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ESSENTIAL GUIDE TO FERMENTATION IN BIOREACTORS

Fermentation for Nutrient-Rich and Flavor-Intense Foods

Fermentation is a metabolic process that uses microorganisms, such as bacteria and yeast, to transform organic substances into various chemical compounds. These compounds can vary in complexity, from simple molecules like ethanol derived from sugar to intricate molecules that serve as the foundation for advanced pharmaceuticals or other high-value products through metabolic engineering.

The fermentation process is conducted in specialized vessels called bioreactors or fermenters, depending on the specific application and the organisms involved. Although both bioreactors and fermenters are utilized in biotechnology processes, there is a notable distinction between them. Bioreactors are used to cultivate mammalian and insect cells, whereas fermenters are used to cultivate microorganisms like bacteria, fungi (primarily yeast), or algae.

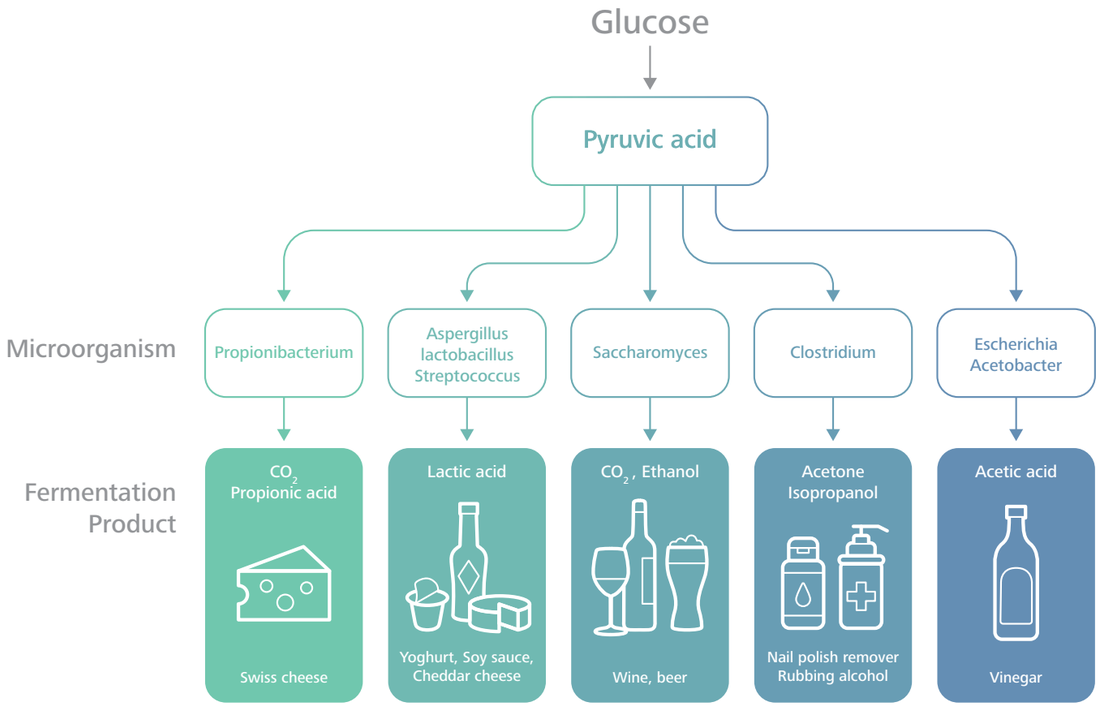

Figure legend: Examples of products produced by fermentation

What is a Bioreactor?

A bioreactor is an advanced equipment crucial for modern biotechnological innovation. These precision devices, equipped with the latest sensors and control systems, are designed to finely tune environmental parameters such as temperature, pH, and oxygen levels, creating ideal conditions for the cultivation of cells or microorganisms.

As a 3 in 1 bioreactor, fermenter and photobioreactor, the IKA HABITAT offers outstanding features and benefits over traditional bioreactors in biological processes that optimize the quality of the final product and enable its scalability. In certain applications, these vessels are indispensable, enabling contemporary biotechnological advancements beyond the reach of traditional methods.

/// Difference between Bioreactors and Fermenters

The main differences in the technical design between bioreactors and fermenters lie in the mixing and aeration processes, as well as the height to diameter ratio (H/D). These design disparities significantly impact the cultivation of microorganisms and cells.

For example, the mixing environment for microorganism cultivation is typically intensive, characterized by the effective dispersion of gas bubbles and high aeration rates. In contrast, cell cultures require gentle mixing with a lower aeration rate to maintain their viability and growth.

Furthermore, the optimal H/D ratio of the vessel differs between microorganism cultivation and cell cultures. For microorganism cultivation, an H/D ratio of 3:1 is considered ideal, while cell cultures thrive best with an H/D ratio of 2:1. Another key difference is that cell cultures can grow either in suspension or adherently, whereas microorganisms always grow in suspension.

/// Importance of a Bioreactor for Fermentation

Bioreactors can bring a level of precision to fermentation processes that traditional methods cannot match, allowing for greater control over the environment in which microorganisms grow and produce biochemical products. Unlike traditional fermentation pots or open-air systems, which are subject to fluctuating external conditions, fermentation-capable bioreactors maintain a carefully monitored and controlled space. They consistently regulate temperature, pH, oxygen levels, and nutrient flows to optimize the performance of the microbes.

The precision offered by these bioreactors during fermentation enhances product quality. The environments can be finely tuned to meet the specific demands of various processes, providing high-standard outputs for products ranging from alcoholic beverages to complex pharmaceuticals. Production uniformity and reliability that may be difficult to achieve with traditional equipment are more attainable in the controlled confines of a bioreactor.

Furthermore, the scalability inherent in bioreactor systems allows for a more managed transition from benchtop experiments to industrial-scale production. The scaling process in bioreactors is generally more straightforward and replicable than in basic fermentation vessels, which may not consistently replicate small-scale conditions at larger volumes. Coupled with automation, bioreactors can substantially improve process efficiency while preserving the integrity of the product regardless of the scale.

Bioreactors are also designed to minimize the risk of contamination—a critical consideration, especially when the products are for sensitive industries such as food and pharmaceuticals. While traditional practices may be adequate for some fermentation purposes, the stringent sterility requirements for these sectors are more reliably met within the highly controlled environment of a bioreactor. end product is high in quality and meets the necessary safety standards.

/// Why IKA HABITAT Bioreactors are Optimal for Fermentation

Precise environmental control for fermentation

Mass flow controllers precisely regulate the input of air, nitrogen, and oxygen, optimizing microbial growth during fermentation. Dissolved oxygen (DO) levels are a critical parameter in this process.
A dedicated carbon dioxide supply system maintains optimal pH levels, while headspace gassing options facilitate efficient oxygen transfer with minimal disturbance to the fermentation process. This precise control over the fermentation environment promotes consistent and reproducible results.

Advanced monitoring with next generation sensors

Advanced sensors for comprehensive bioprocess monitoring, including new-generation sensors for biomass, cell viability, and off-gas analysis, offer high selectivity, sensitivity, and long-term stability. These sensors enable contamination-free bioprocessing and improved operator efficiency by monitoring dissolved carbon dioxide, conductivity, turbidity, Redox, cell viability, off-gas, temperatures, and non-intrusive foam.
Soft-sensors can be used to calculate and display specific batch data, such as parameter setpoints, organism-specific rates (μ, qs, RQ, etc.), and extended batch values (culture broth weight, biomass).

Reducing shear stress

IKA HABITAT Bioreactors have a reactor geometry with a pitched blade and impeller design that ensures a gentle yet efficient mixing without the risk of damage from excessive shear forces. This approach optimizes the growth and maintenance of suspension and sensitive adherent cells. A new chaotic mixing mode that follows mathematical principles of chaotic-dynamic systems also provides for a more homogeneous mixture.

DESIGN AWARD 2023

/// How IKA HABITAT Bioreactors Enhance Lab Operations

IKA HABITAT Bioreactors are more than mere cultivation tools; they are integrated solutions designed to enhance operations with smoother, more efficient workflows tailored to the dynamic needs of our customers.

Award-Winning Design

Recognized with the iF DESIGN AWARD 2023, the IKA HABITAT Bioreactor integrates the capabilities of a bioreactor, photobioreactor, and fermenter, reducing the need for multiple setups and switching. Its ergonomic handling, intuitive operation, and user-friendly features, such as an open skid, unique lid stand, and lightweight components, reduce operator fatigue and improve portability. The compact design maximizes bench space. The bioreactor's intelligent support systems and controls make it accessible to both beginners and experts.

Consistent Quality

The IKA HABITAT Bioreactor sets the benchmark for consistent quality in bioprocessing by ensuring that each production cycle meets the high standards expected in the industry.
Its sophisticated control systems and precision engineering provide a dependable foundation for operations, guaranteeing uniform outputs that streamline the entire downstream process. Variable-speed, bi-directional peristaltic pumps and an optional fifth pump provide for diverse fluid management. This fidelity in performance facilitates the scalability of production and significantly reduces the occurrence of batch failures, mitigating downtime and waste.

Solutions that Scale

IKA HABITAT Bioreactors excel from micro-scale research to industrial production. They feature a chaotic mixing option for faster mixing, an advantage especially beneficial at the beginning of an experiment. The bioreactor’s design includes a range of vessel volumes from 0.5L to 10L, available in both single and double-wall configurations. Properly-sized motors for each volume—small for up to 2L, and larger for 5L to 10L—ensure efficient operation and customization in contrast to the standard one-size-fits-all motor approach. Advanced, integrated control systems guarantee consistent scale-up processes, enabling seamless capacity growth.

Cross-Platform Integration

OPC UA integration and extensive interface options including USB, Ethernet, and RS-232 to provide comprehensive data connectivity. The lid's additional ports enable customized modifications to accommodate a range of bioprocessing applications.

Global Presence, Local Support

IKA's global presence provides comprehensive support, including technical service, spare parts, calibration, qualification, and commissioning, empowering customers to achieve their bioprocessing goals.

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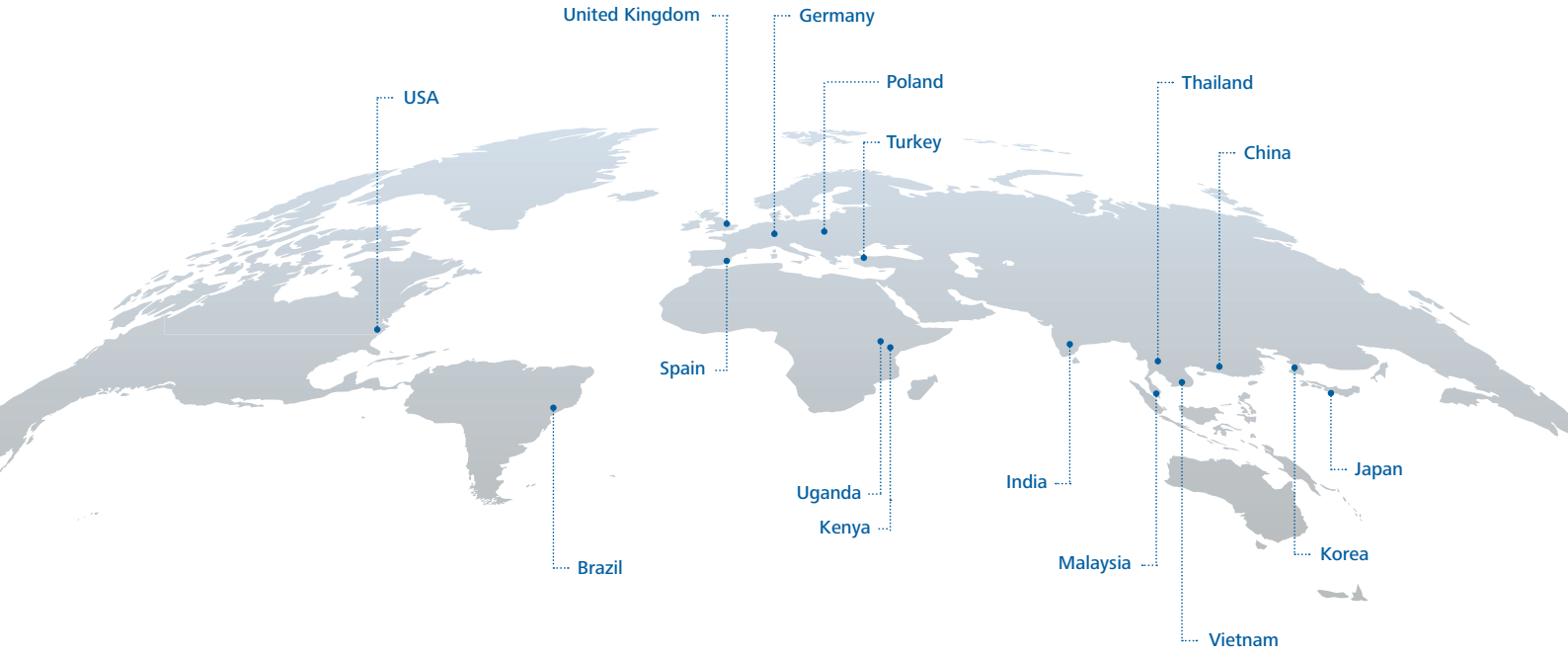

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