Fraunhofer IGB

FRAUNHOFER INSTITUTE FOR INTERFACIAL ENGINEERING AND BIOTECHNOLOGY IGB

INNOVATIVE ASEPTIC TECHNOLOGIES FOR FOODSTUFFS AND BIOTECHNOLOGY

HYGIENIZATION – CELL DISRUPTION – EXTRACTION OF FUNCTIONAL INGREDIENTS – PROCESS INTENSIFICATION

NEW METHODS OF PRESERVATION

The challenge – stabilization without loss of functionality

Longer shelf life while achieving the same product quality – the food industry, for example, is faced with the challenge of preserving or stabilizing foodstuffs without impairing the taste or healthy components. Cosmetics manufacturers and pharmaceutical companies are also familiar with these problems. Biogenic substances have to be handled with great care to avoid any loss of functionality.

Consequently there is a demand for innovative aseptic processing methods that stabilize the product without affecting the quality. This is not always possible with conventional methods such as heat sterilization since heat-sensitive substances like vitamins and enzymes are destroyed in the process. Also, the addition of chemical preservatives may have negative effects on the product. This results in the need for developing alternative sterilization processes, on the one hand to take into account the consumers' greater health awareness, on the other to comply with the increasingly stringent laws and regulations.

Physical, product-friendly methods of hygenization

Researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart are therefore developing new product-friendly processes for biological stabilization and hygienization based on physical principles. In the "Aseptic Technologies" working group in the Physical Process Technology department, food technologists and process engineers, and also other specialists, bring together their expertise to complement their research strengths. This interdisciplinary approach results in the development of new technological solutions for the product-friendly inactivation of contaminating microorganisms. Preservatives are not required for this, so foodstuffs retain their vitamins and there are no adverse effects on basic cosmetic or pharmaceutical substances.

1 *In the cosmetics production careful processing methods are required.*

2 *Ingredients such as vitamins should be conserved in preservation.*

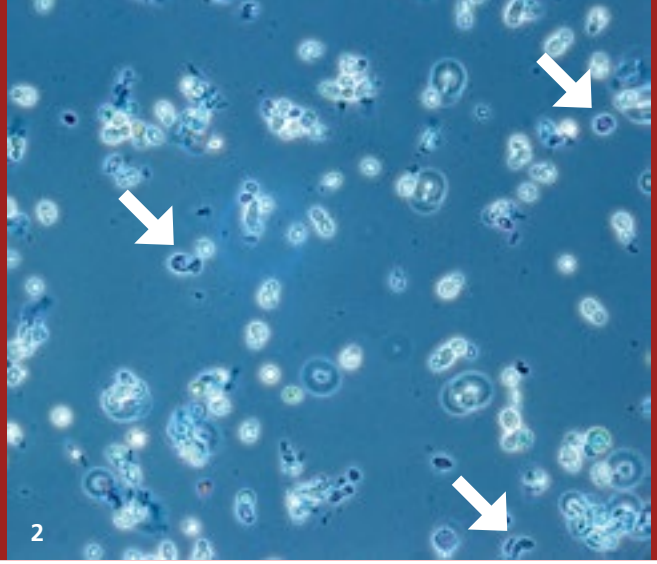
3 *New techniques reduce the high water consumption in the mozzarella production.*

From inactivation mechanisms to industrial implementation

The emphasis of our work here is, in the first place, to understand and describe the mechanisms by which contaminating microorganisms are inactivated during the course of the process; and secondly the interactions of the various parameters in the system (e.g. temperature, pressure, viscosity, pH value etc.). In this way the methods can be technologically optimized and implemented in a production process.

Two technological approaches are currently the main focus of our developments: microwave and pressure change technology, PCT for short. The conception, development and testing of these processes from laboratory scale to piloting on an industrial scale always takes place in close cooperation with partners from industry. In this way our scientists can respond directly to the precise requirements of the end-users of the applications.
Numerous innovations have already been put into practice, for example new methods of milk pasteurization with microwaves or the preservation of wine using pressure change technology.

In addition to the product-related effects, the new methods developed at the Fraunhofer IGB can also achieve increased process efficiency. Conventional processes are often associated with an excessively high consumption of energy and water. For example, in a research project we were able to demonstrate how water and energy could be saved in the production of mozzarella and milk powder, thus reducing the costs at the same time.



PRESSURE CHANGE TECHNOLOGY

Pressure change technology (PCT) is a non-thermal and non-chemical process for treating liquids with suspended microorganisms.

The principle

This method – also known as "cold pasteurization" – is mainly used between 5°C and 40°C at pressures of up to approx. 50 MPa. The liquid or suspension to be treated as well as the working gas (e.g. argon or nitrogen) are each placed under working pressure and then mixed homogeneously. In the case of microorganisms with cell membranes the gas diffuses through the membrane into the cells until the cytoplasm is saturated with gas. When subsequently the mixture is abruptly brought down to ambient pressure, the gas resumes its original gaseous state of aggregation and expands. This process destroys the cells eruptively. Cavitation effects may also result in damage to particle surfaces.

Preservation of liquid foods

At the Fraunhofer IGB we are further developing pressure change technology for the preservation of liquid foodstuffs such as fruit juices or wine. The aim of a current project for the stabilization of wine without preservatives is the inactivation of microorganisms participating in the fermentation process. The use of inert process gases such as argon or nitrogen prevents the oxidation of sensitive components. This method was first of all realized and validated as a batch process: parameters such as temperature, retention time, gas type and the effect on the microorganisms involved (yeasts, lactic acid bacteria), and also physical-chemical and sensory properties of the product are investigated. At present we are demonstrating the technology in a mobile plant under real conditions at the end-users' facilities.

1 *Demonstration plant for pressure change technology.*

2 *Inactivation of microorganisms by cell destruction.*

3+4 *By using the PCT wine can be produced with significantly reduced sulfite addition.*

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Cell disruption for biotechnological processing

Pressure change technology is also suited to disrupting plant-based or microbial cells to extract intracellular metabolites. Thus we have been able to demonstrate the disruption of microalgae cells using PCT in order to extract superior-quality components for food supplements or cosmetics. For example, combining the PCT process with high-pressure extraction and the use of various process gases, omega-3 fatty acids can be extracted with greater energy efficiency than previously. A further advantage of high-pressure extraction compared with conventional extraction methods is that no solvent is required, thus avoiding pollution of the process water. This in turn facilitates the treatment and the reutilization of the process water.

Advantages

- Component-friendly preservation without chemical additives
- Flavors, aromas and nutritional-physiological properties are not impaired in the preservation of liquid foodstuffs.
- Protection from oxidation by using inert process gases
- Can be applied flexibly in the process
- Inactivation of oxidative enzymes (polyphenoloxidase, peroxidase)
- Extraction and/or recovery of valuable cellular components under mild conditions
- Environmentally friendly – no chemicals used, recovery of the process gas
- Energy-efficient

Applications

- Preservation of liquids by inactivation of microorganisms and enzymes (“cold pasteurization”)
  - Stabilization of alcoholic and non-alcoholic beverages, dairy products, plant-based extracts
- Stabilization of suspensions or liquid preparations for pharmaceutical and cosmetic applications
- Gentle cell disruption to obtain intracellular products
  - Release of high-quality, thermolabile components from plant-based, animal or microbial cells

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PROCESS INTENSIFICATION WITH MICROWAVES

Heating food in households or in industrial production processes by means of energy input from a high-frequency energy field such as microwaves is a widely used method. We are currently researching the further development of this technology to achieve continuous process control with rapid and, at the same time, homogeneous heating for the preservation or further processing of liquid and highly viscous products (e.g. milk concentrates or foods with chunky components).

The special expertise of the Fraunhofer IGB in this field is the design of the reactors and the homogeneous waveguide coupling of the energy field. Basing our work on the analysis of the product-specific energy absorption, we are further developing models for applications of microwave reactors in the production of foodstuffs. We then investigate these models by carrying out scientific studies.

In addition to this, the high-frequency technology supports thermal extraction methods and increases the process efficiency, for example by minimizing the extraction time or the use of solvents.

Advantages

- Continuous system
- Targeted energy input by means of specific antenna design
- Shorter heating time
- Improved sensory product characteristics
- Reduced fouling

Microwave pasteurization of milk

In the EU-funded project MicroMilk, the Fraunhofer IGB – together with the University of Hohenheim and equipment manufacturers – have developed a novel method for pasteurization of milk with microwaves. The system preserves the valuable components of milk, reduces the use of cleaning agents and is also suitable for heating highly viscous and concentrated dairy products more quickly than previously. The core of the microwave method and a result of extensive simulation is a compact reactor, which is divided into different compartments. The microwaves are coupled into a waveguide, which simultaneously acts as the reaction chamber. In the follow-up project MicroMilk Demo the system now is being demonstrated in industry.

Applications

- Microwave pasteurization of milk and viscous milk products (e.g. yoghurt)
- Microwave pasteurization of fruit juice and juice concentrates
- Heating or pretreatment of intermediate products

1 *Dairies – potential applications for microwave technology.*
2 *In the EU project "MicroMilk" a new pasteurization process is developed.*
3 *Ingredients of milk are preserved.*

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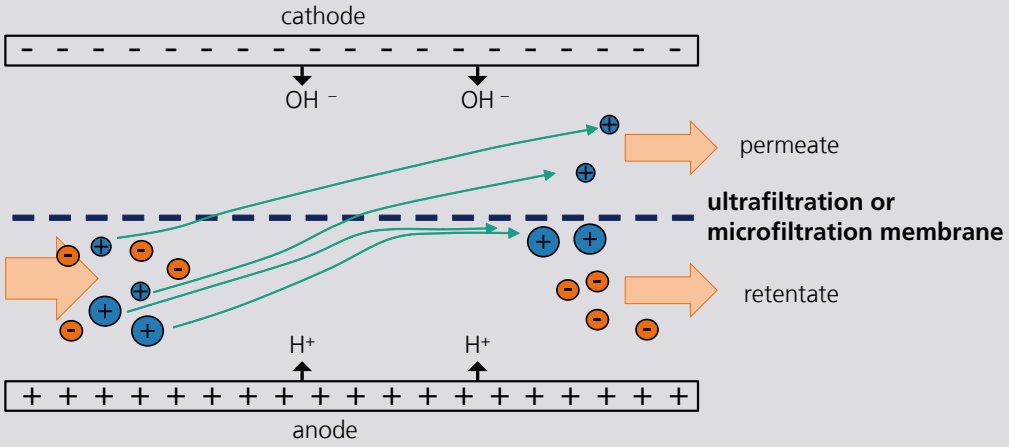

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EXTRACTION AND SELECTIVE SEPARATION PROCESSES

The product-friendly, environmentally compatible and efficient extraction of functional components from biogenic raw materials or residues as well as intermediate products from agriculture and food production is a further research focus of the "Aseptic Technologies" working group.

The main emphasis of our work is on the development of extraction methods and fractionation by means of high-pressure technology in combination with pressure change technology (PCT) and the use of electrophoretic and mechanical separation processes for the purification of the components. The integration of high-pressure processes, for example, enables valuable components to be extracted from microalgae in an energy-efficient way without the use of solvents.

Released proteins, peptides and also other charged biomolecules can be separated or enriched selectively by means of electro-membrane filtration, as the molecules can be concentrated in just one process step and separated on the basis of functional fractions. Electro-membrane filtration combines mechanical pressure filtration across a porous membrane with the motion of ions and molecules in an electric field. Thus the separation is not carried out only on the basis of their size, but at the same time also according to the charge. Compared with classical ultrafiltration this increases the yield and reduces the amount of work and expenditure for cleaning the plants.

Applications

- Extraction of functional substances (e.g. fatty acids, essential oils)
- Selective enrichment of proteins and peptides for food supplement
- Removal of unwanted substances

INTEGRATED APPROACH TO THE PROCESS

In order to be able to develop suitable, practicable alternatives to commonly applied methods, the conception of our processes has to be adapted to meet the requirements of the production process, for example of foodstuffs or active substances. To do this, it is necessary to analyze and validate the overall process – from product development, processing and stabilization through to the plant technology and packaging system.

Concepts of hygienic design and cleaning in place (CIP) play a central role here. We also undertake the further development and process-technological optimization of product-friendly, alternative methods and their integration into the production process. In connection with this we take into account established standards of food production and risk analysis procedures such as hazard analysis and critical control points (HACCP).

We also consider resource and energy efficiency in the conception and implementation of the systems developed.

1 *Protein fractionation by electro-membrane filtration.*
2 *Functional principle of the electro-membrane process.*
3 *Process analysis in a demonstration plant.*

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SERVICES

We work in an interdisciplinary team establishing new processes for the hygienization and biological stabilization of biogenic products, for example pasteurization by means of pressure change technology and microwave heating, or for extracting functional components from biogenic raw materials or residues by means of electrophoretic, high-pressure extraction and fractionation methods – from the conception phase, through trials on a laboratory scale, followed by technical scale-up to piloting on an industrial scale.

We focus our research work on the special requirements of food, cosmetics and pharmaceutical products. We design processes and plants with a view to hygienic principles and to production in compliance with international guidelines. In order to implement our plant concepts we work together with a network of qualified firms from the field of mechanical engineering and plant construction.

Services at a glance

- Customized process development including validation and industrial implementation
- Scientific advice and investigations of microbiological and chemical-physical stabilization of liquid or pasty products by means of high pressure and microwave heating
- Scientific advice and studies of the selective extraction and/or enrichment of functional components from biogenic raw materials or residues using electrophoretic or high-pressure methods
- Optimizing processes with regard to microbial stability, insuring that valuable components are not destroyed in the process, as well as energy efficiency and reduction of water consumption
- Laboratory plants for test trials and feasibility studies
- Design specification of process unit and components, e.g. by integrated combination of 3D CAD design and numeric modeling of fluids, electromagnetic fields and heat transfer with latest software
- Developing hygienic processes and plants together with risk analyses for the processes under investigation

1 *Demonstration plant as part of EU project "MicroMilk".*

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Fraunhofer IGB

The Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB develops and optimizes processes and products in the fields of health, chemistry and process industry, as well as environment and energy. We combine the highest scientific standards with professional know-how in our competence areas – always with a view to economic efficiency and sustainability. Our strengths are offering complete solutions from the laboratory to the pilot scale. Customers also benefit from the cooperation between our five R&D departments in Stuttgart and the institute branches located in Leuna and Straubing. The constructive interplay of the various disciplines at our institute opens up new approaches in areas such as medical engineering, nanotechnology, industrial biotechnology, and environmental technology. Fraunhofer IGB is one of 69 institutes and independent research units of the Fraunhofer-Gesellschaft, Europe's leading organization for applied research.

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