FOOD PRODUCTION | UV-C | DAIRY | INDUSTRIAL HYGIENE

UV-C in the Dairy Industry: Protecting Quality at Every Stage

UV-C Technology as a Synergistic Hygiene Solution Across the Milk and Dairy Production Chain

> In the food industry, **UV-C technology** is emerging as a powerful **synergistic solution** — one that integrates seamlessly into established **hygiene protocols** and strengthens their effectiveness across multiple stages of production. In the dairy sector, **thermal pasteurization** remains the primary benchmark for the **safety of milk and dairy products**. At the same time, scientific research is defining with greater precision the role UV-C can play in other critical phases of the process: the treatment of **air**, **water**, **brine**, and **product-contact surfaces**.

UV-C technology is a **purely physical method**: it requires **no chemicals**, leaves **no residues**, involves no rinse cycles, and generates no waste to manage. When properly implemented, it also has **no effect on the composition, flavor, or nutritional profile** of the product.

These characteristics make UV-C straightforward to integrate into **existing production lines** without disrupting established processes or production cycles. **Pasteurization** remains the **central pillar of dairy safety**, while UV-C acts as a **complementary hygiene barrier** — targeting **air, water, surfaces, and brine** at every **critical control point**.

A Growing Regulatory Recognition

Regulatory authorities in both **Europe** and the **United States** are progressively evaluating specific application areas for **UV technology** within the dairy supply chain.

European Union — UV-Treated Milk as a Novel Food

In the European Union, UV treatment of milk has already been authorized for specific purposes, including **extending shelf life and increasing vitamin D3 content**. The application is intended to follow **conventional pasteurization** and falls within a regulatory framework that also establishes general hygiene requirements for the heat treatment of milk and colostrum.

United States — Equivalence to Pasteurization (2025)

In the United States, **for the first time, a UV-C-based process** has been recognized as **equivalent to pasteurization** for select powdered dairy ingredients, including **whey protein concentrate**, **milk protein concentrate**, and **lactoferrin**.

These regulatory recognitions represent **concrete precedents** and pave the way for an increasingly structured use of **UV-C technology** throughout the dairy supply chain.

Operating Parameters and Key Factors Determining UV-C Effectiveness

UV-C Dose

The **energy delivered to microorganisms**. It depends on **lamp intensity** and **exposure time**. Increasing power output or reducing the distance from the source raises the delivered dose.

Log Reduction

The standard unit for measuring effectiveness: **3-log = 99.9%** of microorganisms inactivated; **4-log = 99.99%**. Determined by the combined effect of **dose**, **UVT**, and **system geometry**.

System Geometry

Encompasses **lamp arrangement**, **spacing**, and the **path traveled** by air or product — all engineered to deliver a **uniform dose** throughout the treatment zone, eliminating shadow areas and maximizing performance.

UV Transmittance (UVT) in Liquids

The ability of a liquid to **allow UV-C radiation to pass through it**. UVT is **high in process water**, but drops significantly in **whole milk**, **whey**, and **concentrated brine solutions**.

Scientific Evidence in the Dairy Sector

Independent research on milk and dairy liquids consistently confirms the **effectiveness of UV-C treatment** when systems are **properly engineered and optimized**.

Extended Shelf Life in Ricotta Cheese — Ricciardi et al., 2020

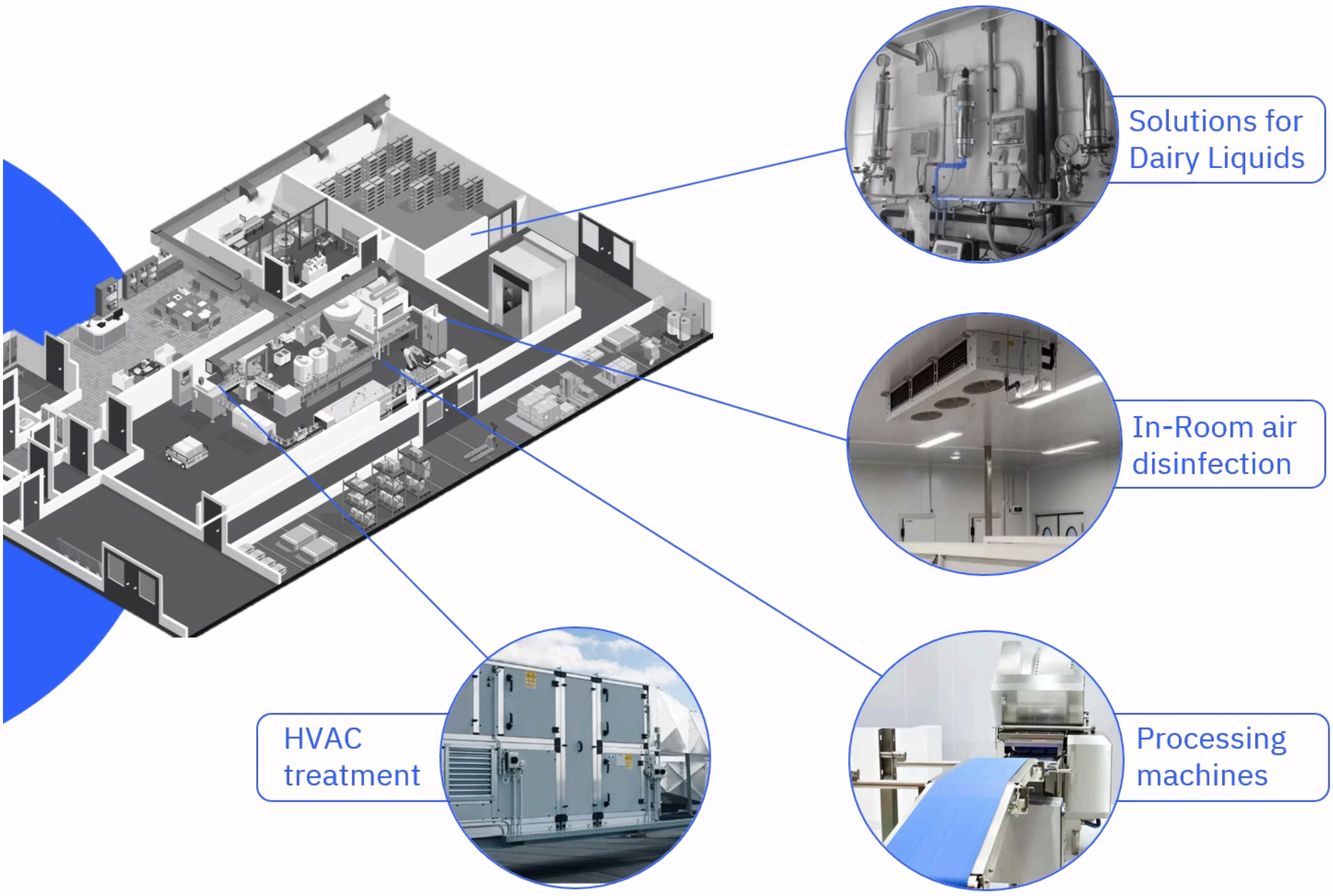
In a study using ricotta inoculated with *Pseudomonas fluorescens*, continuous UV-C surface treatment extended shelf life from **fewer than 5 days to more than 6 days** — a **50% improvement** — effectively suppressing spoilage microorganisms without compromising sensory quality. The findings highlight the potential of **post-process UV-C treatment**, particularly when combined with **modified atmosphere packaging** and refrigeration.

Up to 99.68% Mold Reduction on Pasta Filata Cheese — Koca & Urgu Öztürk, 2020

On Kashar cheese exposed to environmental contamination, UV-C surface treatment at a dose of **1.93 kJ/m²** achieved a **2.49-log reduction** in mold counts (**99.68%**), dropping below the detection limit at **9.63 kJ/m²**. Testing revealed no measurable changes in product composition or texture, confirming the effectiveness of **direct UV-C irradiation on solid dairy products** prior to wrapping.

These results make one point clear: the level of **microbial reduction** achievable depends critically on **system design** — not just on the technology itself. A reactor that is not properly optimized for the specific liquid or product being treated can deliver **significantly lower performance**, even when the nominal applied dose appears equivalent.

UV-C Integration Points in the Dairy Production Process

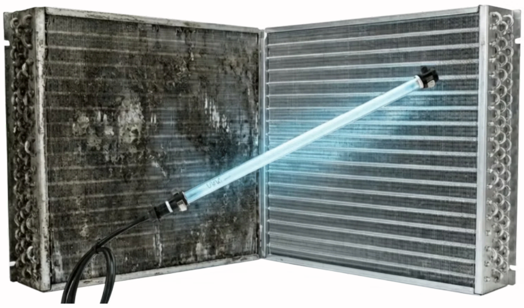


UV-C can be **seamlessly integrated into existing production workflows**, extending hygienic control to the media and surfaces surrounding the product — before, during, and after thermal treatment. **Air, water, equipment surfaces, whey, and brine** can all serve as recontamination pathways or contribute to microbial spread within the facility. The primary application areas can be grouped into **four key categories**.

1. Air and HVAC Systems

Air handling units are a **critical component of hygienic control** within dairy facilities — yet when not properly managed, they can become a **significant source of contamination**.

Biofilm on coils.



Cooling coils in air handling units are **cold, moist surfaces** continuously exposed to air carrying organic particles, humidity, and microorganisms. Under these conditions, bacteria, yeasts, and molds can adhere to the surface and develop **biofilm** — a moist, adhesive layer that accumulates progressively on the coil.

UV-C lamps installed inside the air handling unit and directed at the coil surface help **inhibit biofilm formation**, keeping both the coil and the air passing through it significantly cleaner.

Energy Efficiency
Biofilm buildup impairs heat exchange, increasing the load on the HVAC system.

Air Treatment.

This same application extends to the treatment of both **ambient air** and **process air** — including air used for **pneumatic conveying** of curd, salt, and milk powder; equipment pressurization; and direct injection into processing equipment. Equipment maintained under **slight positive pressure** — typically between **0.05 and 0.1 bar** — can use UV-C-treated air to reduce the risk of reintroducing contaminants, including **mold spores**, into products that have already undergone processing.

2. Localized Air Treatment in Production Environments

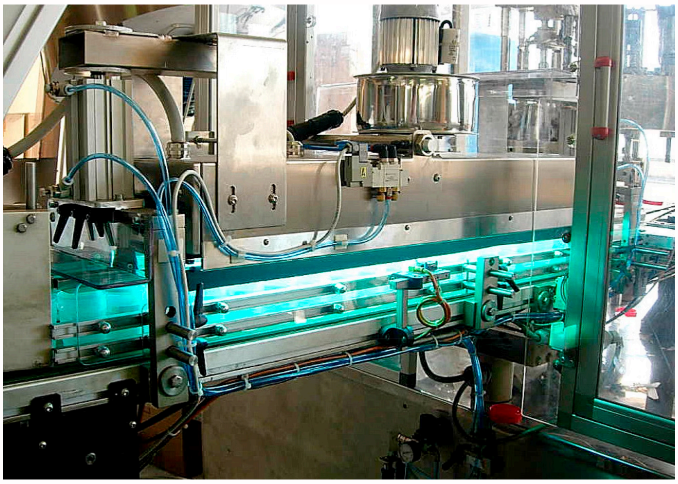
Beyond **centralized treatment** in air handling units, **dedicated systems** can be deployed to address **air quality** directly within **production, storage, and pre-packaging areas** — providing targeted protection exactly where it's needed most.

These systems can help reduce **airborne mold and yeast levels** and safeguard **high-risk points** in the facility, including **evaporator coils**. When not properly managed, these surfaces can become recurring sources of **microbial contamination** that spreads throughout the surrounding environment.

IAQ = Extended Shelf Life

Reducing **microbial and fungal load** in production and storage areas lowers the risk of **environmental contaminants** reaching the finished product — with direct, measurable benefits for **shelf life**.

3. Processing Machinery and Packaging Materials



UV-C modules can be integrated directly into **processing and packaging machinery** — positioned above **conveyor belts**, near **filling heads**, or at **capping stations**. This allows for **continuous treatment** of surfaces in close proximity to the product, or those that come into **direct contact** with it, embedding disinfection seamlessly into existing equipment and workflows.

The same approach extends to **packaging materials**. **Cups, sealing films, caps**, and other components can be treated **inline immediately before filling**, significantly reducing the **microbial load** on surfaces that will come into direct contact with the product.

Surface treatment modules are typically **compact** and designed for **easy integration** onto existing conveyors, fillers, and capping machines — with **no need to redesign or replace existing equipment**.

VDMA Standard

The **VDMA guidelines** for hygienic filling machines require a minimum **4-log (99.99%) microbial reduction** for aseptic-class machines using UV packaging treatment. Reference organism: *Aspergillus* spores (VDMA, doc. no. 10/2005, rev. 2023).

Testing on Dairy Packaging Lines

Independent research on dairy packaging disinfection reports results of the same order of magnitude. Treatment of **yogurt cups and sealing film**, combined with **low-concentration hydrogen peroxide**, achieved reductions of up to **4 log (99.99%)** in microbial load.

On **cheese processing lines**, reductions of **5 log (99.999%) for bacteriophages** and **3 log (99.9%) for thermophilic bacteria** have also been reported (Chawla et al., 2021, *Applied Sciences*).

4. Process Liquid Treatment

The choice of **system architecture** for UV-C treatment of liquids is governed by the **UV transmittance** of the medium, and falls into two primary configurations.

High-Transmittance Liquids

For liquids with relatively **high UV transmittance** — such as **process water** and, under certain conditions, whey — the liquid flows through a vessel housing a UV-C lamp inside a tank or sealed chamber. **Residence time** is engineered to ensure the required dose is consistently delivered.

Low-Transmittance Liquids

Lower-transmittance liquids include those with **sodium chloride concentrations up to 25%**, such as the **brine used in cheese salting**. The high salt content and organic load can limit UV-C penetration; a particularly effective configuration in these cases directs the liquid to flow in a **thin, controlled layer** in close proximity to the lamp.

The key production benefit is the creation of a **continuous, chemical-free hygienic barrier** for liquids that are reused, recirculated, or brought repeatedly into contact with the product. UV-C treatment curbs the **progressive buildup of spoilage microorganisms and pathogens** within recirculation circuits.

Conclusion: A Continuous, Chemical-Free, Integrated Barrier

UV-C is a **physical, non-thermal, chemical-free technology** that can be seamlessly integrated into dairy facilities alongside **pasteurization** — targeting **air, surfaces, water, whey, and brine** at critical points throughout the process.

Its value lies in strengthening **hygienic control** at strategic locations: it can cover **air in contact with products and equipment**, machine and container surfaces, process liquids, and production environments in general.

For Quality Assurance Managers

UV-C provides an **additional layer of documented, verifiable environmental control** that strengthens **HACCP plans** and supports **regulatory compliance** — including recent European and U.S. authorizations for UV technology in the dairy supply chain.

For Process Engineers and Technicians

Dose-response validation data enable **quantified performance claims**. Integration into **HVAC systems, line machinery, and liquid circuits** requires no redesign of existing infrastructure.

For Executive Management

A structured, validated UV-C program demonstrates **science-based, proactive risk management** — an approach increasingly expected by **regulatory authorities** and **major retail customers** in an evolving compliance landscape.

> When properly **sized and validated**, UV-C treatment can become a **continuous, physical barrier integrated directly into the production process** — without interrupting operations or altering product characteristics.

This article is intended for informational purposes only and does not constitute legal or regulatory advice. For any specific application, always consult the relevant regulatory authorities and applicable standards for your jurisdiction and product category.

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