettable.

Depending on its complexity, cleaning a production line and getting it running again can take hours or days. Specific protocols must be followed to properly clean the impacted environment. Often manufacturers bring in third-party contractors that may cost thousands of dollars per hour.

The larger or more complicated the contamination is, the longer it takes—and the more it costs—to remediate. And when contamination is not caught in time—and a product ships—a costly and time-consuming product recall may become necessary. Product recalls are not only financially expensive, they can have a material impact on a company's standing with suppliers, distributors and consumers. Recalls can also cause a backlash in the stock market, causing a company's value to plummet once news of a contamination breaks. Damage to a brand's reputation can take years to overcome, depending on the scope of the contamination and resulting media coverage. Most U.S. consumers can probably name at least one brand or product category associated with a food recall caused by contamination.

Beyond the financial costs of food contamination, there is a very real human toll. According to data from the U.S. Centers for Disease Control and Prevention, each year approximately 48 million people in the United States (about 1 in 6) become sick from food-borne illnesses; 128,000 are hospitalized; and 3,000 die from these (largely preventable) illnesses. Other CDC data show that there are thirty-one major pathogens acquired in the United States (versus from foreign travel) that are responsible for these illnesses. Nontyphoidal *Salmonella* was found to be the leading bacterial cause of illness (11%), and the top cause of hospitalizations (35%) and death (28%). Another common food-borne bacterium, *Listeria* monocytogenes, is estimated to be the third-leading bacterial cause of death (19%). What's even more troubling is that the actual numbers are likely much higher, with public health experts believing that cases are under-reported because only a small proportion of these illnesses are confirmed by laboratory testing and reported to public health agencies.*

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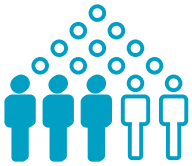


3,000
people die every year from food-borne illnesses*

$10 MILLION
average direct cost per food recall due to contaminaton**

* Source: Centers for Disease Control and Prevention, 2011 annual data
** Source: Grocery Manufacturers Association

Antimicrobial Light: A New Way to Clean in the 21st Century

Until recently, the choices to combat microbial contamination within food and beverage manufacturing environments were typically limited to:

- Wiping and mopping with strong chemicals
- Power-washing and deep cleaning by specialized cleaning services
- Disassembling equipment, cleaning it and rebuilding it, typically using outside services

Now there is a new approach to mitigate contamination: antimicrobial light, a light wave frequency between 400 and 420nm that specifically targets bacteria, fungi, yeast, and mold by creating an inhospitable environment that prevents further growth of microbes on surfaces within the production environment.

Originally discovered in England in 1892 using filters and sunlight, this light technology has evolved to become flexible and highly efficient using the digital tuning capability of LED. The breadth and depth of use cases are phenomenal: chief among them, food safety. In the case of food and beverage manufacturing, Vyv's lights can be configured precisely to target specific areas (throughout all Production Zones) where bacteria are present, likely to grow or likely to be transmitted to other Zones. The key benefit of Vyv's antimicrobial lighting solutions is the fact that Vyv has patented a single LED diode to emit this specialized light, enabling it to both illuminate large places such as manufacturing environments, while also providing continuous protection inside very small and hard-to-reach spaces, such as directly within the processing line itself, or underneath equipment.

Vyv antimicrobial light is unlike UV light, which is inherently dangerous because it attacks DNA to destroy the cellular structure in all living things (including people). Vyv's technology uses a selected light wave that meets the international standard for continuous and unrestricted use around humans (IEC 62471, 2019). There are countless advantages to antimicrobial light as an ideal complement to more traditional ways of cleaning. Studies show that Vyv's antimicrobial LED light technology can be used on materials like stainless steel, glass or plastic surfaces, whereas UV is known to degrade materials found in food and beverage manufacturing environments. This new class of antimicrobial lights cleans continuously, as part of a multi-layered defense system.

This new class of antimicrobial lights cleans continuously, as part of a multi-layered defense system.

A New Foundation to a Layered Antimicrobial Defense System

Food and beverage manufacturers can benefit from an enhanced layered approach to post-contamination cleaning by leveraging the continual cleaning power of Vyv's LED light technology. This technology is proven to be effective in defending against both the growth and the spread of microbes. Once in place, these lights work nonstop, keeping production environments at a significant reduction in microbe count. By using these lights, episodic spraying and wiping can potentially be reduced. Using less harsh chemicals and having a cleaner processing line and environment will also save time and money.

In a world where one bad headline can amount to millions of dollars in lost market capitalization, and the cost of a product recall averages $10M it's worth taking a look at how an investment in this new type of continuous antimicrobial light can reduce the impact of contamination; promote the company's commitment to the health and wellness of its employees and customers; and directly impact the bottom line.

7 Ways Antimicrobial Light Delivers a Cleaner Bottom Line An ROI Guide for Food & Beverage Manufacturers

1. Less unexpected downtime. Reduces the need to hire expensive contamination clean-up crews on short notice. Also less financial opportunity cost of lost productivity.
2. Reduce strength of chemicals used for episodic cleaning and the expense of disposing of chemical waste.
3. Decreased potential for FDA fines or recalls (see Figure 2).
4. Less exposure for materials to corrosive chemicals that degrade the rubbers and plastics in production equipment. Therefore, potentially decreased demand and frequency for expensive replacement parts and labor.
5. Less damage from mold, and therefore, decreased need for mold remediation
6. Less product loss (waste) due to microbial contamination.
7. Neutral or positive impact on the value of your brand integrity and ultimately, stock value by gaining a reputation as a meticulously clean manufacturer and corporation that is committed to hygiene, health and wellness.

Figure 1: **7 Ways Antimicrobial Light Technology Delivers a Cleaner Bottom Line**. Source: Vyv, 2020

Vyv's new class of antimicrobial light provides significant benefits and payback in multiple ways:

- Increased up-time
- Greater protection for your brand's reputation and integrity
- Tangible proof of the company's investment in health and wellness for employees and customers
- Less time, money and effort spent on sanitation overall

The Impact of Microbial Contamination

In 2019, the FDA issued approximately 350 recalls, market withdrawals and safety alerts. Of that number, 111 were attributed to potential or confirmed microbial contamination—data that demonstrate that the incidence of bacterial growth is the leading cause of market disruption for the food and beverage industry. Regardless of the resolution of each occurrence—whether a fine, forced or voluntary recall, quiet self-directed market withdrawal or alert—a few things are certain: production in each instance was stopped; products had to be discarded; and specialized cleaning needed to be hired quickly.

Nearly one-third (32%) of FDA recalls, market withdrawals and safety alerts for food and beverages are due to "potential for or confirmed microbial contamination."

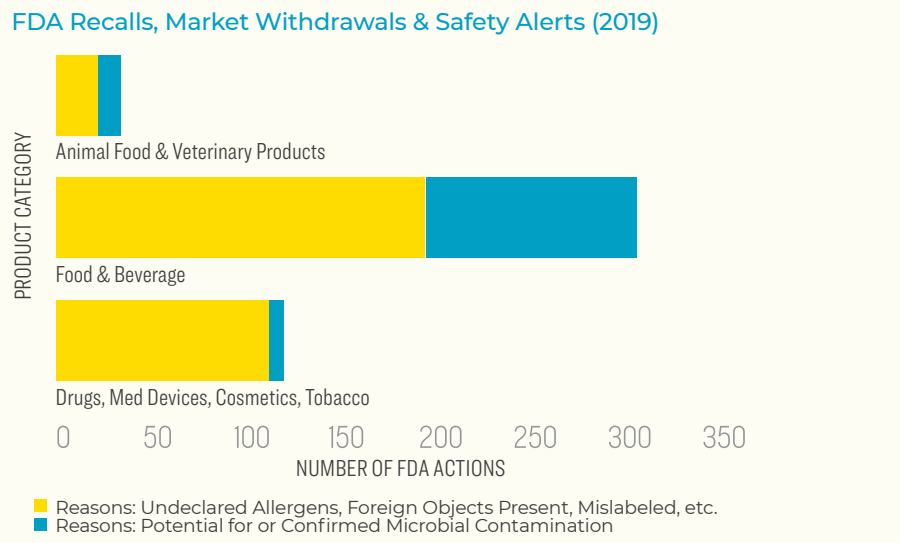


Figure 2: **FDA Recalls, Market Withdrawals & Safety Alerts.** Source: FDA, 2020

Applying Vyv's Continuous Cleaning Solution to Food and Beverage Processing

Vyv's antimicrobial LED light technology provides both illumination where and when light is needed and creates an inhospitable environment for pathogens and other microbes in manufacturing environments where bioburdens require tight control. Vyv works to attain the maximum dosage levels of antimicrobial action by tuning the power of these lights to specific lux levels, angles and distances from the targets. This comprehensive approach has been tested in many settings, all concluding that Vyv antimicrobial LED light technology is a powerful and highly sustainable way to reduce pathogens while at the same time having no negative impact on surfaces.

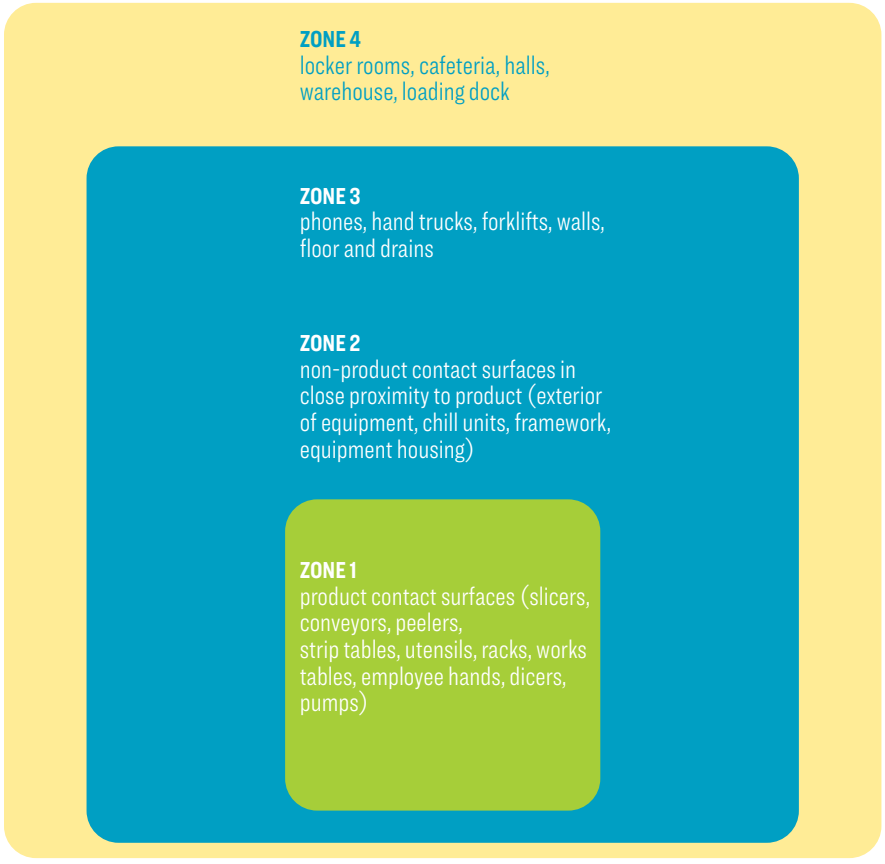
Consider a warm, humid processing environment where mold can easily grow unabated. Vyv's lighting technology is flexible enough to light the entire production line, as well as the hard-to-reach spaces, flipping that ideal environment for growing mold into a textbook case for the efficacy of Vyv antimicrobial light.

Zeroing in on Production Zones

Of the three components of food production—raw ingredients, the manufacturing process itself and the processing environment—it is the processing environment that the FDA's Food Safety Modernization Act (FSMA) looks at most closely. An environmental monitoring program is necessary for measuring the overall effectiveness of microbiological controls in food processing facilities, enabling companies to be proactive in preventing food-borne contamination.

The Environmental Monitoring Zone Concept is a framework that separates food and beverage production environments into four zones, each with specific propensities for bacterial growth. The highest risk is in Zone 1, with diminishing risk progressing to Zone 4. *Salmonella* and *Listeria* (and *E. coli* in meat processing) are the most common bacteria found in Zones 1 and 2, where there is a direct risk for contamination. Zones 3 and 4 are comprised of "infrastructure" including phones, computers, forklifts, hallways, floors, locker rooms and loading docks. The zones are interconnected by workers and machinery which create a risk of cross-contamination. All of the zones can benefit from antimicrobial lighting that is tuned and targeted to the surfaces in each one. Therefore, reducing the bioburden in any of the zones can have a positive impact on the sanitation of the entire production f acility, as well as the health and wellness of employees, specifically in Zones 3 and 4.

Food Production Zones (for FSMA compliance)



Source: Safe Food Alliance, 2020

Proof of the Efficacy of Vyv's Antimicrobial Light Technology in Relevant Environments

Case Study 1 | **Office Environment**
Analogous to Zone 4

Vyv's results from an installation in an office environment are analagous to Zone 4. Results of a study conducted in a busy company break room showed that Vyv antimicrobial light was effective in reducing the bioburden on the surfaces in five key areas of the room: near the toaster, refrigerator, sink, water cooler and trash can. The same items and similar surfaces are found in Zone 4 of food production facilities—break rooms, locker rooms, cafeterias and hallways. Each of the five sites were swabbed once per day for 10 days at roughly the same time each day. Sites were sampled before the antimicrobial lights were installed to gather baseline values and again at 8 and 12 weeks post-installation.

The baseline (pre-install) counts were indexed as 100% of the total and the percent of bioburden remaining compared to that baseline was calculated for the two post-install time points. The addition of antimicrobial light decreased the presence of bacteria in all areas:

- Average decrease of 1-log, or 90%, in surface bioburden after Vyv's antimicrobial technology was installed, compared to baseline
- 1.12-log decrease was reported at 12 weeks post-install
- An average of 89.8% and 92.4% decreases in surface bioburden across all sites were reported at 8 and 12 weeks post-installation respectively

After 12 weeks under Vyv antimicrobial lights, the average reduction in bioburden across all surfaces was **92.4%.**

Source: Vyv, 2020

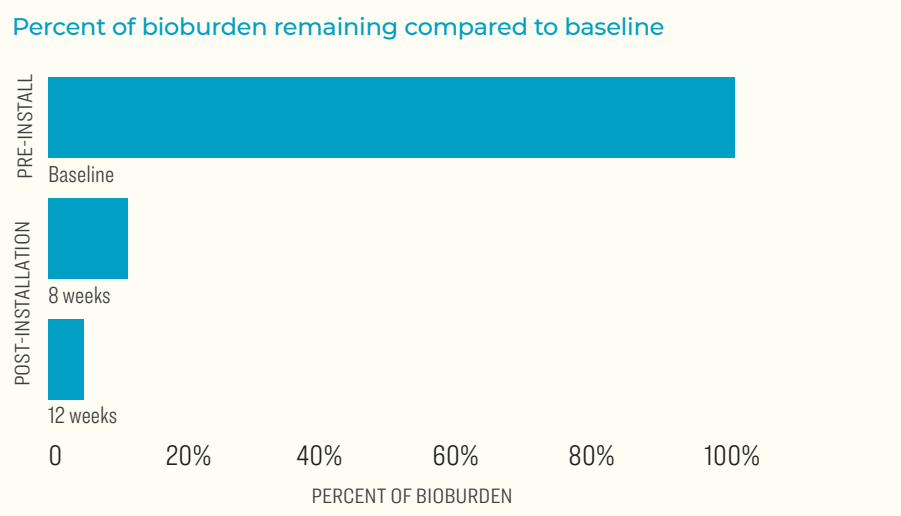


Figure 3: **Results of Vyv antimicrobial lighting in an office environment.**
Source: Vyv, 2020

Case Study 2 | **SUNY/Stony Brook University Hospital: Nurses' Station**
Analogous to Zone 3

Another Vyv study, at New York's Stony Brook University Hospital, was conducted in and around the nurses' station adjacent to the Medical ICU, including the surrounding hallways and waiting room. The results showed reductions in bacteria on the office equipment in the station: phones, computers, mice, countertops, copy machines and keyboards. In all, twenty surfaces were tested and all showed dramatic decreases in bioburden, on average decreasing from a colony count of 55 CFU/Plate to 30. The testing took place over a 24-week period and the site was active non-stop (similar to many food production facilities). With no downtime, there was no opportunity to turn the Vyv lights on as "blue-violet lights" where they would be in cleaning mode only. Instead, they were constantly providing illumination as well as antimicrobial impact throughout the twenty-four weeks.

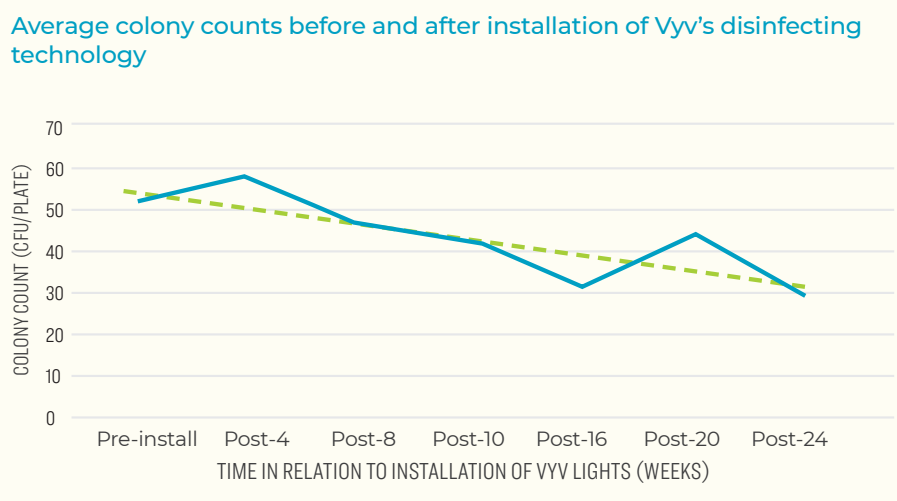


Figure 5. **Average colony counts across 20 surfaces before and after the installation of Vyv lights.** (Source: Vyv, 2020)

STONY BROOK UNIVERSITY	
SITE #	**LOCATION DESCRIPTION**
1	Nursing Station 1 (NS1) Keyboard
2	NS1 Phone
3	NS1 Phone
4	NS1 Chair Arm
5	NS1 Crash Cart/Paper Disposal/COW
6	Nursing Station 2 (NS2) Keyboard
7	NS2 Phone
8	NS2 Copy Machine
9	NS2 Chair Arm
10	NS2 Crash Cart/Paper Disposal/COW
11	Nursing Station 3 (NS3) Keyboard
12	NS3 Phone
13	NS3 Mouse
14	NS3 Keyboard #3
15	NS3 Countertop
16	Core Fax Machine
17	Core Phone
18	Core Printer
19	Family Room Tabletop
20	Family Room Seat Cushion

Figure 4. **Sampling sites adjacent to MICU nurses' station.** Source: Vyv, 2020

Case Study 3 | **HP Hood LLC: Food/Dairy Production Environment**
Analogous to Zones 1 and 2

A third study conducted with New England dairy HP Hood proved that Vyv's antimicrobial technology reduced 90-99% of each bacterial species found in the manufacturing process without harming the surrounding materials.

Vyv measured the presence of eleven microbial species—a wide range of dairy, spoilage, and pathogenic microbial strains in liquid conditions—and compared their growth under Vyv antimicrobial lighting to the same strains grown under ordinary fluorescent lights. The experiments were performed at higher lux intensities to accelerate results, but did not impact the results themselves—they were just delivered sooner.

Small samples were taken from the liquid cultures at a variety of time points and plated. Two of the species were specific to dairy processing, and therefore are not reported here. The results—across the board—of the nine remaining microbial species all showed 90% or 99% reductions in bacterial counts compared to the control cultures. The results clearly demonstrate the ability of Vyv's antimicrobial lighting technology to play a role in reducing the presence of pathogens and spoilage microbes that are found in food and dairy processing.

The second objective was to evaluate the degradation of manufacturing materials under Vyv antimicrobial lights vs normal LEDs. Materials testing consisted of exposing a variety of gaskets, tubing, wash-down hoses, bottles and finished packaged products to Vyv lights and comparing them to materials exposed to normal LEDs to check for material breakdown. The lights were set to at least 1000 lux (2x the more typical 500 lux) and materials were exposed for as long as seven days. At the conclusion of the testing period, the food processing materials showed no difference in quality after being exposed to the antimicrobial lights, compared to ordinary LED lights.

Antimicrobial technology was proven to eliminate 90-99% of each bacterial species found in the manufacturing process without harming the surrounding materials.

Conclusion

Vyv's antimicrobial lighting has been proven effective in use cases that occur in food and beverage manufacturing facilities. The technology's flexibility in its ability to cover large areas as well as tiny crevices makes it even more valuable in this environment, as the number of practical applications within each of the Production Zones are numerous. Companies that lead the way by investing in a multi-layered defense system that includes antimicrobial light will benefit from the hard and soft ROI described in this paper. Early adopters will be able to use this approach as a competitive differentiator and can portray themselves as innovators to their shareholders, employees and customers.

More about Vyv antimicrobial lighting at **vyv.tech**