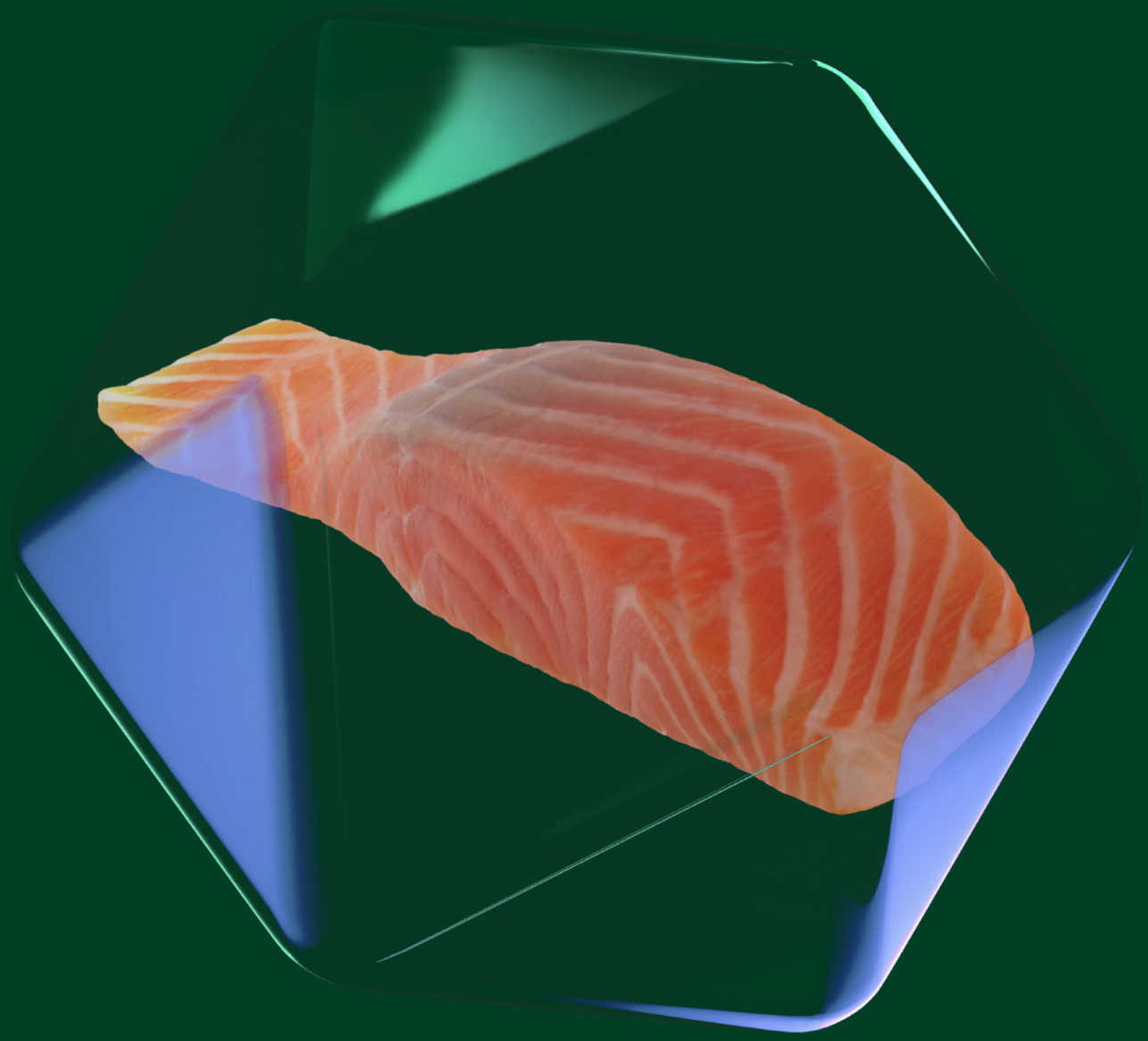
phageguard | Phage technology
Listeria control



How phages reduce *Listeria* in salmon processing

PGL

Micreos Food Safety B.V. | phageguard.com

Power of bacteriophages

Nature's force for balancing bacteria

Bacteriophages (or phages) are biological entities that serve to maintain the natural balance of bacterial populations. Every 48 hours, phages can reduce half of the world's bacterial population. This effect is due to their immense abundance. Phages are everywhere and outnumber bacteria by a factor of 10, making them the most common microorganisms on our planet. For reference: 1 ml seawater contains 1 billion phages.

The unique ability of phages

Similar to bacteria, phages are extremely diverse, with each phage having the unique ability to target a specific bacterial species down to the level of bacterial strains. This also includes food pathogens encountered in the food industry.

Phages: the future of food safety

Since 2005, Phageguard focused on developing phage solutions that specifically target *Salmonella*, *Listeria*, and pathogenic *E. coli.* Our precision-targeted phage products enable customers to achieve optimal pathogen control, without altering the organoleptic properties of treated foods or compromising natural/organic processing standards.

Phageguard L

The power of anti *Listeria* phages PGL

Designed for the food industry to control *Listeria*, Phageguard L (PGL) offers natural control of prevalent *Listeria* spp., including *Listeria monocytogenes,* on salmon. Leveraging the precise targeting ability of phages, PGL provides effective *Listeria* reductions while preserving the delicate sensory attributes of seafood. As a result, PGL acts as a modern shield, improving the food safety of your salmon products while maintaining the integrity of your brand.

- **Effective against prevalent *Listeria* spp.**
- **Organic-listed and clean-label**
- **Non-hazardous (harmless to humans, animals, and plants)**
- **No wastewater pretreatment required**
- **Specifically targets *Listeria* and therefore has no impact on the color, taste, texture, or odor of the final product**
- **Non-corrosive**
- **Can be applied to both salmon and food contact surfaces as an additional measure within the food safety management system**

Versatile application possibilities

- In-line spray setups
- Handheld spraying systems
- Dip tanks
- Existing equipment

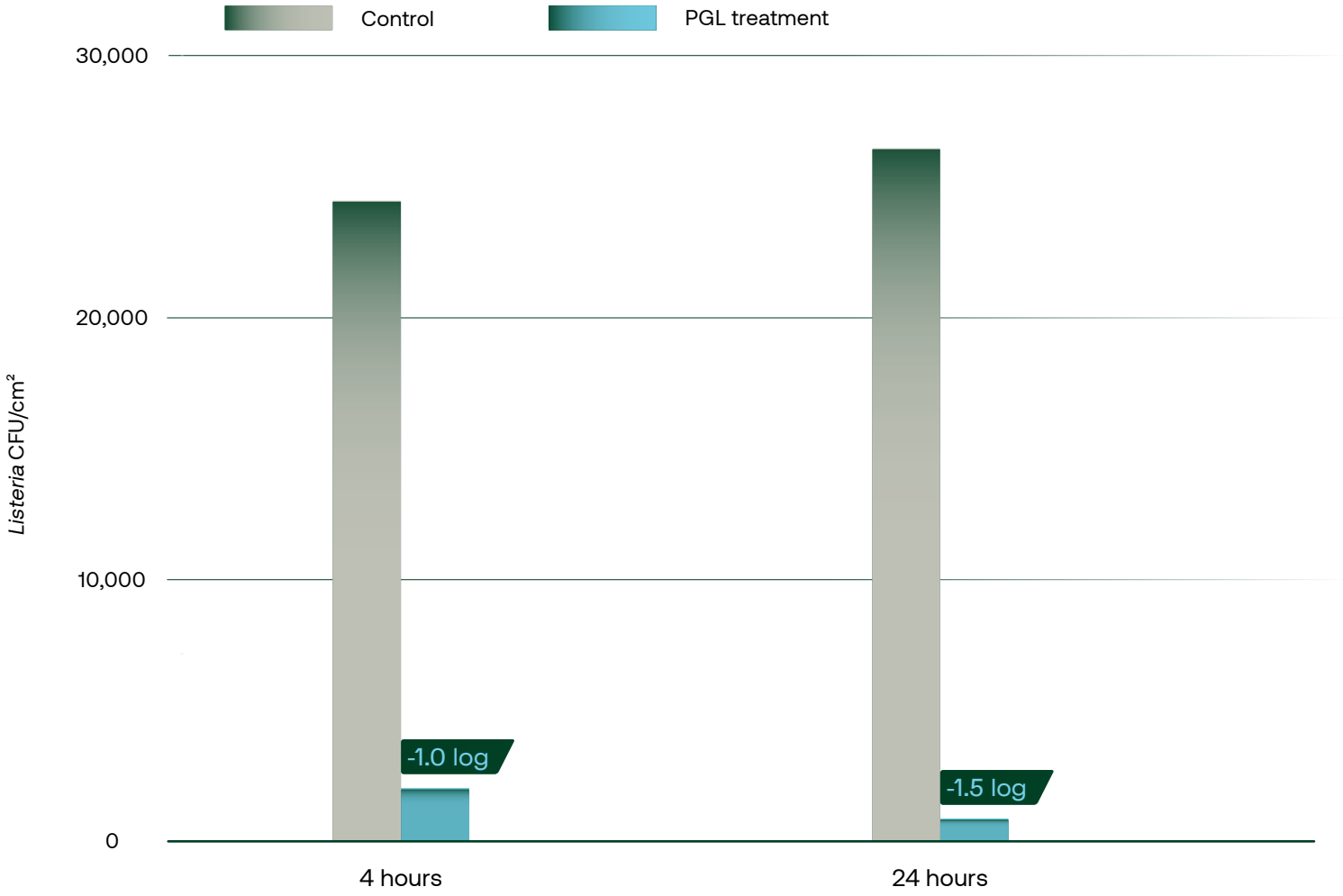
Raw smoked salmon

Reducing *Listeria* on raw smoked salmon

Phageguard L (PGL) was applied as a single low dose to raw smoked salmon. After 4 hours post-application, PGL delivered *Listeria* reductions of 1.0 log. After 24 hours post-application, PGL delivered further *Listeria* reductions of up to 1.5 log, while continued growth was observed in the control sample. The control consisted of tap water measured over the same time span as the treated samples.

1.5 log Reduction

A single low dose of PGL reduced *Listeria* on the raw smoked salmon by up to 1.5 log. The achieved reductions were measured at 4 hours and 24 hours post-application.



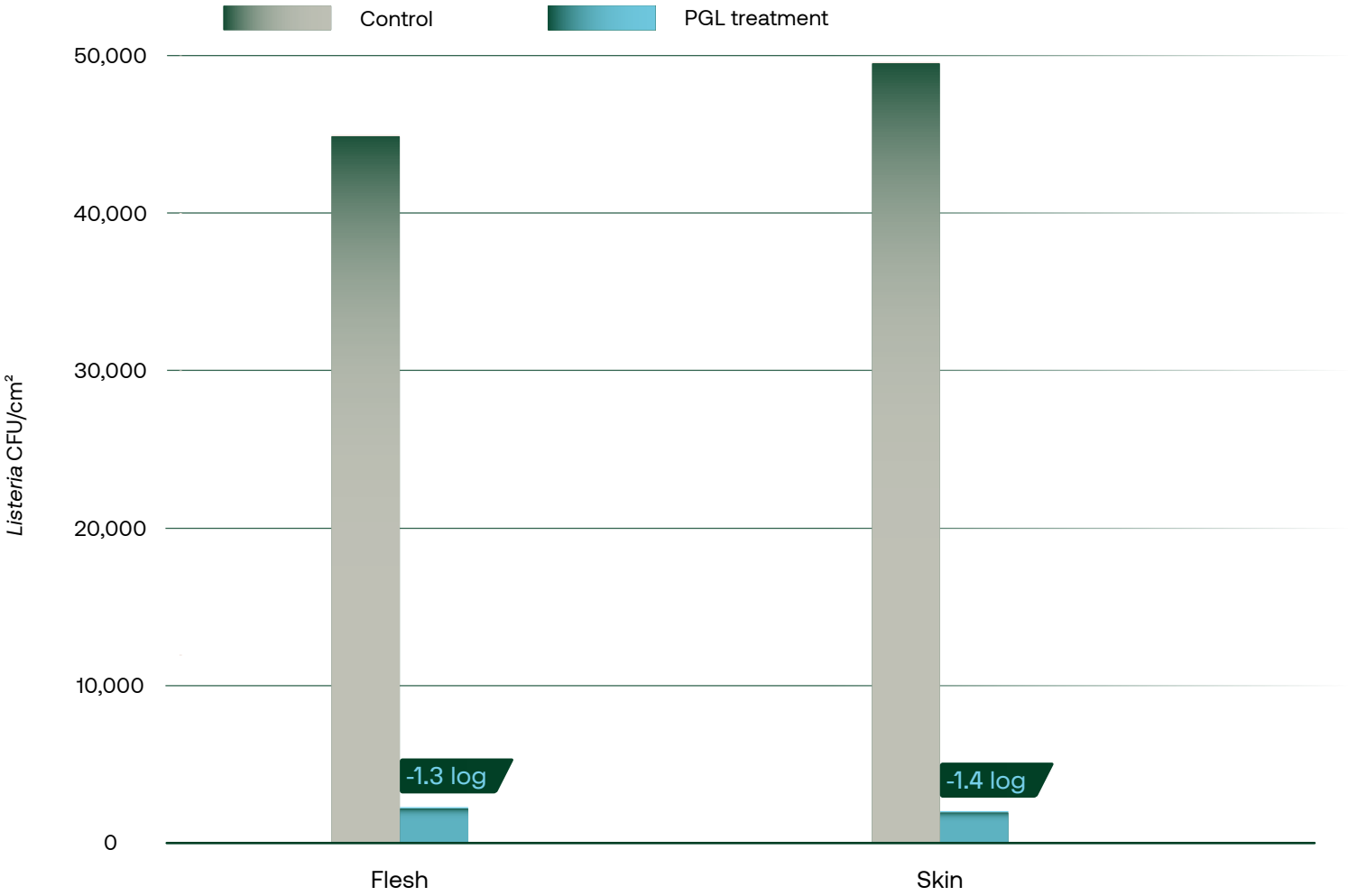
Skin-on salmon fillets

Reducing *Listeria* on raw, fresh skin-on salmon fillets

Phageguard L (PGL) was applied as a single low dose using a spray system on the conveyor belt. After 24 hours post-application, PGL delivered *Listeria* reductions of 1.3 log on salmon fillets placed flesh-side up and 1.4 log on fillets placed skin-side up. The control consisted of tap water measured over the same time span as the treated fillets.

1.4 log Reduction

A single low dose of PGL reduced *Listeria* on the salmon fillets placed skin-side up by up to 1.4 log. The achieved reductions were measured at 24 hours post-application.



Compliance

Trusted by government institutes around the globe

Phageguard L (PGL) has received approvals from government agencies around the globe and has been GRAS affirmed by the FDA since 2006. Furthermore, PGL is OMRI-organic listed, produced in an FSSC 22000 certified facility, and both halal and kosher certified to ensure alignment with a broad range of salmon processors.

- ✓ USA, FDA GRAS (GRN 218) - 2006
- ✓ USA, USDA approved processing aid (Directive 7120.1) – 2007
- ✓ Canada, Health Canada: Processing aid – 2011
- ✓ Australia/ New Zealand. FSANZ processing aid – 2012
- ✓ Israel, Food Control Services Ministry of Health: approved processing aid – 2014
- ✓ Chile, Undersecretary of Public Health (MINSAL) (ORD. B34/N794) - 2022
- ✓ Dubai, DM Food Safety Department - 2025
- ✓ Costa Rica, Ministry of Health of the Government of Costa Rica - 2026

FSSC 22000 OMRI LISTED® HALAL EUROPE CERTIFICATION UNDER SUPERVISION OF THE CHIEF RABBINATE OF HOLLAND

Partnerships

Collaborations with universities and research institutes

Phageguard has collaborated with numerous universities and research institutes to build a strong scientific foundation supporting our applied phage technology for controlling food pathogens. Published studies over the years demonstrate its effectiveness, versatile application across various food products, and compatibility with other food safety interventions in multi-hurdle approaches commonly used in industry.

The Americas

University of Nevada | Mississippi State University | California Polytechnic State University | Cornell University | University of Connecitcut | University of Maryland | University of Wisconsin-Madison | Oregon State University | Food Science Institute | McMaster University | Aemtek | Instituto Tecnológico de Querétaro | Universidade Federal da Bahia

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Europe

WUR Wageningen University | ETH Zürich | University of Ghent | Utrecht University | Institut Pasteur | Insitut du Porc | Nofima | TNO | Universidad D Cordoba | Universitat de Lleida | Radboud University | Max Ruber Institute | BfR Institute for Risk Assessment | Quadram Institute | Food Valley | Aristotle University of Thessaloniki | Universtitat de Lleida | Nizo | IFIP | CEBAS | CSIC | ISS | RCT Gelderland | Oost NL | Han University of Applied Sciences | Saxion Hogeschool | DIL | KU Leuven

Supporting the industry

Study cases and industrial implementations

The following overview presents the seafood sectors in which Phageguard currently supports the industry, as well as the R&D projects that further explore the versatility of phage implementation to expand our services.

PGL Industrial implementations - postharvest *Listeria* control

- Salmon
- Tuna
- Herring
- Catfish
- Shrimp
- Mussels
- Fish roe
- Production surfaces

PGS Industrial implementations - postharvest *Salmonella* control

- Exotic fish
- Shrimp
- Tuna

Phage technology
Listeria control

Applied phage technology to control food pathogens

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