



Membrane filtration in the dairy industry



About us

Global - yet Local. GEA designs and engineers customer-orientated membrane filtration solutions for the dairy industry.

The GEA Group is an internationally operating technology group focusing on process technology and components for demanding processes in various end markets.

GEA is a leader in filtration technology providing membrane filtration plants for microfiltration, ultrafiltration, nanofiltration and reverse osmosis. GEA is known worldwide for its design of the most advanced cross-flow membrane filtration systems available and the dedicated technology centres for dairy filtration are located in Hudson, USA and in Skanderborg, Denmark.

GEA is uniquely positioned to provide both customized membrane filtration plants as well as complete process lines specifically tailored to the dairy industry and to our customers' requirements. The technology centres are responsible for the development of new applications and filtration processes together with the Application Center Dairy and the local GEA sales offices, strategically positioned all over the world.

In close collaboration with our customers and based on a deep and fundamental understanding of the processes within the dairy industry, we seek to deliver the optimal filtration solution. GEA believes in long-term customer relations and we always aim at exceeding our customers' expectations.

Please visit www.gea.com to learn more.

Technology overview

Membrane filtration is a separation process which separates a liquid into two streams by means of a semi-permeable membrane.

The two streams are referred to as retentate and permeate. By using membranes with different pore sizes, it is possible to separate specific components of milk and whey. Depending on the application in question, the specified components are either concentrated or removed/reduced. Membrane filtration can basically be divided into 4 main technologies:

Microfiltration (MF)

Microfiltration is a low pressure-driven membrane filtration process, which is based on a membrane with an open structure allowing dissolved components to pass while most non-dissolved components are rejected by the membrane.

In the dairy industry, microfiltration is widely used for bacteria reduction and fat removal in milk and whey as well as for protein and casein standardization.



Ultrafiltration Unit

Ultrafiltration (UF)

Ultrafiltration is a medium pressure-driven membrane filtration process. Ultrafiltration is based on a membrane with a medium-open structure allowing most dissolved components and some non-dissolved components to pass, while larger components are rejected by the membrane.

In the dairy industry, ultrafiltration is used for a wide range of applications such as protein standardization of cheese milk, powders, fresh cheese production, protein concentration and decalcification of permeates as well as lactose reduction of milk.

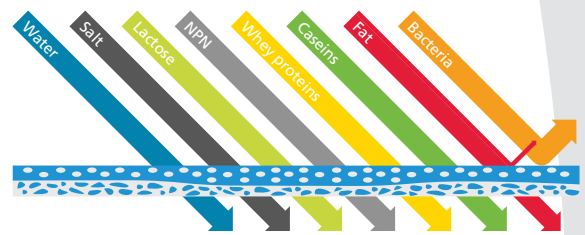
Nanofiltration (NF)

Nanofiltration is a medium to high pressure-driven membrane filtration process. Generally speaking, nanofiltration is another type of reverse osmosis where the membrane has a slightly more open structure allowing predominantly monovalent ions to pass through the membrane. Divalent ions are - to a large extent - rejected by the membrane. In the dairy industry, nanofiltration is mainly used for special applications such as partial demineralization of whey, lactose-free milk or volume reduction of whey.

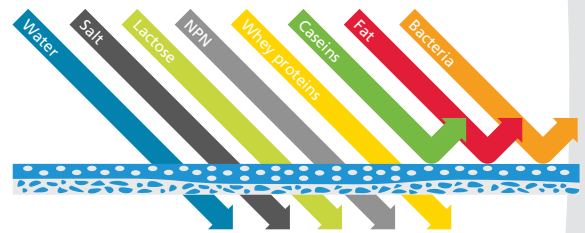
Reverse Osmosis (RO)

Reverse Osmosis is a high pressure-driven membrane filtration process which is based on a very dense membrane. In principle, only water passes through the membrane layer.

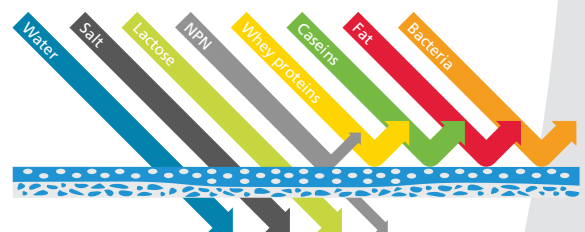
In the dairy industry, reverse osmosis is normally used for concentration or volume reduction of milk and whey, milk solids recovery and water reclamation.



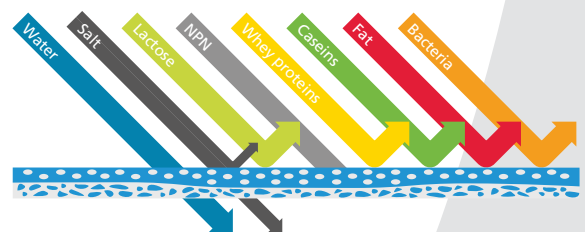
Microfiltration (membrane 1.4 µm)



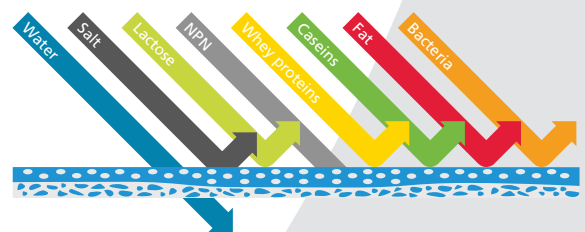
Microfiltration (membrane 0.1 µm)



Ultrafiltration



Nanofiltration



Reverse Osmosis

Processing units - the values are obvious

GEA provides membrane filtration units specifically tailored to meet the needs and requirements of each single customer.

With our extensive theoretical and practical experience within membrane filtration along with our well-defined standard modules, we are able to design membrane filtration units for all membrane filtration applications within the dairy industry. Our unique plant sizing software ensures the optimal plant configuration without jeopardizing the final performance of the plant.

The “Plug-and-Produce” unit philosophy provides our customers with several benefits such as space-saving designs, seamless integration and short installation time.

GEA's experienced team of engineers constantly focuses on improving the design of our processing units. As a consequence, we are able to deliver membrane filtration solutions where energy consumption and noise emission are at the lowest possible level and where product and detergent waste is reduced to an absolute minimum.



Ultrafiltration Unit

Membrane types

GEA offers a wide range of membrane types for the dairy industry. Based on our profound theoretical and practical experience within dairy filtration, we are always able to find exactly the right type of membrane to meet the specific requirements of the application in question. The range of membranes includes a number of different types which can be split into two main groups - polymeric (organic) and ceramic (inorganic).

Polymeric

Polymeric membranes include a range of different membrane types such as spiral wound, hollow fibre and flat sheet (plate-and-frame) membranes - all of which are made from organic materials. Polymeric spiral wound membranes provide a high membrane area per element leading to smaller and less expensive plant designs. Cleaning of this type of membranes is, however, complicated, and the lifetime of polymeric membranes is consequently relatively short.

As polymeric membranes come in a wide range of pore sizes, they can be used for a large number of dairy filtration applications from RO to MF.

Ceramic

Ceramic membranes include a number of membranes which are all made from inorganic materials. As ceramic membranes are very resistant to temperature and chemicals, they are easy to clean. The lifetime of ceramic membranes is longer than that of polymeric membranes. However, due to the limited membrane area per element, ceramic membranes are relatively expensive. Ceramic membranes come in a limited range of pore sizes, and are normally only used for microfiltration and in some cases ultrafiltration processes.



Polymeric membranes



Ceramic membranes

Microfiltration (MF)

Bacteria reduction

ESL (Extended Shelf Life) Milk

Microfiltration is today widely used in the production of high-quality market milk and ESL milk. As opposed to traditional heat treatment where the microorganisms of the milk are inactivated and the chemical composition of the milk is changed, microfiltration physically removes bacteria, spores, dead cells and impurities from the milk, leaving practically no autolyzable cells and causing no undesired changes to the chemical composition of the milk.

Cheese milk

Improvement of cheese milk can be achieved using microfiltration. The natural content of anaerobic spores in milk - such as clostridia - which can survive normal pasteurization and cause undesired gas formation in the cheese, can be reduced by means of microfiltration. Furthermore, microfiltration can avoid or significantly reduce the addition of normal inhibitors (e.g. nitrate) thereby achieving preservative-free cheese and whey.

Milk and whey powders

Microfiltration can improve the quality of milk and whey powder considerably through a reduction of bacteria and spores. As a consequence, heat treatment can be kept at an absolute minimum which - among other things - contributes to a preservation of the functional properties of the whey proteins in the powder.

Cheese brine sanitation

The chemical and microbiological quality of the cheese brine used for salting cheese products is critical for the final quality of the cheese. As brine may contain undesired microorganisms, cheese brine has traditionally been subjected to different types of treatment such as heat treatment, kieselguhr filtration, UV treatment or even addition of preservatives. Microfiltration can easily replace any of these processes avoiding the many disadvantages involved. Please see page 18 for more information about GEA's COLDSAN® concept.



Milk protein fractionation

Casein Standardization of Cheese Milk

When it comes to obtaining process control and quality, a uniform and stable production process is of the highest importance to any cheese manufacturer. By using microfiltration, it is possible to fractionate casein and whey proteins and thereby to standardize the concentration of casein in the cheese milk to obtain the correct ratio between casein and fat.

Casein and native whey production

Microfiltration can fractionate milk proteins into casein and whey proteins. The fractionated casein can be used in the production of high-quality casein and caseinate or in the production of special casein-rich milk products. The Native Whey fraction (permeate) contains whey proteins in their natural form which are unaffected by heat treatment, enzymes (rennet) or bacteria (starter cultures). This product is especially suited for the production of high-quality liquid stabilizer, Whey Protein Concentrate (WPC) and Whey Protein Isolate (WPI).

Milk fat removal

Protein isolate

In the production of protein isolate - e.g. Milk Protein Isolate (MPI) or Whey Protein Isolate (WPI) - where a protein level of more than 90% in the total solids is required, the fat content constitutes a limiting factor. The milk fat is concentrated to a very high level, and in order to achieve the final protein concentration, removal of the milk fat is required. Microfiltration is the obvious solution for performing this fat removal.



Microfiltration Unit

Ultrafiltration (UF)

Protein concentration

Cheese milk

Ultrafiltration followed by a traditional cheese production process can be used for pre-concentration of cheese milk. In this way, the protein level of the cheese milk is kept constant which contributes to an optimization of the utilization of the cheese-making equipment. The by-product of the ultrafiltration process (permeate) is perfectly suited for lowering the protein content of other products such as e.g. skim milk powder.

Milk protein concentrate

Ultrafiltration is commonly used in the production of Milk Protein Concentrate (MPC) where it can lead to an increase of the protein content in the total solids. The by-product (permeate) is perfectly suited for lowering the protein content of other products such as e.g. skim milk powder.

Whey protein concentrate

Whey Protein Concentrate (WPC) is obtained using ultrafiltration on different whey types (sweet, acid or casein) or different types of permeates from microfiltration of milk. Depending on the required protein concentration level, different ultrafiltration techniques can be applied (e.g. dilution with water also known as diafiltration). The final composition of the WPC depends on several factors such as the original composition, the level of concentration, the membrane itself and the processing parameters. The by-product (permeate) - mainly containing lactose - is suitable for further valuable processes.

Protein standardization

Milk

Ultrafiltration can be used to standardize and increase the protein content of milk without the use of additives such as milk powder. Protein-enriched milk has additional health benefits and improved taste, and is also very suitable for the production of fermented milk products (yoghurt, crème fraîche, kefir etc.). To optimize the protein utilization in the dairy, the ultrafiltration permeate can be used for lowering the protein content of the milk.

Cheese milk

As the protein content of milk varies significantly depending on the season and the breed of cow in question, it can be difficult to maintain a constant protein level of the milk. Protein standardization using ultrafiltration can eliminate these protein variations, ensuring a uniform cheese production process and an optimization of the utilization of the cheese-making equipment.

Decalcification (calcium removal)

Ultrafiltration can be used as a superior separation unit in a decalcification unit for the decalcification of RO or preferably NF pre-concentrated permeates for lactose production. As calcium-phosphate is highly insoluble, it can be easily removed by means of the UF technology following a thermal precipitation process. Applying this technology will in general result in high-quality lactose, where the reduction of calcium-phosphate will lead to a higher lactose yield and lower mineral content in the final lactose product as well as generally improved evaporator running times. Depending on the UF separation unit's concentration degree, calcium can be refined into a natural calcium-phosphate product.

Yield increase

White cheese

Ultrafiltration is widely used in the production of white cheese where the whole milk is concentrated to 34-40% total solids by means of ultrafiltration. The retentate (concentrate) from the ultrafiltration process is pasteurized and mixed with starter culture, rennet and salt and subsequently filled directly into the packaging, where the entire cheese production process then takes place. The process is very simple and increases the yield by more than 20% compared to traditional production methods.

Fermented products

Fermented products is a term used as a common denominator for fresh cheese products like quark, cottage cheese, fromage frais, cream cheese and many more. By including ultrafiltration in the production of fermented cheese, it is possible to adjust the product in order to achieve the exact combination of consistency, texture and flavor. A standardization of the protein level prior to fermentation for these types of products will result in several benefits such as yield increase and a reduction in the amount of acid whey.

Lactose reduction

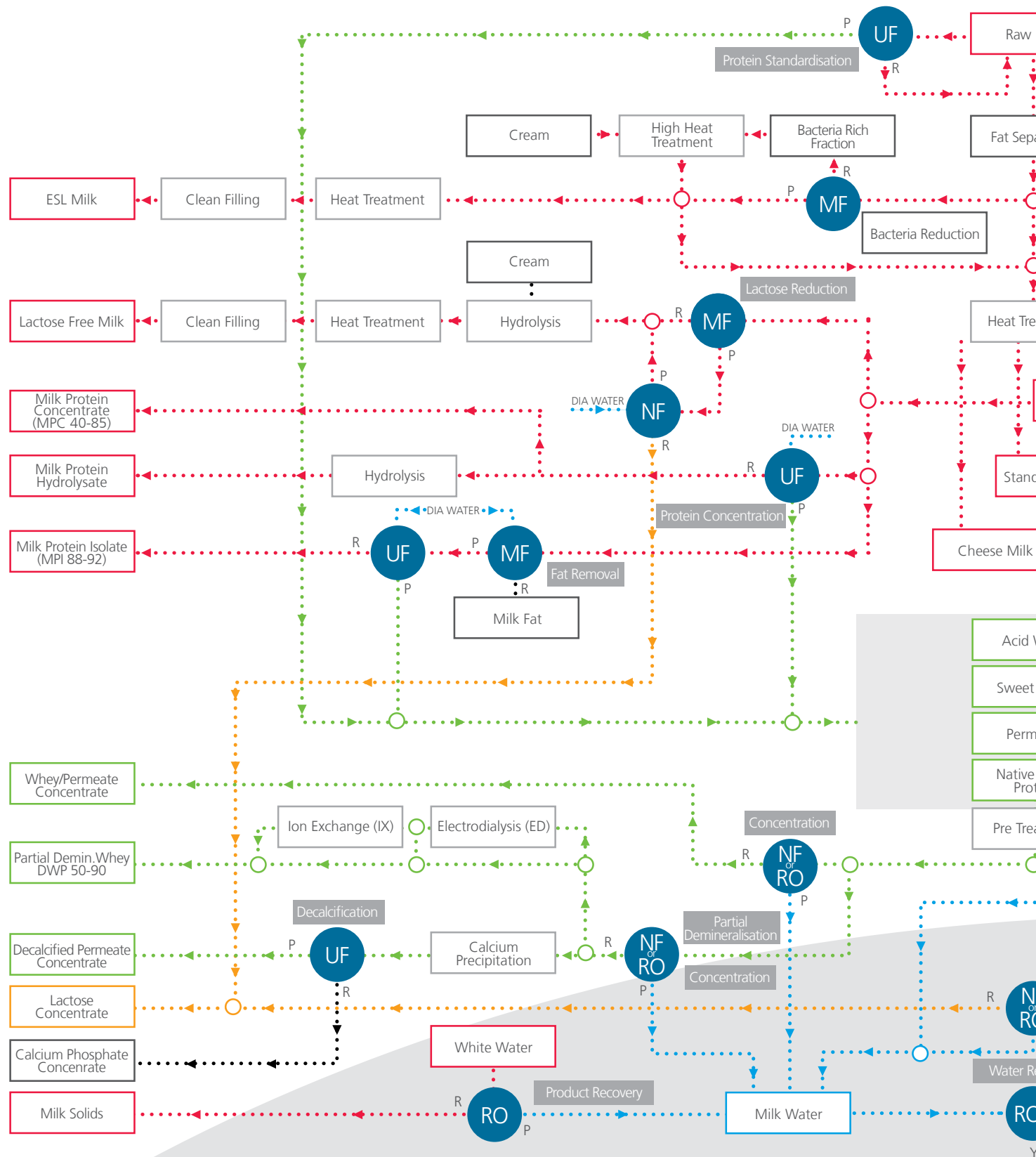
Lactose-free milk

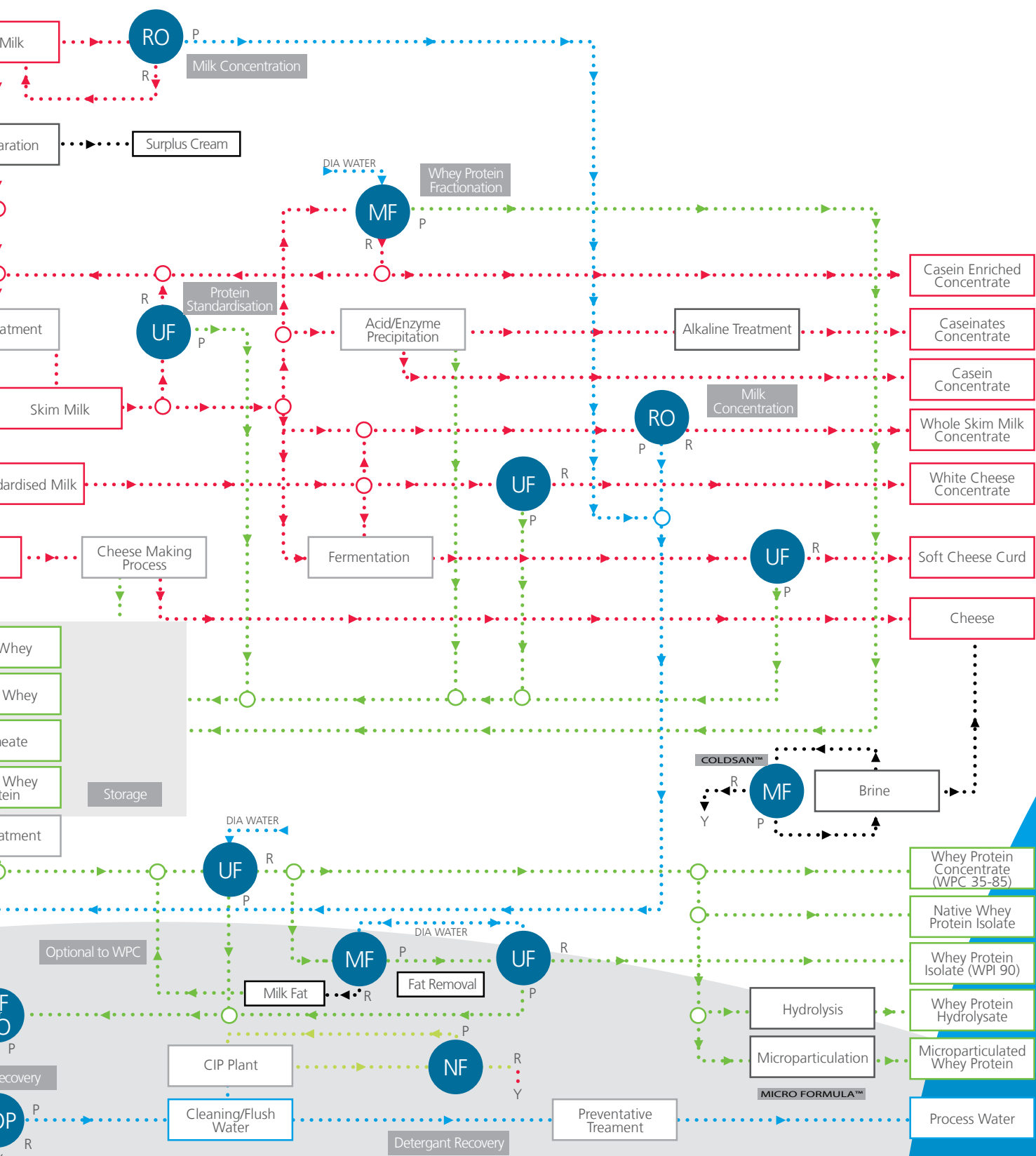
In the production of lactose-free milk, ultrafiltration plays an important role in achieving a sensory experience similar to that of fresh milk. Before the milk undergoes an enzymatic process (hydrolysis), most of the lactose is removed by means of ultrafiltration.



The ultrafiltration technology provides increased flexibility and yield in cheese processing.

Dairy map overview





Nanofiltration (NF)

Concentration

Whey and permeate

Nanofiltration of whey and permeates will reduce the mineral content – especially sodium and potassium chlorides (monovalent ions) – in these products, and since both whey and permeates in most cases need to pass through a concentration step prior to further processing, nanofiltration becomes a very attractive technology, as it combines volume reduction with partial demineralization in one and the same process step.

Volume reduction

In order to achieve savings on transportation costs, it is possible to apply nanofiltration for volume reduction (concentration) of whey and permeates. With nanofiltration technology, higher flux rates can be achieved, making nanofiltration a financially attractive alternative compared to other technologies, e.g. reverse osmosis.

Lactose

Lactose is mainly produced from whey and permeates, and nanofiltration plays an important role in a modern lactose production facility. By applying nanofiltration, lactose can be concentrated before further processing - i.e. crystallization. Further, nanofiltration will reduce the amount of minerals which in turn will provide a more efficient crystallization process and will consequently result in a lactose product with a higher degree of purity.



Nanofiltration is a cost-effective technology for partial demineralization of whey.

Partial Demineralization

Demineralized whey

When producing demineralized or non-hygroscopic whey powder where low lactose and mineral contents are required, nanofiltration can be applied as an economically attractive supplement to electrodialysis and ion-exchange technologies. Depending on the type of whey, the demineralization degree can reach more than 30%, making the electrodialysis and ion-exchange processes more efficient.

Demineralized whey powders

Demineralized whey powders (DWP D35, D50, D70, D90) intended e.g. for use in the production of baby food, can - depending on the degree of demineralization - be manufactured by means of nanofiltration and combinations of ultrafiltration and nanofiltration as well as nanofiltration combined with electrodialysis (ED) before evaporation and spray drying.

Lactose Reduction

Lactose-free milk

Nanofiltration is a commonly applied technology for the production of high-quality lactose-free milk products. As the membrane layer in the nanofiltration technology rejects lactose but allows passage of various minerals, the milk will maintain most of its original composition and the consumer will get a sensory experience which is almost similar to that of fresh milk.

Detergent recovery

Purification of CIP (Cleaning-In-Place) solutions

In processing plants where the detergent consumption is high, nanofiltration can be applied in order to achieve a purification of the CIP solutions used (e.g. NaOH and HNO₃). Removal of impurities and reduction of the COD level enable a very long recycling period, where the loss of detergents is reduced to a minimum. In order to maintain a constant concentration level, priming will still be required.



Reverse osmosis (RO)

Pre-concentration

Supplement to evaporation

Reverse osmosis can be applied as a supplement to evaporation. If a new evaporation line is required or an existing line is to be extended, huge savings can be obtained by joining the two technologies. Reverse osmosis is a very efficient way of removing water from the milk or whey prior to the evaporation stage. By installing a reverse osmosis plant upstream of an existing evaporator, the capacity of the evaporator can be increased considerably depending on the application and type of evaporator in question.

Concentration

Total solids increase

Reverse osmosis can be used to concentrate skim milk or whole milk in order to increase the total solids content. This is – among other things - relevant for fermented products. As reverse osmosis practically removes only water, the technology can be applied as an energy-efficient alternative to evaporation or the addition of milk powder, which are the most common ways of increasing the total solids content of milk.

Volume reduction

Reverse osmosis can be applied to reduce the volume of milk or whey - e.g. for saving transportation costs. Volume reduction based on reverse osmosis is an alternative to nanofiltration.



Product recovery

In order for a modern dairy production facility to be able to meet the many demands – both economical and environmental - put forward by the surrounding society, waste recovery has become increasingly important. From the first cleaning flush, sweet “white water” is collected in a dedicated collection tank. The sweet “white water” is concentrated to the required total solids content by applying reverse osmosis, and the recovered solids can subsequently be returned to the production process - e.g. to increase the total solids in yoghurt milk. The by-product of this concentration process - water - can also be utilized as described in the following section.

Water recovery

Water recovery and “polishing”

Permeates originating from reverse osmosis or nanofiltration processes as well as condensates from evaporators are practically water. With an additional reverse osmosis treatment normally referred to as “Polishing”, this water can be purified and re-used for cleaning purposes. With further heat treatment or UV light treatment, it is even possible to use the water as process water.

Effluent control

Some production facilities – such as large whey processing sites – have an excess amount of water which must be discharged. As water disposal is normally connected with emission taxes depending on the COD level among other factors, subjecting the water to a reverse osmosis process can lower the COD level and reduce emission taxes significantly.



COLDSAN®

Minimize the loss of salt and water and reduce the microbiological content by more than 99.5% while maintaining the chemical balance in brine.

Securing first-class cheese brine

Dumping of cheese brine is normally very costly, and in some countries it is even prohibited due to the high salt content of the brine. Purification and recycling of the brine is therefore preferable and can even provide several advantages, such as reduced operating costs and improved cheese quality.

Cheese brine - if not treated properly - can contain large amounts of undesired microorganisms, such as gas-producing lactobacilli, pigment-producing micrococcus, pathogenic bacteria, yeast and mould which all affect the final cheese quality.

Unlike traditional brine treatment methods such as heat treatment, kieselguhr filtration or the addition of preservatives, microfiltration physically removes the undesired microorganisms, dead cells and physical contaminants from the brine without causing any significant change to its chemical composition.

GEA has developed a brine sanitation unit - COLDSAN® - which is simple to operate and easy to install in connection with existing brine systems.

The COLDSAN® unit is fitted with polymeric microfiltration membrane elements which are widely recognized as the most effective method of cheese brine sanitation.

The GEA COLDSAN® unit ensures high-quality cheese and prevents problems in terms of bad rind, off-flavors and texture failures.



GEA Filtration Brine Sanitation Unit Polymeric MF membrane elements are widely recognized as the most effective method for cheese brine clarification.



COLDSAN®

MICRO FORMULA®

With low maintenance cost, benefit from long production time between CIP (18–20 hours) and increase yield with protein and water binding effect.

Microparticulation - formulating highly functional whey proteins

Although microparticulation (MP) is not a membrane filtration technology, microparticulation technology emanates from filtration technology because the base product is Whey Protein Concentrate (WPC), which is produced by means of ultrafiltration.

Microparticulation is a combination of heat and mechanical treatments. The heat treatment denaturates the whey proteins, and a controlled mechanical treatment enables the formulation of a very exact whey protein particle size.

The microparticulated or formulated whey proteins have useful properties which can be used in a wide range of dairy products, for instance as fat replacers or natural liquid stabilizers.

With the MICRO FORMULA® unit developed by GEA Filtration, we have taken the microparticulation technology one step further by simplifying the process described above. The MICRO FORMULA® unit has a number of unique features such as the TTS (Temperature, Time, Shear) unit which enables complete control of the size and distribution of the particles.

The MICRO FORMULA® unit is easy to operate and the simplified process, combined with long running times between CIP cleanings, results in very low maintenance and operating costs.



A simple unit for microparticulation of whey proteins, the MICRO FORMULA® unit makes it possible to utilize whey, a bi-product from cheese production, to increase product yield and replace fat.

GEA Service – For your continued success

GEA offers you a unique and individual membrane replacement service.

Membrane replacement service

Our philosophy is that there is no such thing as standardized service, and our maintenance is based on the needs and demands of the customer and the specific unit. We do not manufacture our membranes ourselves, but work with some of the largest and most respected suppliers in the business.

In general, a polymeric membrane has a life cycle between one and three years. The purchase of membranes through GEA is an easy one-step solution, where you only have to approach one supplier to get both the best membrane equipment and the best guidance and expertise. When you buy your membranes through GEA, you do not only get a high-quality product; you also get the years of knowledge and experience that we have gained in the membrane business. Naturally, we are also prepared to meet any specific requirement which you may have with regard to membrane type and brand.

A neglected filtration unit increases the risk of a breakdown, which means loss of time and money. We therefore focus on preventive maintenance and regular service to save you from expensive downtime. GEA relies on a number of dedicated service employees who can make service optimization visits on request. An optimization carried out by GEA may result in lower energy consumption, longer running times, reduced consumption of detergents and a minimization of product loss.

GEA supports and supplies replacement membranes for all known membrane filtration technologies, including microfiltration, ultrafiltration, nanofiltration and reverse osmosis. Furthermore, we can supply membrane filtration accessories such as ATD's (Anti-Telescope Devices) and end-plugs.



Service is key to membrane separation. Maximize profits with regular service to keep membranes in top operating condition.

Working with GEA Service means partnering with a dedicated team of service experts. Our focus is to build, maintain and improve customer performance throughout the entire life cycle of the plant and its equipment.

Beginning of Life Services

Getting you started with seamless support for instant productivity and performance

Lifetime Services

Keeping it running with the cost-efficient way of ensuring safety and reliability

Extended Life Services

Constantly improving by sharing our knowledge to safeguard your investment

Consulting & Enhanced Operations

Together with you by enduring commitment to you and your business



Sustainable process solutions

Membrane filtration technology offers several possibilities for achieving more sustainable processes.

Membrane filtration - process technology for the 21st Century

A modern dairy facility is faced with a number of demands from the surrounding society. One of those demands - which is becoming increasingly important - is the environmental issue. The consumer awareness of the environmental impacts of various products has risen significantly over the past decade, as consumers have been exposed to an ever-increasing amount of information regarding environmental concerns through the media.

In order to live up to the demands from consumers and authorities, many dairies have already formalized sustainability goals which are designed to increase resource efficiency and reduce their environmental footprint. In other words - sustainable products and production lines have become an integrated part of the dairy industry today.

GEA's processing solutions meet the needs of the present without comprising the future. Our membrane technology offers cost-effective processing solutions, enabling dairies to reach their sustainability goals in both a simple and very cost-effective way.



The membrane filtration technology offers several possibilities for achieving more sustainable processes in the dairy industry - all of which also imply reductions in production costs:

- Concentration or volume reduction $\approx$ lower transportation costs
- Product recovery $\approx$ less waste and higher yield
- Water recovery $\approx$ reduced water consumption and effluent volume
- Cheese brine sanitation $\approx$ recycling of cheese brine and less effluent
- Clarification of CIP solutions $\approx$ recycling of CIP chemicals
- Pre-concentration $\approx$ reduction of energy consumption





We live our values.

Excellence • Passion • Integrity • Responsibility • GEA-versity

GEA is a global technology company with multi-billion euro sales operations in more than 50 countries. Founded in 1881 the company is one of the largest providers of innovative equipment and process technology. GEA is listed in the STOXX® Europe 600 Index. In addition, the company is included in selected MSCI Global Sustainability Indexes.

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