

Discovering *Bacillus* Strains that Tackle the Most Challenging Odors



Author: Jennifer Cray

Newly discovered *Bacillus* strains used to formulate Microbial Discovery Group's (MDG) microbial-based cleaning product ingredient SporActiv® CLEAR are effective against some of the most challenging odor compounds. The most common concerns in industrial, institutional, and consumer (IIC) cleaning applications are odors and the removal of organic material like fats, oils, and grease (FOG) and stains. Many *Bacillus* strains perform well against a wide variety of organic material, but we found that the market-leading *Bacillus* strains available today were not able to tackle many difficult-to-degrade odor compounds. We set out to find *Bacillus* strains that could deliver next-level performance as a cleaning product ingredient and fill gaps in the market by demonstrating impressive results against FOG, stains, and difficult odors.

Why choose *Bacillus* for your cleaning products?

Consumer demand for environmentally friendlier microbial-based cleaners is steadily increasing. In fact, the microbial-based cleaning product market alone is projected to be valued at \$8.52 billion by 2030.¹ These products replace chemicals with beneficial strains of bacteria as the active ingredient. The bacteria in these products use organic material like FOG, food waste, and odor compounds as food sources. As the microorganisms grow and consume more of these food sources, they remediate stains, drain buildup, and odors.

Bacillus species are some of the most frequently used organisms in microbial cleaners thanks to their ability to digest a wide variety of substrates. One way *Bacillus* achieve this is through the production of enzymes that help break down complex nutrients in the environment into simple compounds that *Bacillus* can consume. This also makes the nutrients more easily accessible to the rest of the native microbial community to be used as food. The extra activity boost from the whole community helps remediate even more organic material. Through this process, *Bacillus* break down and remove lingering FOG, food, waste materials, and odors in IIC applications like kitchen drains or stains on floors. While *Bacillus* are generally very effective at removing organic material, some odor compounds can prove more challenging.

Smell can leave a big impression on people, with 93% of US adults saying that foul odor would cause them to have negative overall opinions of an organization.² Odors can originate from a wide range of sources. They are typically the byproduct of the breakdown of biological material, but the specific compound causing the odor and the resultant smell varies. Bathroom odors, for instance, are often caused by compounds like ammonia, uric acid, and skatole (a foul-smelling component in feces). Many *Bacillus*-based cleaners can utilize ammonia and uric acid to support *Bacillus* growth and effectively reduce odors associated with these compounds. It is uncommon, however, to find *Bacillus* that are able to break down and remediate skatole. This inspired us to search for new *Bacillus* strains that can perform against difficult-to-degrade odor compounds that other market leading ingredients can't tackle.

Bacillus Excel at Digesting Common Stain Culprits

Removal of organic material is a key function of microbial-based cleaning products. Some of the most challenging tasks involve the removal of FOG, which can be persistent and build up over time, and food materials, which leave stains. *Bacillus* bacteria are able to effectively use many common stain culprits and fat sources (e.g., bacon fat) to support bacterial growth (Figures 1 and 2). We have screened an additional 450+ substrates and found that our *Bacillus* can use nearly 300 of these nutrient sources, including different types of carbon, nitrogen, phosphorous, sulfur, vitamins, and more. *Bacillus* work to remediate all of these substances from the environment, leaving sinks, floors, and drains cleaner.

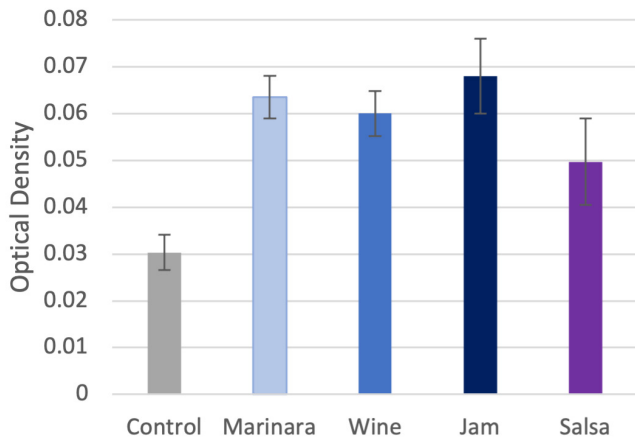


Figure 1: Bacterial growth was measured in minimal growth media treated with *Bacillus* (control) and that same media with the addition of several food substrates. There is an increase in bacterial growth when the food is added compared to the control where the food is not present. This indicates that *Bacillus* can use these food substrates to support bacterial growth. Bacterial growth was measured as optical density at 600 nm after three days.

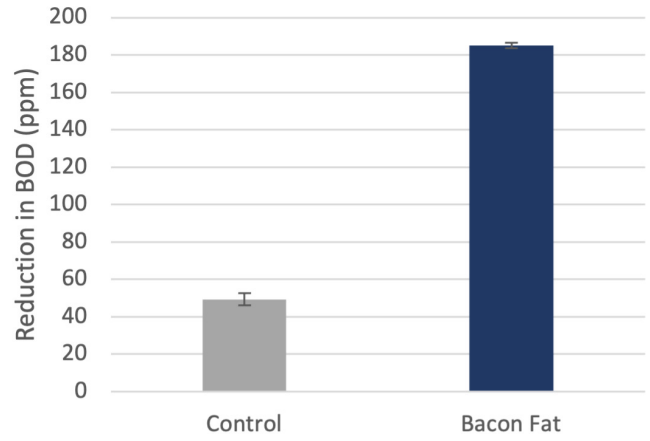


Figure 2: This graph represents the bacterial activity in minimal growth media treated with *Bacillus* (control) and that same media with the addition of bacon fat. There is a large increase in bacterial activity when the bacon fat is present, indicating that *Bacillus* consumed the bacon fat and used it to support bacterial growth. Bacterial activity was measured as the reduction in biological oxygen demand (BOD) after five days.

Odors Prove More Challenging to Remove for Many Products

While mitigating FOG and food residue is a major function of microbial-based cleaning products, odor remediation has proven to be a more challenging target. All bacteria have different strengths and capabilities when it comes to obtaining nutrients from the organic matter available in their environment. Even individual strains of the same species possess distinct abilities and specialize in utilizing different materials. For instance, some volatile fatty acids (VFAs), common culprits of foul-smelling garbage disposals, are easily digested by *Bacillus*. Other odor compounds, like trimethylamine and putrescine (substances that smell like bad fish or rotting meat and could appear in a restaurant kitchen), are more difficult. It is rare to find bacteria that can digest these challenging odor compounds that cause issues in so many IIC applications (Figure 3).

MOST MARKET INGREDIENTS CAN DIGEST

Acetic acid Uric acid
Lactic acid Ammonia

SOME MARKET INGREDIENTS CAN DIGEST

Butyric acid Propionic acid
Valeric acid Trimethylamine

FEW/NO MARKET INGREDIENTS CAN DIGEST

Isobutyric acid Dimethyl sulfide
Isovaleric acid p-cresol
Ethyl mercaptan Putrescine
Benzyl mercaptan Skatole

SPORACTIV® CLEAR

Odor-causing compounds that SporActiv® CLEAR has shown efficacy against in lab testing:

- Acetic acid
- Lactic acid
- Ammonia
- p-cresol
- Benzyl mercaptan
- Propionic acid
- Butyric acid
- Putrescine
- Dimethyl sulfide
- Skatole
- Ethyl mercaptan
- Trimethylamine
- Isobutyric acid
- Uric acid
- Isovaleric acid
- Valeric acid

Figure 3: *Bacillus* from microbial-based cleaning product ingredients in the IIC market were screened for efficacy against 16 odor compounds. Of the compounds tested, some were digested by almost all market ingredients (green), while others were broken down by only some market ingredients (yellow). It was extremely rare to find an ingredient on the market with efficacy against the remaining compounds (red), but the *Bacillus* strains in SporActiv® CLEAR digest all 16 odor compounds tested (purple).

Discovering the Best *Bacillus* for the Job

In order to find *Bacillus* capable of handling some of the toughest odors, we searched at the source. Bacteria were isolated from highly odorous environments, including wastewater samples, landfill leachate samples, and dirty garbage disposal swabs. The strains collected from these challenging locations were put to the test against a diverse array of odor compounds (Table 1). Of the 400 strains evaluated, only 2% were able to utilize at least half of the odor substrates tested. These newly discovered strains were able to remediate difficult-to-degrade odor compounds from their environments as they broke them down for use in supporting bacterial growth (Figure 4). The rare odor reduction capabilities these strains possess are relevant to a wide variety of IIC applications.

These new, high-performing odor strains were then combined with effective food-, waste-, and FOG-reducing strains to formulate SporActiv® CLEAR. This product uses *Bacillus* as the active ingredient to fight odors instead of harsh chemicals like disinfectants or biocides. Those chemical products address odors by wiping out all bacterial activity, but this method eliminates beneficial organisms along with the target undesirable bacteria. They also may not be as effective on odors that are already present. Further, chemical cleaning ingredients may leave some organic material behind that will eventually begin to degrade again, and the odor will return. The *Bacillus* strains discovered by MDG can remediate odor at the source by breaking down the odor compounds themselves. Additionally, they are able to act on any leftover organic material and help prevent new odors from forming in the future. As a result, SporActiv® CLEAR provides lasting odor reduction for some of the toughest applications.

Table 1: Odor compounds investigated in this study along with a brief description of what they are and the smells associated with them.

Compound Name	Description
Acetic acid	VFA with vinegar odor
Ammonia	Component in urine
Benzyl mercaptan	Sulfur compound with skunk odor
Butyric acid	VFA with rancid odor
Dimethyl sulfide	Sulfur compound common in fish and vegetables with a rotten cabbage odor
Ethyl mercaptan	Sulfur compound with rotten egg smell, common additive to odorless gasses
Isobutyric acid	VFA with sweaty feet odor
Isovaleric acid	VFA with rotten cheese odor
Lactic acid	VFA with sour milk odor
p-cresol	Derived from breakdown of aromatic amino acids, sickly-sweet odor common in used toilets
Propionic acid	VFA with smell of body odor
Putrescine	Associated with the smell of rotting flesh with a putrid odor
Skatole	Component in feces
Trimethylamine	Odor associated with bad fish, also produced as plants with high nitrogen content degrade
Uric acid	Component in urine
Valeric acid	VFA with spoiled milk odor

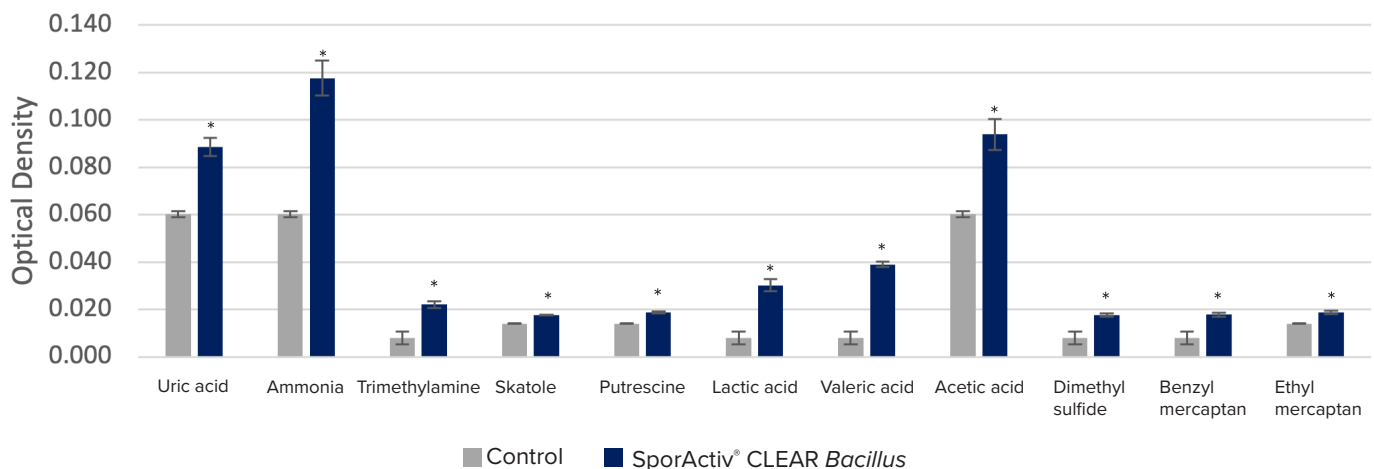


Figure 4: Bacterial growth was measured in minimal growth media treated with SporActiv® CLEAR *Bacillus* (control) and that same media with the addition of several odor compounds. There is an increase in bacterial growth when the odor compound is added compared to the control where the odor compound is not present. This indicates that SporActiv® CLEAR can use these common sources of odor to support bacterial growth. Asterisk indicates that the odor compound value is significantly different ($p < 0.05$) than the control. Bacterial growth was measured as optical density at 600 nm after two days.

Summary

Bacillus products provide effective solutions in a variety of IIC applications due to their ability to utilize common stain and odor compounds to support bacterial growth, thereby promoting continuous odor and waste reduction. SporActiv® CLEAR contains newly discovered *Bacillus* strains with elevated performance against tough-to-degrade odor compounds that other *Bacillus* products cannot break down. MDG's high-performing ingredient delivers enhanced odor remediation while also maintaining efficacy against FOG, food, and waste, making it ideal for use on pet stains, bathroom odors, drains, and more.

References

1. CleanLink. (2024, March 26). *Why microbial-based cleaning products are on the rise*. <https://www.cleanlink.com/news/article/Why-Microbial-Based-Cleaning-Products-Are-On-the-Rise--30763>
2. Oxy-Gen Powered. (2020, January 29). *New poll finds 79% of Americans say a foul odor at a restaurant would negatively impact their perception of the business* [Press release]. https://www.oxygenpowered.com/news_detail.php?nid=33