Plant-based milk alternatives

Krones expertise using oat drink production as an example

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Plant-based milk alternatives
healthy and sustainable alternatives to milk

Milk alternatives made from soy, almond or oats have long since established themselves on our supermarket shelves. The reasons for their major popularity are varied and range from health aspects to an intrinsic motivation to achieve more sustainable nutrition.

Health

- Existing food intolerances, e.g. allergy to cow's milk and lactose intolerance
- Good nutrient profile (depending on the resource: high values for proteins, carbohydrates, vitamins, dietary fibre, etc.)

Sustainability

- Environmental protection: to influence and reduce one's personal CO_2 footprint and water consumption through nutrition
- Animal welfare: a conscious trend towards vegan nutrition

Variety

- Nutritional diversity (the most varied resource groups for the production of plant-based milk alternatives possible)
- Nutritional profiles can be individually adjusted by the manufacturer

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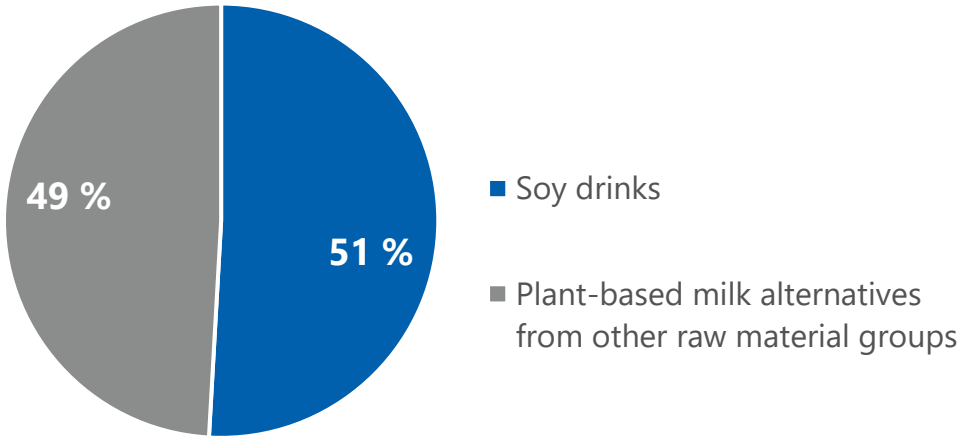
The plant-based milk alternatives market

Soy drinks were the first milk alternatives to establish themselves on the market. And despite already making up almost half the worldwide consumption, the total number of beverages based on other plant resources has since caught up.

While Global Data forecasts a growth of three percent per year for both animal milk and soy drinks between 2020 and 2025, the consumption of other plant-based milk alternatives should increase by around five percent in the same period.

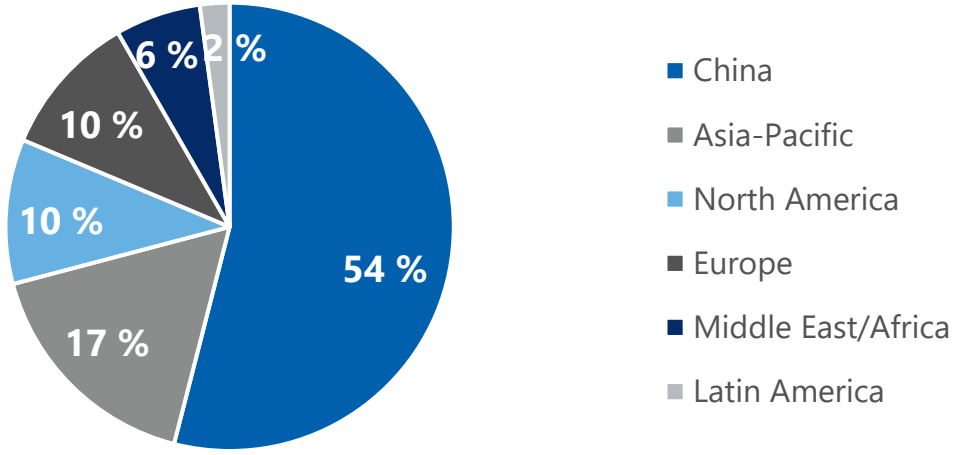
Plant-based milk alternatives are still most popular in the Asian region – however the consumption is expected to increase by six percent in North and Latin America and four percent in Europe between 2020 and 2025.

Worldwide consumption of plant-based milk alternatives (in 2020)



Source: Global Data

The strongest markets for plant-based milk alternatives (in 2020)



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Which groups of raw materials are suitable for the production of plant-based milk alternatives?

Grains (e.g. oats, rice, spelt)

Ingredients:
~ 10 % grain
~ 1 – 2 % oil (rapeseed, sunflower)
~ 85 – 95 % water
~ additives (e.g. salt, enzymes, calcium, potassium, sugar, flavourings)

Nuts (e.g. almond, coconut)

Ingredients:
~ 2 – 8 % nuts
~ 92 – 98 % water
~ additives (e.g. salt, stabilisers, sugar, flavourings)

Legumes (e.g. soy, peas, lupins)

Ingredients:
~ 7 – 10 % legumes
~ 90 – 93 % water
~ additives (e.g. salt, stabilisers, flavourings)

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How do the process steps differ

Grains

When oat, rice, spelt, etc. are used in the form of meal, the first process step is starch hydrolysis. Some water and enzymes are added to the meal and they are heated gently.

Nuts

The nuts are normally purchased as a kind of paste and then mixed with water to create a homogeneous mass.

Legumes

The content of the pod, for example peas or beans, first need to be soaked. After dispersing, the suspension is cooked to inactivate the existing enzymes.

The next steps are the same for all types of raw material: After separating the solids, the acquired base is mixed with a variety of additives (oil, stabilisers, salt, sugar, flavourings, etc.). This is followed by the heat treatment of the product.

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Focus: oat drink production
Process steps: three variants

Krones offers three options for producing oat drink. They generally differ when it comes to the raw-material base and the system set-up.

Variant 1

- Raw-material base: **ready-to-use oat base**
- Is blended in conventional syrup room systems and emulsified with oil if necessary

Variant 2

- Raw-material base: **oatmeal**
- Is blended in conventional syrup room systems (powder dissolver and process tanks for hydrolysis)

Variant 3

- Raw-material base: **whole oat grains or oat flakes**
- Are ground and then further processed with special hydrolysis tanks comparable to vessels used in breweries

In all variants, a UHT system (Krones VarioAsept M) is then used before the product can be filled on an aseptic system (e.g. from the Contipure AseptBloc series).

More technical details and examples of arrangements of the individual variants can be found on the following pages.

Variant 1: production from finished oat base

The process steps in detail

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Variant 1: production from finished oat base
The process steps in detail

Raw-material base

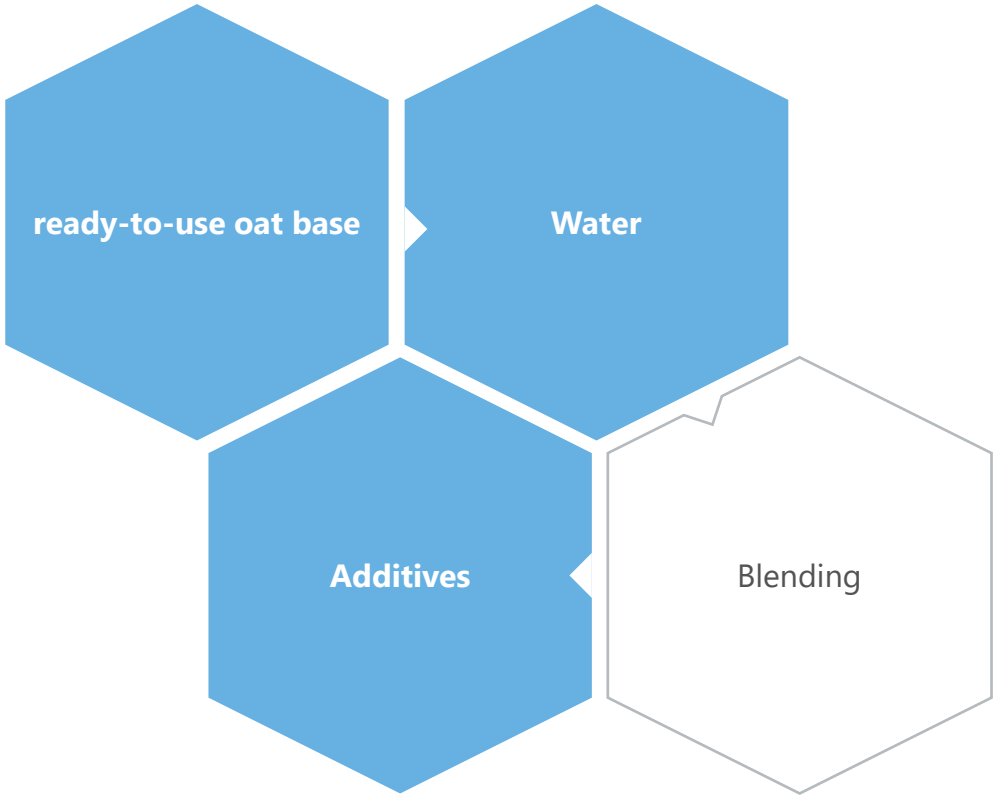
ready-to-use oat base

Suitable for

beverage manufacturers who already own a syrup room and would initially like to test the production of grain-based drinks for themselves and their brand

- Existing equipment can be used (minor extensions may be required)
- Swift market entry possible
- Preservation of flexibility as it is possible to react relatively quickly to changing market requirements
- **But:** relatively high production costs as the basic material is purchased ready-to-use

Overview of the most important process steps



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Variant 2: production from oatmeal

The process steps in detail

Read more about the hydrolysis process on page 21 and onwards.

Variant 2: production from oatmeal
The process steps in detail

Raw-material base

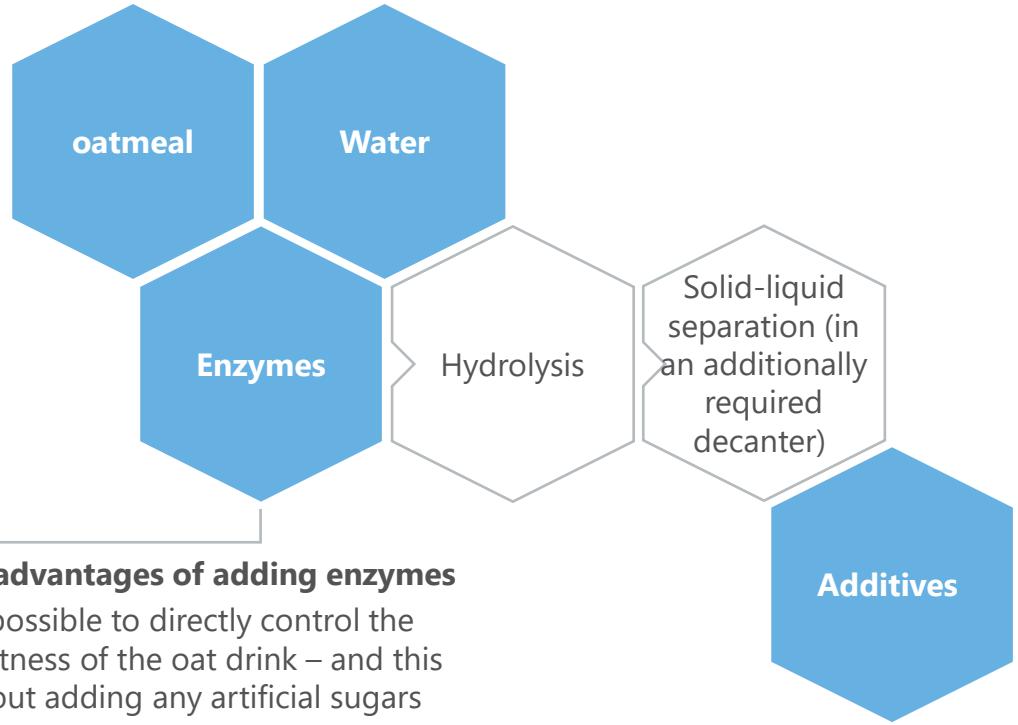
ready-to-use oatmeal

Suitable for

producers who wish to produce medium-sized quantities of oat drink quickly and reliably.

- Swift market entry possible
- Allows individual recipes as the product characteristics can be directly controlled in the hydrolysis process. Recipe can be developed independently from the raw material supplier
- More cost efficient than variant 1 in the long term as oatmeal can be purchased cheaper

Overview of the most important process steps



The advantages of adding enzymes

It is possible to directly control the sweetness of the oat drink – and this without adding any artificial sugars

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Variant 3: production from whole oat grains or flakes

The process steps in detail

Read more about the hydrolysis process on page 21 and onwards.

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Variant 3: production from whole oat grains or flakes

The process options in detail

Raw-material base

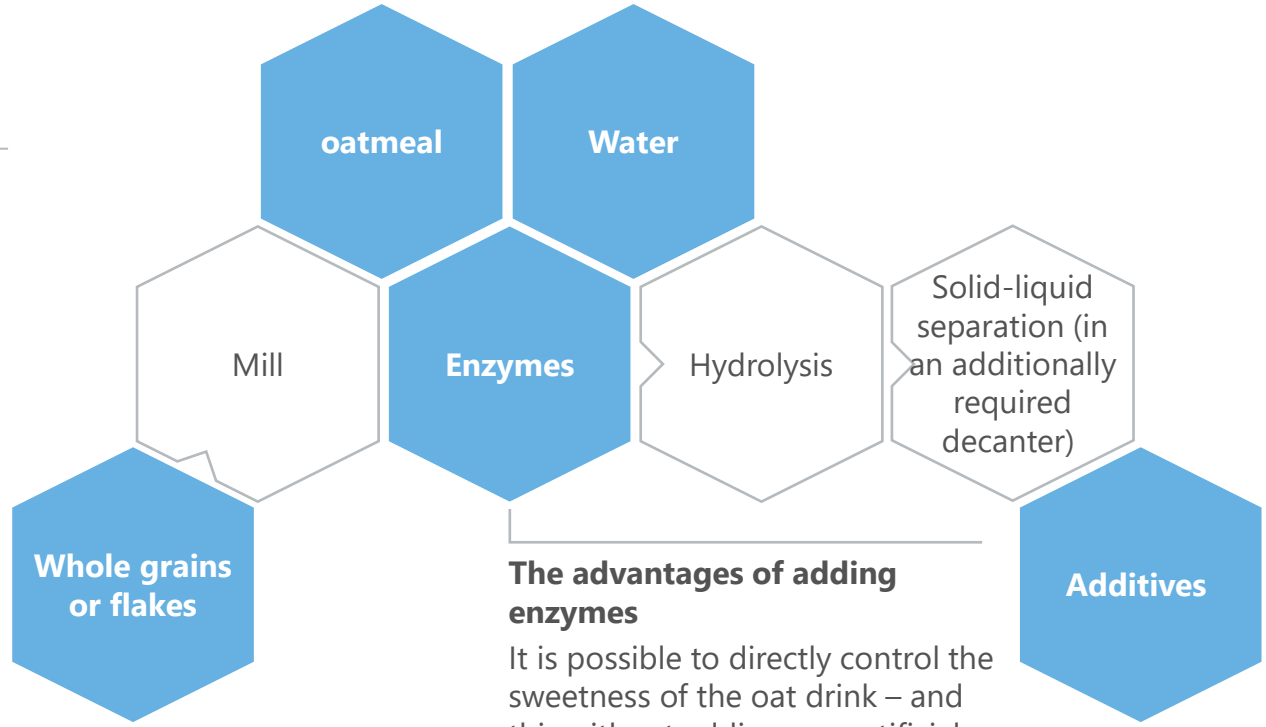
whole oat grains or flakes

Suitable for

producers who attach great value to high product quality and a sustainable overall concept (low energy requirement for greater production quantities)

- Allows individual recipes as the product characteristics can be directly controlled in the hydrolysis process. Recipe can be developed independently from the raw material supplier
- Use of brewery technology makes it possible to control and adapt the hydrolysis process even more effectively
- Energy-efficient variant: focus on a holistic energy concept
- In the long term, the least expensive of the three variants as regards production costs

Overview of the most important process steps



The advantages of adding enzymes

It is possible to directly control the sweetness of the oat drink – and this without adding any artificial sugars

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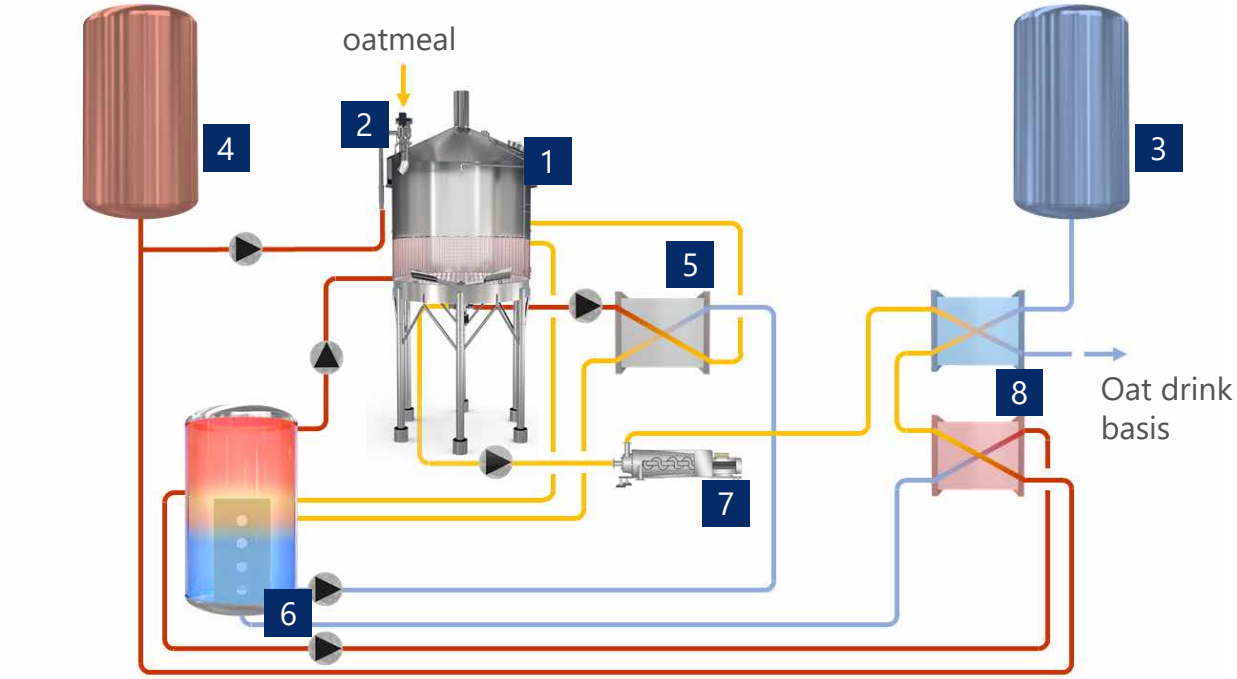
Variant 3: the most sustainable approach
Holistic energy concept

For the manufacture of oat drinks, Steinecker uses the method of operation of a mash vessel with internal pillow plates.

Benefits to you

- Reliable, homogeneous blending and thus efficient oat extraction
- Low supply temperatures that make an efficient energy recovery concept possible



1	Hydrolysis reactor (mash vessel)	5	Heat exchanger (hydrolysis)
2	Pre-masher	6	Energy storage tank
3	Cold-water tank	7	Decanter for the separation of solids and liquids
4	Warm-water tank	8	Product cooler

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Two in-house technical training centres with complete line technology

For optimum recipe development and product tests

Steinecker Technology Center in Freising

Complete test brewery that can also be used for tests with plant-based milk alternatives:

1 Dosing of grain meal into the mash vessel

2 Addition of enzymes for hydrolysis

3 Separation of solids and liquids

4 Cooling of the liquid

→ **Ready-to-use oat base**

All of the other tests are then held in the Neutraubling technical centre

Krones Technology Process Center in Neutraubling

Pilot systems for all downstream processes – from mixing and preservation through to filling

1 Mixing with stabilisers, flavourings, etc.

2 Heating (pipe and plate heat exchangers)

– **Optional:** direct heating with steam injection/infusion

3 Deaeration

4 Homogenisation

5 Filling

→ **Finished oat drink**

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Holistic proficiency of Krones process technology

Benefit from decades of expertise

Krones is not only a supplier of engineering and technology: As an all-round partner, we support you right from the product development stage and work with you to implement the system set-up that is exactly in line with your requirements.

Depending on what you need, we put together a team of professionals from Krones' individual areas of technology for your product:

- **Krones** introduces its skills from the field of thermal product treatment and subsequent filling and also scores points with its global sales and service network.
- **Milkron** perfectly adapts its project and engineering know-how from dairy technology to fit in with the production of plant-based milk alternatives.
- **Steinecker** supports you with expertise in all aspects of processing the widest range of grain types (raw material handling), in particular in enzymatic hydrolysis – and always has its focus on the sustainability of the overall process.

But there is no need to worry, the communication channels remain short and direct for you: The close co-ordination and co-operation, as well as the transfer of knowledge all take place in the background. You are given – depending on the project requirements and the region – **one central contact person**, who will provide you with comprehensive and competent support when you start the production of plant-based milk alternatives.

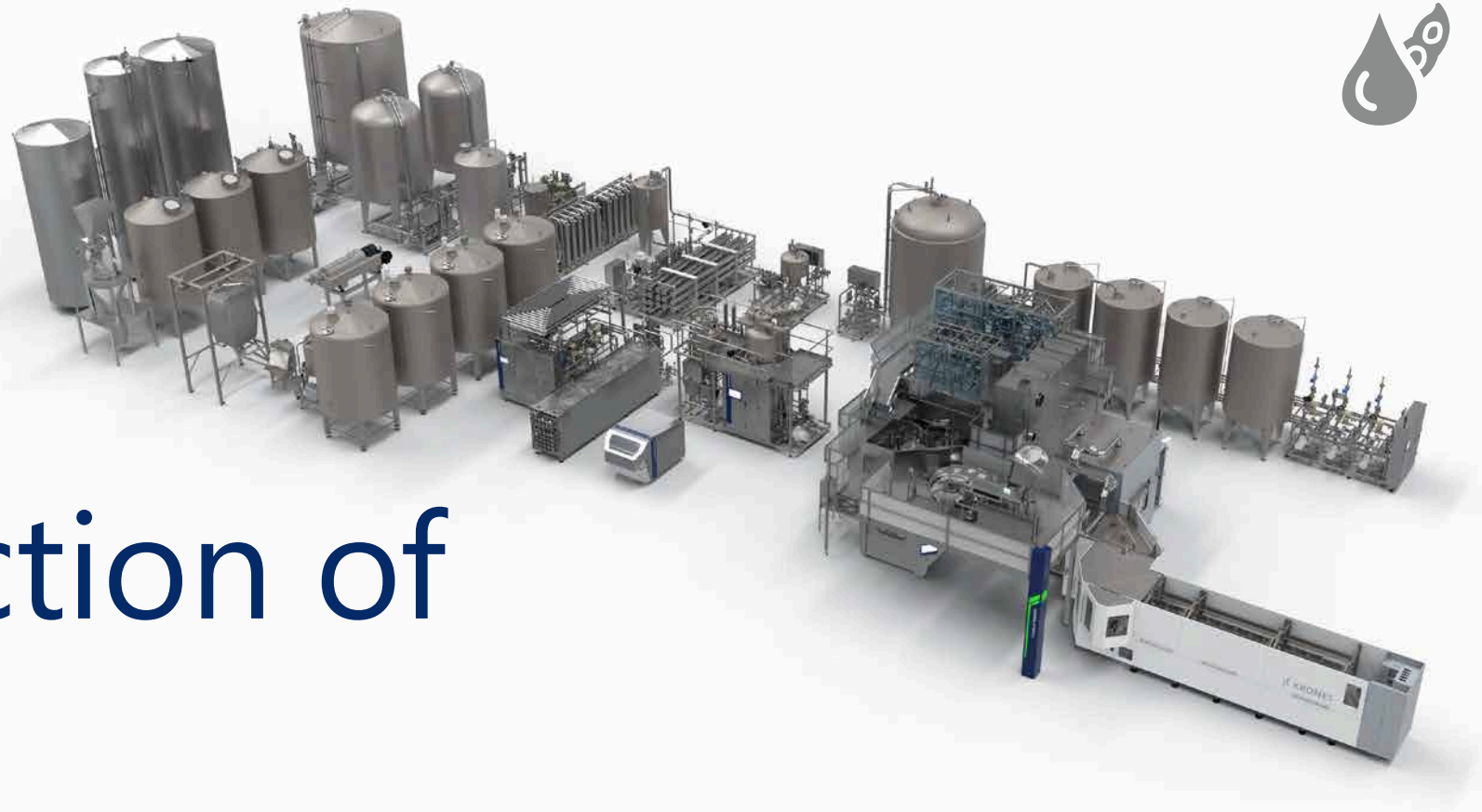
Holistic expertise of Krones process technology

The experts in detail

We not only support you with our own line solutions, but also with integral project support. Our experiences from the process technology for milk and sensitive drinks have been perfectly adapted to the production of oat drinks – and advise and support you in your introduction into a new product category. Our experts are distributed all around the globe. It goes without saying that they work closely with other subsidiaries to utilise the existing wealth of knowledge in the best way possible and transfer it to your project.

Of course, the milk experts in the Krones group know more than a thing or two about the manufacture of plant-based milk alternatives. They predominantly support customers in the European area to realise their projects: from the planning stage through to the engineering and implementation on site.

The team of experts from Steinecker has many decades of experience in supporting breweries all over the world with energy-efficient and Co_2-saving solutions for your brewing process – and it is precisely this expertise that is now utilised in the production of oat drinks. Steinecker supports you in developing and implementing a sustainable concept that is precisely adapted to suit your product requirements.



The production of oat drinks

The process steps of energy-efficient variant 3 in detail

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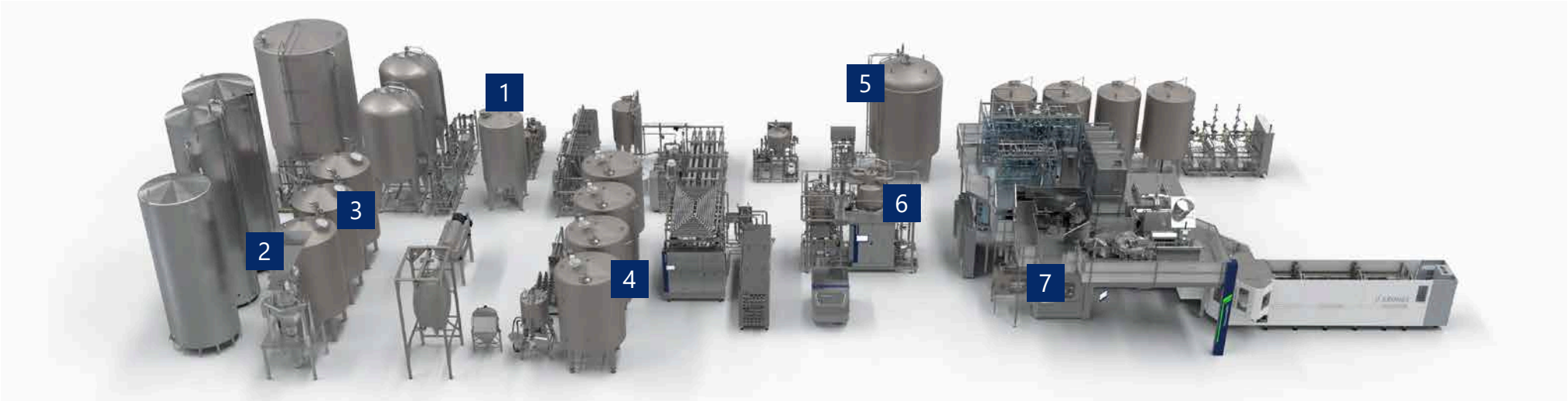
Oat drink production using whole oat grains or flakes

Sample representation of an oat drink line



1 Water treatment

2 Mixing of meal and water

3 Hydrolysis

4 Separation of solids and liquids and blending of additives

5 Product treatment and homogenization

6 Flexible heating options

7 Aseptic filling

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1 Krones Hydronomic water treatment system

In addition to select, high-quality raw materials, the second major ingredient that is important for plant-based milk alternatives is water. And here you can benefit from our turnkey abilities – as Krones is the only supplier in the world who can also include knowledge about ideally treated water, as well as the corresponding line technology. The Hydronomic is designed exactly with a view to plant-based milk alternatives and makes it possible to achieve a standard water quality with a low TDS content and without taste impairments.

At a glance

- It operates with a water treatment process which is tailored exactly to your requirements
- It prepares between 5 and 120 m^3 of water per hour – optionally with a variable production quantity
- Minimised quantity of waste water thanks to its sophisticated technology
- Best possible access for operators and service personnel
- Minimised requirement for cleaning chemicals due to the stainless steel construction which can be sanitised completely with hot water
- It can be expanded thanks to modular design

Our solutions for your water treatment

We adapt the equipment for your individual treatment steps exclusively to suit your economic and technological requirements. With our modular component system, we will always find the correct solution – from the high-end all the way to a cost-attractive basic version.

Hydronomic MF/GAC (Media Filtration)

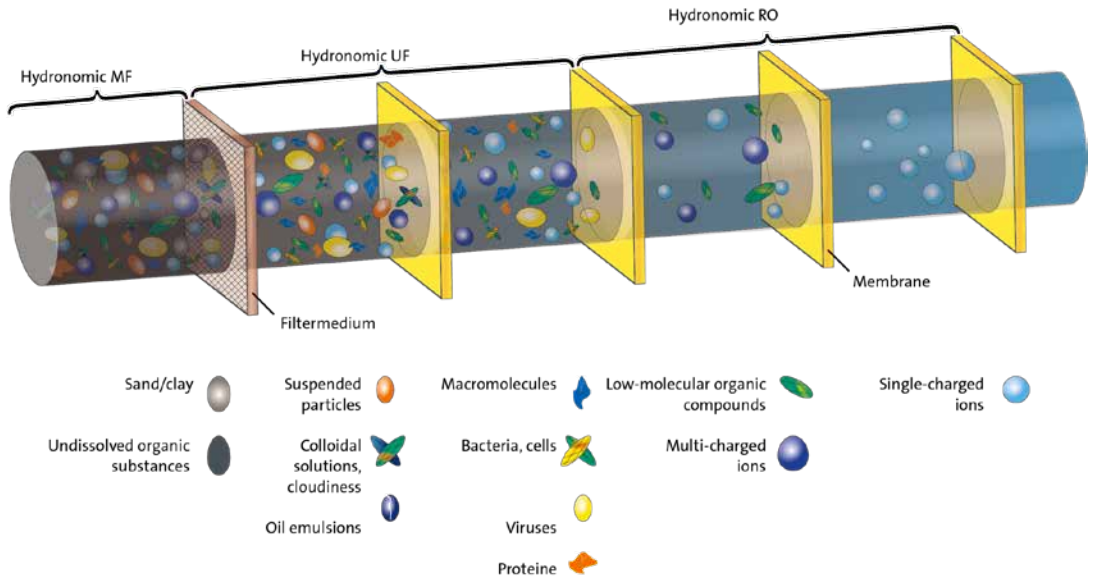
It filters and adsorbs any unwanted and undissolved water content (suspended solids, odorants, organics, chlorine, iron, manganese, etc.) with different filter media (e.g. silica sand, manganese oxide, basalt and activated carbon)

Hydronomic UF (Ultra Filtration)

Uses the most up-to-date membrane technology with hollow fibres (pore size of 0.02 µm) for the ultrafiltration of water in in/out operation

Hydronomic RO (Reverse Osmosis)

Desalinates water with membrane technology in a reverse osmosis technology where the wound membrane module is flushed tangentially



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2 Intensive mixing of oatmeal and water

Before adding enzymes (hydrolysis), an optimised mixing of oatmeal and water guarantees a homogeneous suspension. This procedure is performed in a pre-masher. Its proven technology permits dust and lump-free mixing up to a ratio of 1:2.

Method of operation: expansion as the driving force

- The meal is fed from above and the water then added horizontally in a pocket.
- Swirl vanes at the nozzle outlet of the pocket increase the turbulence in the mixing zone.
- The reduced diameter after the pocket increases the flowing speed and thus causes the media to expand.
- This guarantees that the solids are distributed optimally in the liquid medium.
- These measures force an intimate contact between the finest particles and the water.

The pre-masher is installed above the hydrolysis tank.

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3 Hydrolysis
key process for the final product quality and yield

Particulate starch is made up of alternating hard and soft layers.

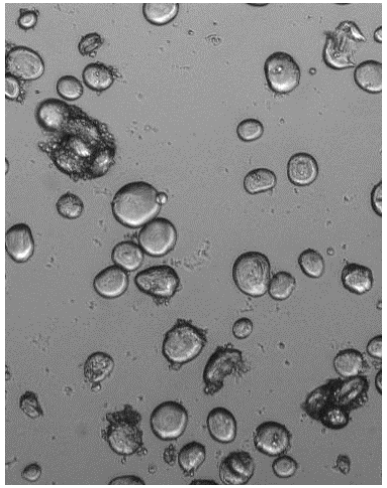
The structure and thickness of the individual layers depends on the growth conditions and influences the gelatinisation temperature of the starch.

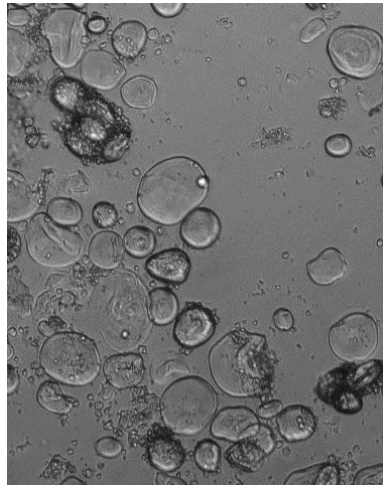
The yield, sweetness and mouthfeel of the finished product depend on the:

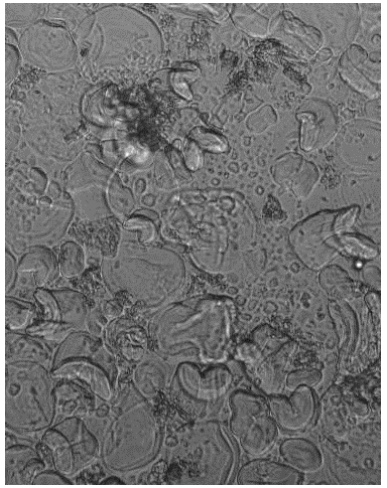
- gelatinisation temperature of the raw material
- Liquefaction of the starch through the effect of α-amylases at temperatures between 80 and 85 °C
- Saccharification with β amylases and glucosidases, that separate maltose from the end of the dextrine chain and have an optimal effect at approx. 60 to 65 °C

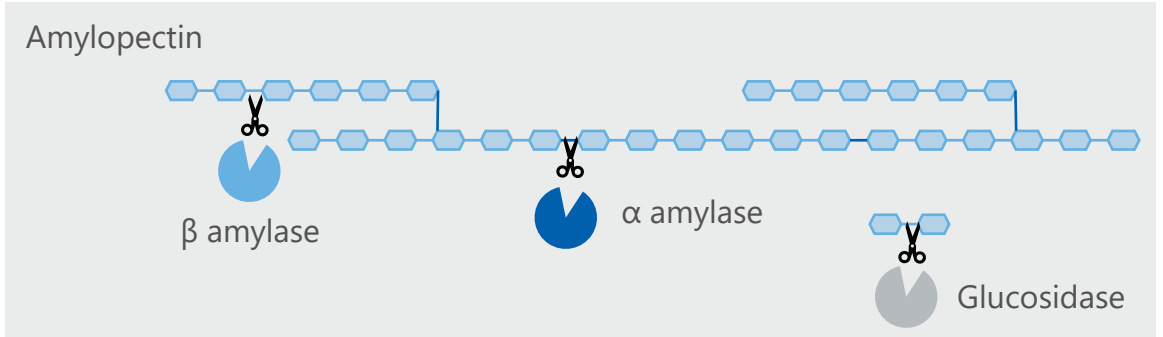
→ The selection of the suitable enzyme (depending on the supplier) is crucial for the balance of the end product as regards sweetness, mouthfeel and yield.

→ Preliminary trials are required to define the required end product.


Starch globules


Starch after gelatinisation


Liquefied starch



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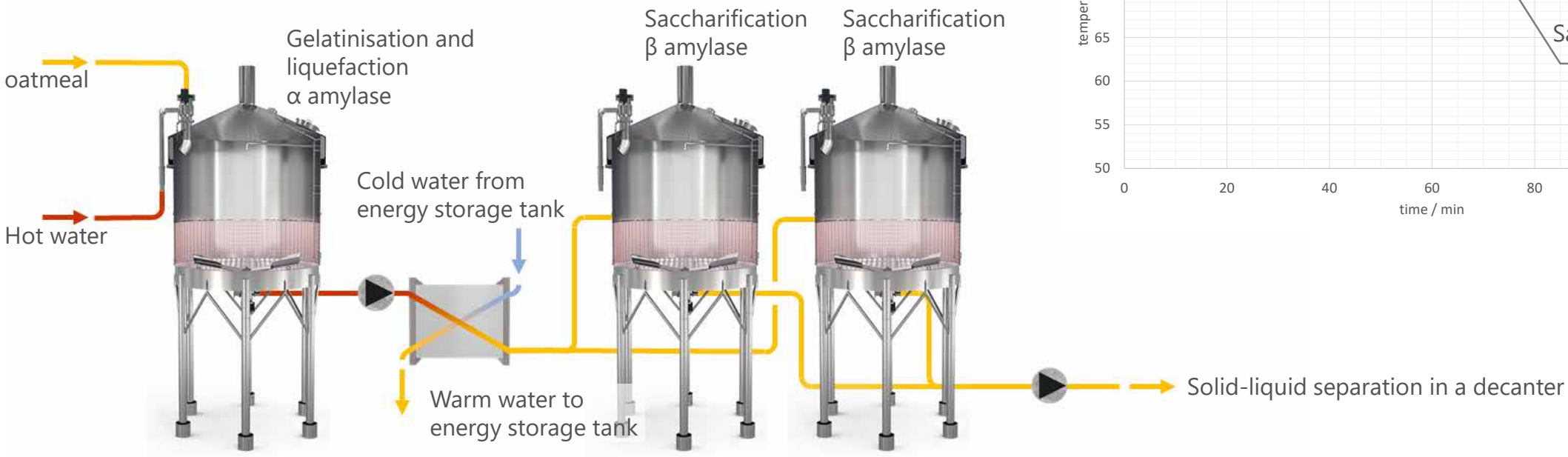
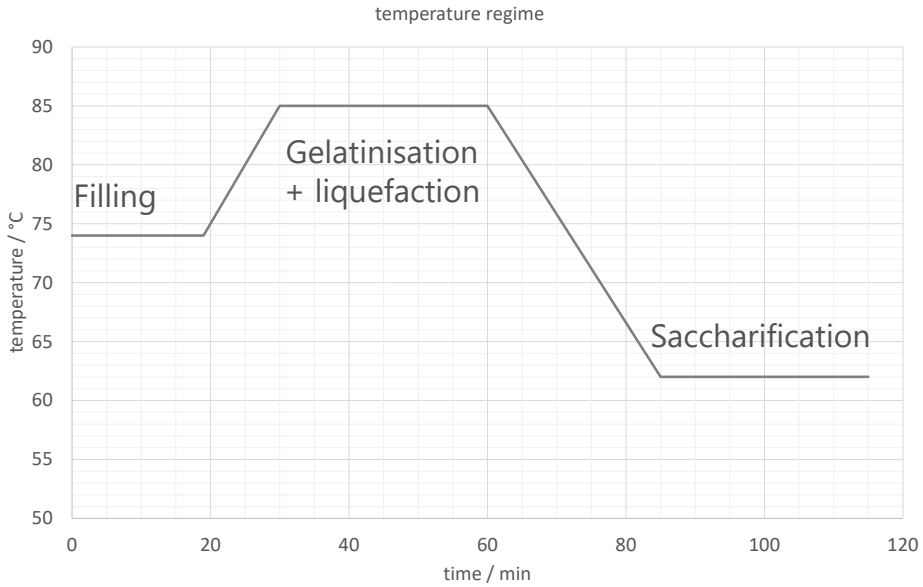
Line concept for continuous hydrolysis

Sequence and duration of a sample process

Filling and heating: 30 min.
Gelatinisation and liquefaction: 30 min.
Cooling to saccharification temperature: 25 min.
Saccharification 30 min.
Separation of solids: 85 min.





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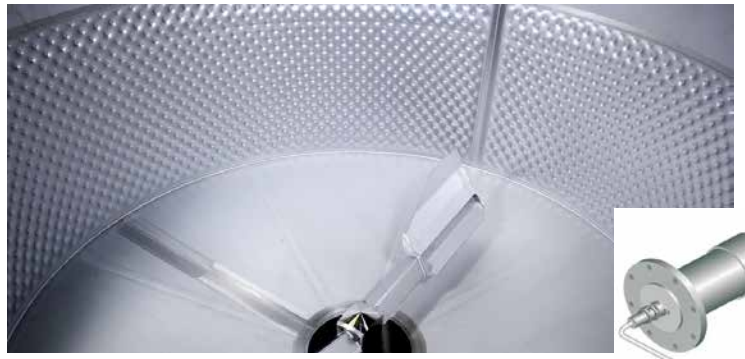
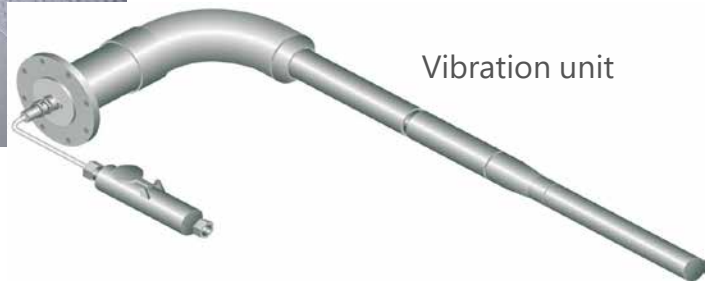
Optimal hydrolyse results
Use of the technology in Steinecker mash vessels

Pillow plates

- Micro-turbulent flow of the suspension thanks to its guidance along the interior corrugated heating surface of the hydrolysis tank: Heat transfer and heating rate improved
- Even heat absorption during mixing without overheating the outer layer
- Reduced fouling and improvement of the quality of the suspension due to low steam pressures of 1 – 2 bar or respectively with hot/warm water



Pillow plates



Vibration unit

Vibration units

- Vibration units that can be integrated in the vessel as an option and can be activated and deactivated as required to optimise the hydrolysis
- Vibrations within a defined frequency range to generate a resonance vibration in the suspension
- Resonance for intensifying physiochemical degradation processes and for the expulsion of gas inclusions from solid particles

Advantages of the structured heating surfaces

Individually configurable – depending on the required result:

- **Lower heating medium temperature** (at the same surface and heating rate)
- **Smaller vessel diameter** (at the same heating rate and heating medium temperature, depending on the specification)
- **Higher heating rates** (at the same surface and heating medium temperature)

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4 Separation of solids and liquids and blending of additives

Separation of solids and liquids

After hydrolysis, the oat-water mixture first goes into a decanter that has to be additionally installed, in which the solids are separated from the liquids.

Blending

In the following process, the oat base is blended with various additives such as oil, salt, flavourings, stabilisers and possibly sugar, depending on the recipe, to form the finished beverage. The configuration can be individually adjusted to suit your requirements.

Possible processes

- The processing and dosing of ready-to-use concentrates and essences
- Dosing and dispersion of powders, for stabilisation for example
- Introduction of flavourings for the final product composition
- Mixing of the final dry substance

Stirring and mixing devices

- Because of the defined dry mass in the finished product, the mixing tanks are equipped with agitators that are adjusted to be compatible with the characteristics of the product.
- Emulsifiers for incorporating oil can be added both in the tank and inline.
- The connection concept and size of the ingredient dosing will be adapted according to the customer and product requirements.

5 Product treatment
Krones VarioAsept M UHT system

- Specifically designed for use in the milk industry and thus in an ideal position to cater to the requirements of plant-based milk alternatives:
  - At the end, reliably inactivates the enzymes needed for hydrolysis
- Output range: Between 3,500 and 60,000 litres per hour
- Proven design which ...
  - meets the highest hygiene requirements
  - Is extremely gentle on the product

Also:

- In-house laboratory for product analysis
- Perfectly matched with the Krones aseptic fillers

Product treatment
Krones VarioAsept M UHT system

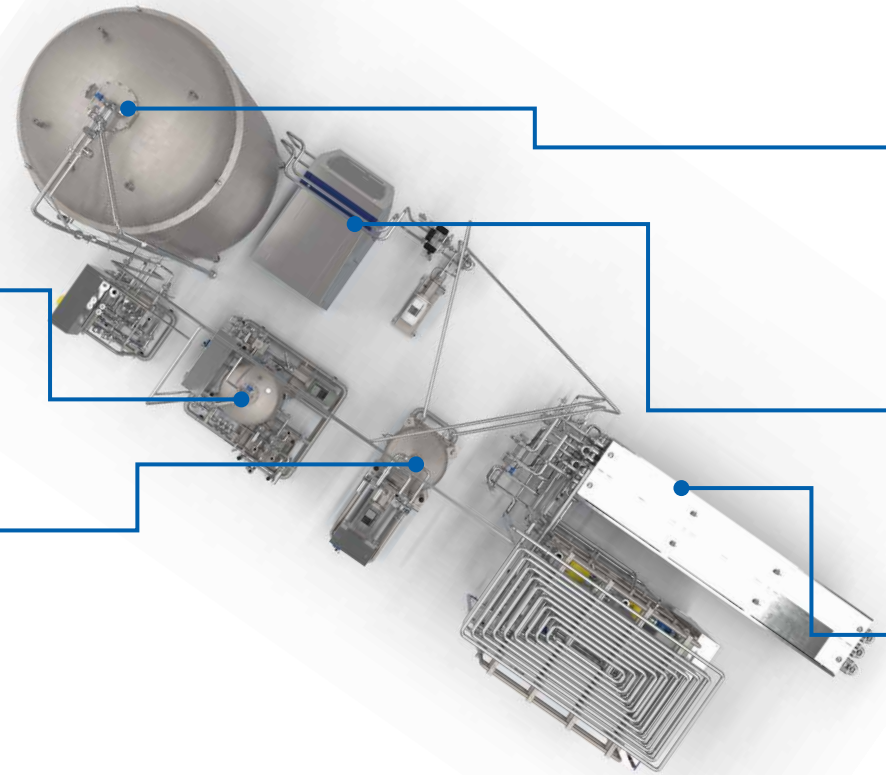
Components of the modular component system

Service module
- Energy supply for product heat exchanger
- Electrical and pneumatic controller with MCC and Krones HMI

Module for media supply
Decoupling of the downstream process for stable production conditions

Krones VarioSpin product deaerator
Deaeration with patented swirl infeed nozzle:
- Ensures that gas bubbles will quickly escape from the product
- Reduces oxidative impact such as loss of vitamins or discolouration of juices

Evoguard valves and pumps



VarioStore tank system for aseptic lines
- Vacuum-sealed and pressurised up to 6 bar
- Fully aseptic, automatic valve manifold between UHT system and buffer tank
- With integrated system for sterile gas filtration

Homogeniser by HST

Heat exchanger
Depending on product requirements:
- Plate heat exchanger
- Tubular heat exchanger with cross-corrugated tubes for less thermal impact

Alternatively: Direct heating

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Homogeniser by HST

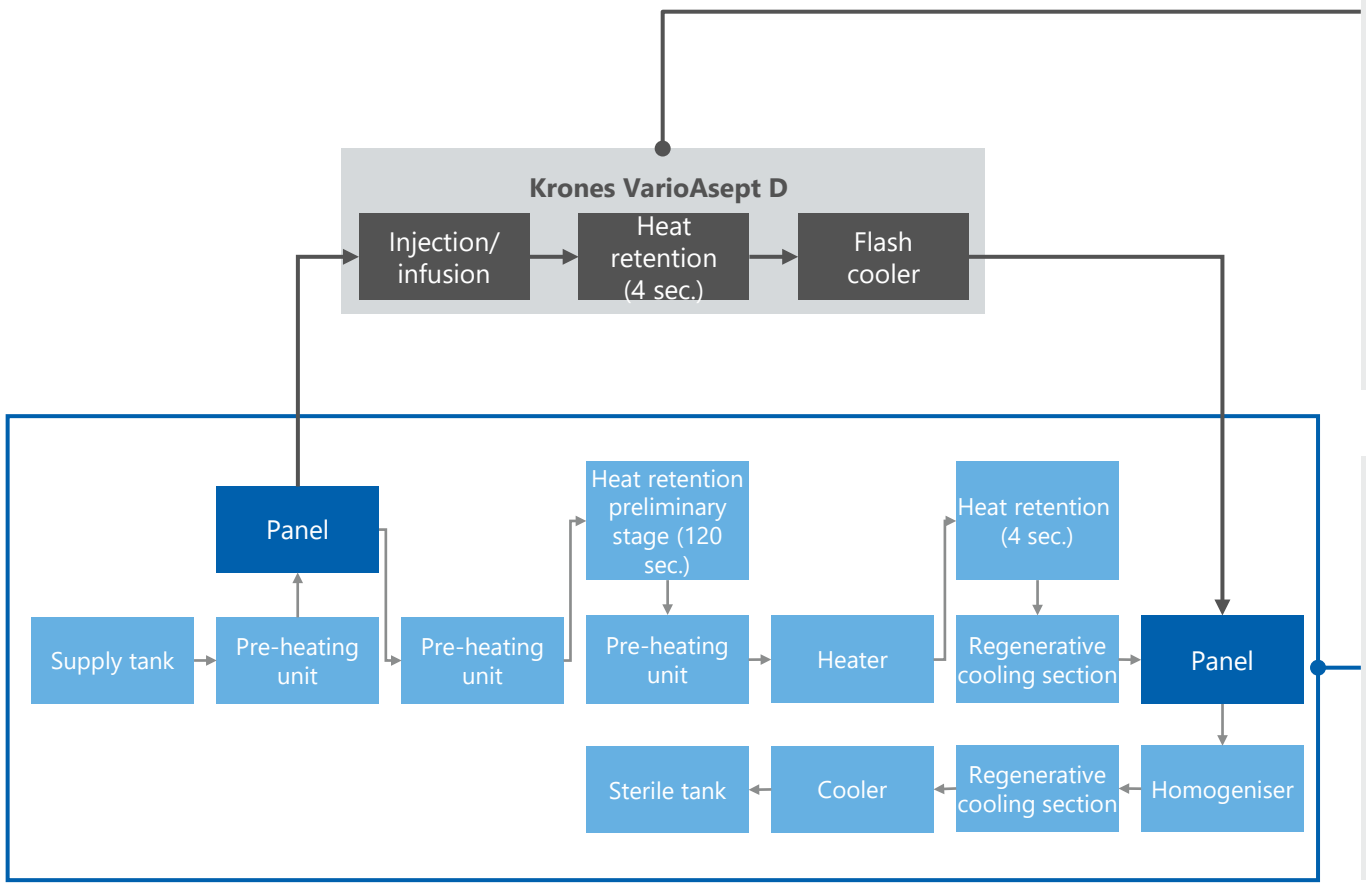
Homogenization is an important process step in the manufacture of plant-based milk alternatives. The system is located in the sterile area, meaning that aseptic homogenization is therefore performed. This way, the agglomerates formed during heating (regardless of whether directly or indirectly) can be removed again, which ensures a high product quality.

The HL/HLI series of **HST homogenizer** is a high-pressure piston pump. It comprises 2, 3, 5 or 6 pistons as well as a downstream homogenizing valve.

Benefits to you

- Large range of outputs: 10 to 60,000 litres per hour
- Operates with a pressure up to 800 bar on production machines and up to 1,500 bar on laboratory machines (depending on configuration)
- Cylinder block of high-alloy, forged and corrosion-resistant stainless steel with very little wear parts
- Excellent results during the CIP process thanks to high finish quality and avoidance of dead spaces
- Robust and wear-resistant drive technology
- Integrated PLC controller for monitoring and control of the homogenizer via the product UHT system

6 Flexible heating options



Direct heating with the VarioAsept D
- Steam injection or
- Steam infusion

Benefits to you
- Extremely short heating and cooling times
- Guarantees the highest product quality (taste and freshness)
- Very long production times possible
- Suitable for products that are difficult to heat (e.g. due to their viscosity, anhydrous content, etc.)

Indirect heating
- Plate heat exchanger or
- Tubular heat exchanger with cross-corrugated tubes for less thermal impact

Benefits to you
- Also suitable for products containing pieces
- High heat recovery rates possible
- Lower investment and maintenance costs
- Temperature profiles directly adjustable to suit the product

7 Aseptic filling systems
Complete the overall expertise of the Krones group

- 10-Year sterility guarantee available
- Automatic adjustment of the handling parts at speeds of up to 36,000 containers per hour

Especially for slightly acidic and pH-neutral products: Contipure AseptBloc

- FDA and 3A certificate available for the entire aseptic block arrangement
- All of the components in the clean room housing block can be completely sterilised: The sterile preform or sterile container never leaves the sterile zone until it reaches the capper
- Up to 168 hours of continuous production in one go
- Output: Up to 72,000 containers per hour

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Evoguard process components
Complete the overall expertise of the Krones group

Valves and valve manifolds

From the simple shut-off function up to the most advanced aseptic processes and complex valve manifolds: The Evoguard valve range combines hygienic and aseptic designs with all the requirements to meet demands on process stability, reliability, and maintainability.

Hygienic pumps

Gentle feed combined with the highest efficiencies, robust design and high maintainability underline the advantages of the Evoguard centrifugal pump series as well as the pumps of Ampco.

Vessel dome fittings

Thanks to the modular approach, individual solutions for tank cleaning and safety can be configured based on the customer's specific requirements.

Evotube tubular heat exchanger

Maintenance-free modules with cross-corrugated tubes ensure an efficient heat transfer combined with gentle product handling. They are developed and manufactured by Krones.

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SOLUTIONS BEYOND TOMORROW

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