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Craft Brewing

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Bad Weather Doesn't Have to Mean Bad Business: Let Enzymes Help

Brew Beer Better

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Alex Merz

Brewing Engineer

NOVOZYMES EU

Brewing with Enzymes by NOVOZYMES

North America

DAUS@novozymes.com

Europe

ASMU@novozymes.com

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Novozymes A/S is the largest global biotechnology company, headquartered in Bagsværd, Denmark.

- Our focus is research & development and production of industrial enzymes, microorganisms, and biopharmaceutical ingredients.

Consumer Bio-solutions

Agriculture & Industrial Bio-solutions

Agenda

- Enzymes
  - 101
  - In brewing
  - Assisting with low quality barley/malt
  - Lowering high energy costs

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Enzyme 101

Active proteins

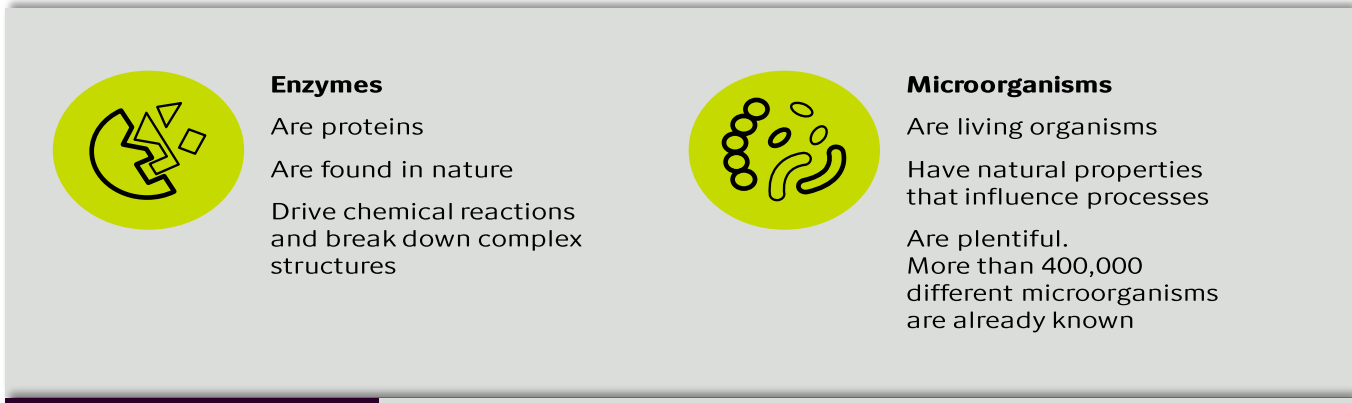
In all living organisms

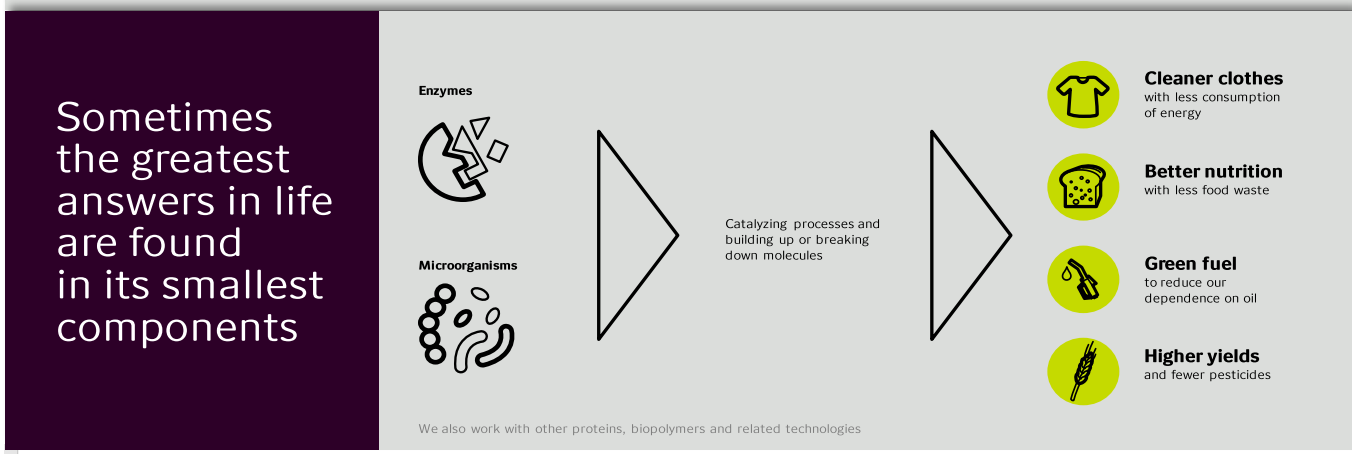
- Plant
- Animal
- Microorganisms-fungal, bacterial

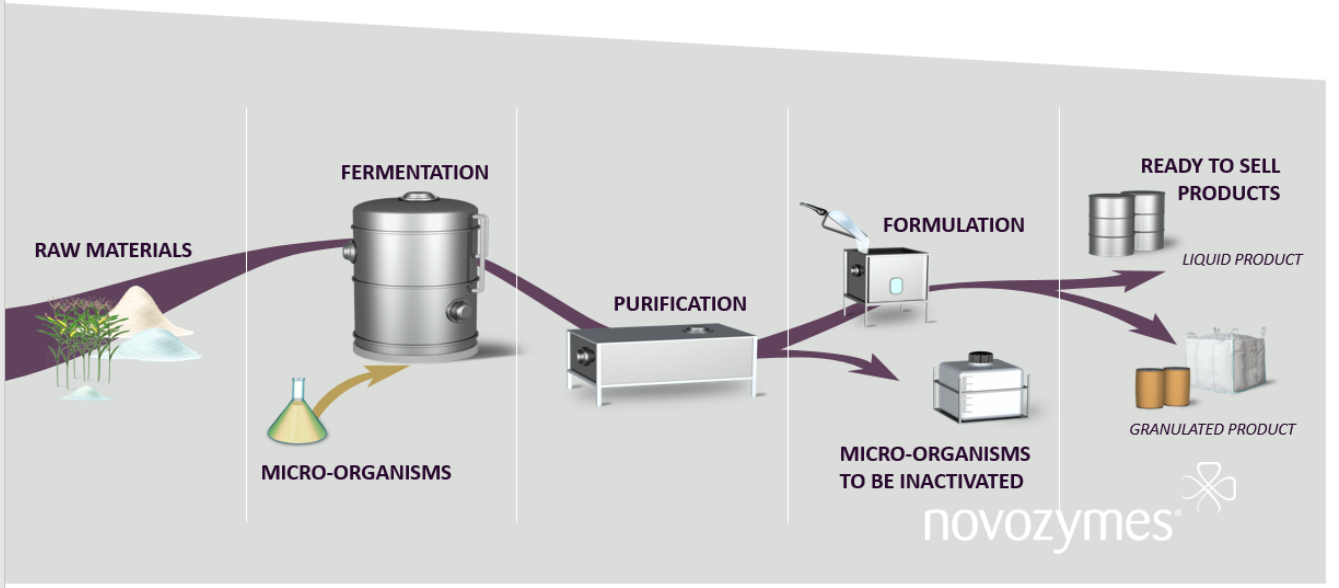
Specific

Works under mild conditions

Can replace/reduce chemicals







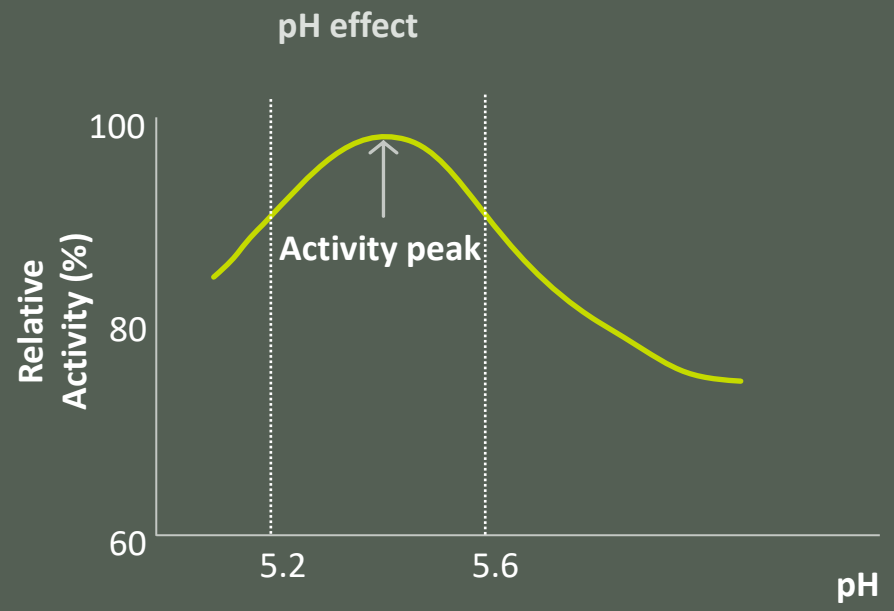
Enzymes need specific conditions to perform

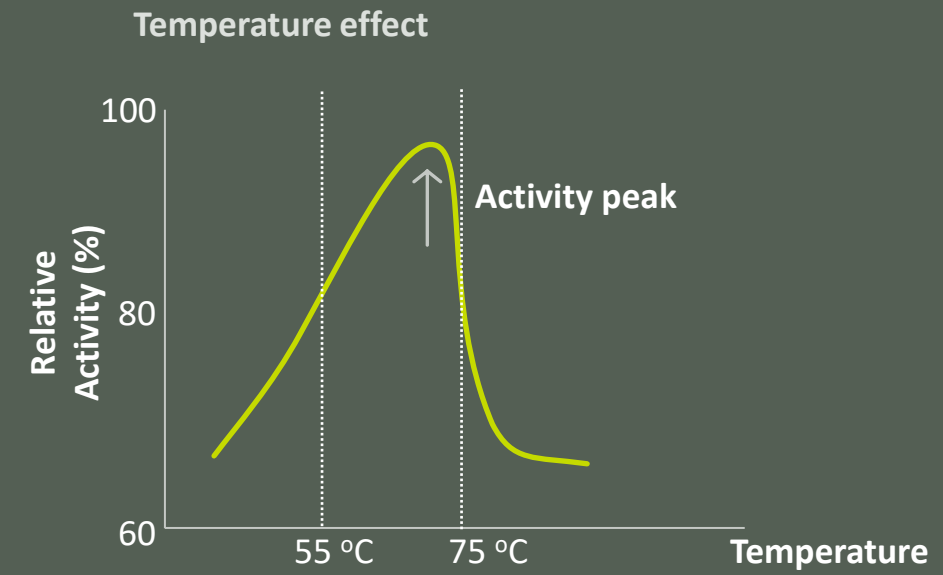
Universal factors

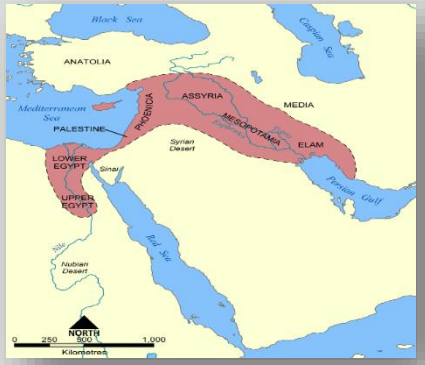
- pH
- Temperature
- Time
- Enzyme dosage

Situational factors

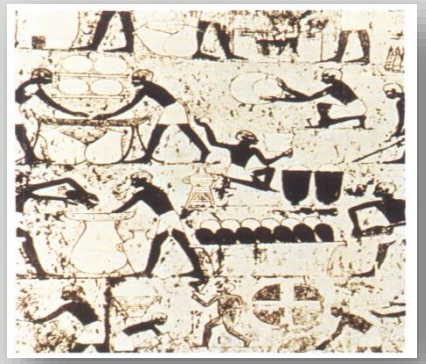
- Solids level
- Oxygen
- Stabilizers
- Inhibitors
- Water quality







~10.000 BC



~2.000 BC

1425 AD

1516 AD

~1900 AD

Enzymes in brewing: expressed during malting needed for degradation of starch and other high molecular components

Enzymes expressed during barley malting

	T_{opt} [°C]	pH_{opt}	Substrate	Product
α-Amylase	65 – 75	5.6 – 5.8	High- and low molecular α-glucans	Oligosaccharides
β-Amylase	60 – 65	5.4 – 5.6	α-glucans	Maltose
Limit dextrinase	55 - 60	5.1	Limit dextrins	Dextrins
…				

	T_{opt} [°C]	pH_{opt}	Substrate	Product
Endopeptidase	45 – 50	3.9 – 5.5	Proteins	Peptides, free AS
Carboxypeptidase	50	4.8 – 5.6	Proteins, Peptides	Free AS
Aminopeptidase	45	7.0 – 7.2	Proteins, Peptides	Free AS
Dipeptidase	45	8.8	Dipeptides	Free AS

	T_{opt} [°C]	pH_{opt}	Substrate	Product
β-Glucan Solubilase	62 – 65	6.8	Matrix bound β-Glucan	Soluable high molecular β-Glucan
Endo-1,3- β-Glucanase	<60	4.6	Soluable high molecular β-Glucan	Low molecular β-Glucan
Endo-1,4- β-Glucanase	40 – 45	4.5 – 4.8	Soluable high molecular β-Glucan	Low molecular β-Glucan
…				

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Goal of mashing

Solubilize key malt/adjunct constituents (sugars, starch, amino acids, peptides, protein)

Hydrolyze high molecular components into fermentable molecules (starch, sugars; protein, peptides → amino acids)

- *Malt delivers both the substrate (i.e. starch, protein) and the enzymes (catalyst) transforming it into components fermentable by brewing yeast*
- *Applying the right biochemical and physical conditions (pH, temperature, water: grist ratio, content of ions etc.) in order to maximally utilize the malt-enzyme potential and substrate availability (i.e. solubilizing, gelatinization)*

Mashing with exogenous enzymes

Process efficiency

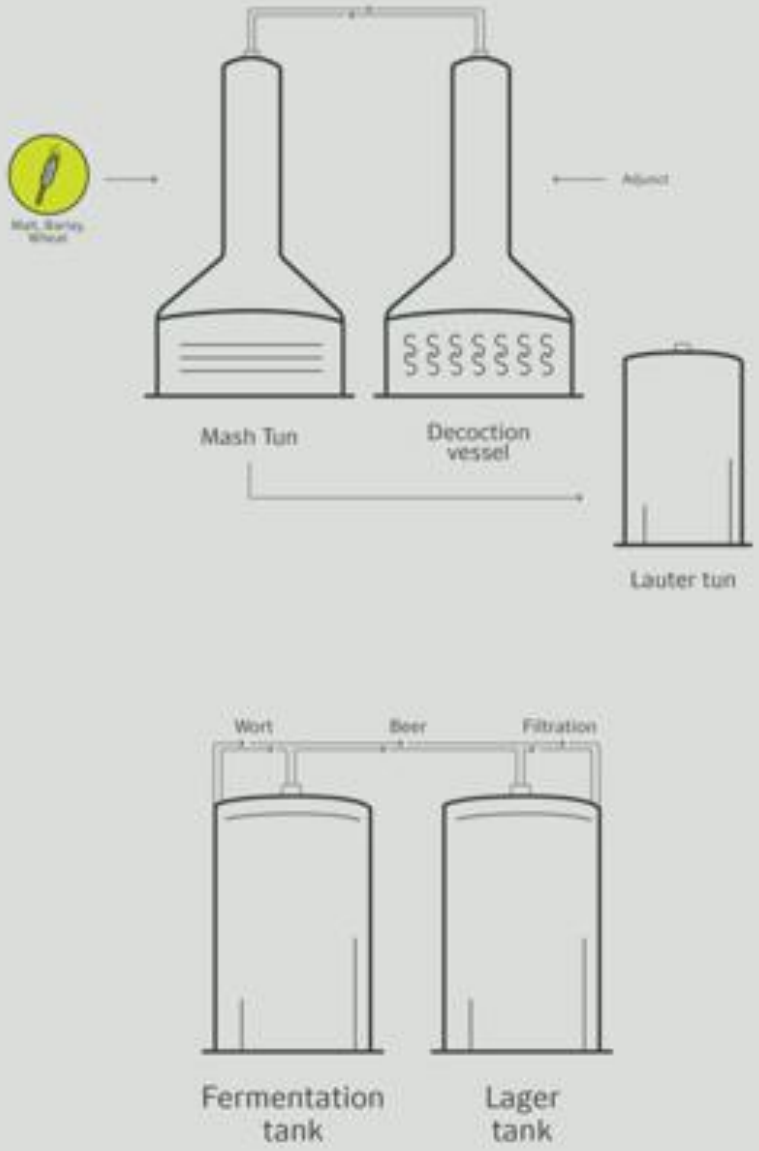
- Improved planning reliability
- Reduced losses
- Increased flexibility on raw material (type, quality)

Space to innovate

- Use of untraditional raw materials
- Enhance/reduce concentration of present beer components

Improve sustainability

- Reduced water, energy consumption and CO_2 emission
- Usage of locally grown raw material

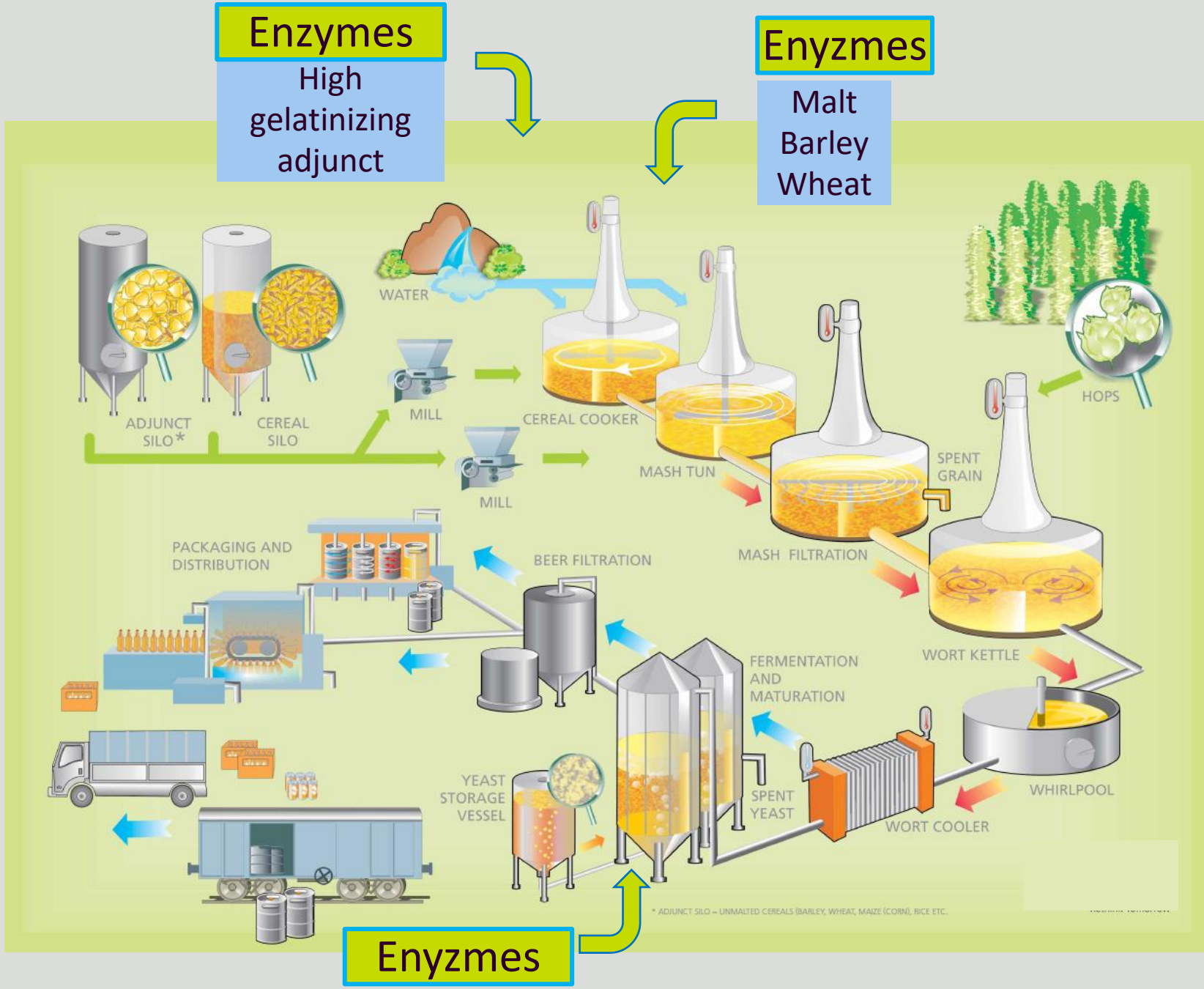


Most brewing enzymes are added into

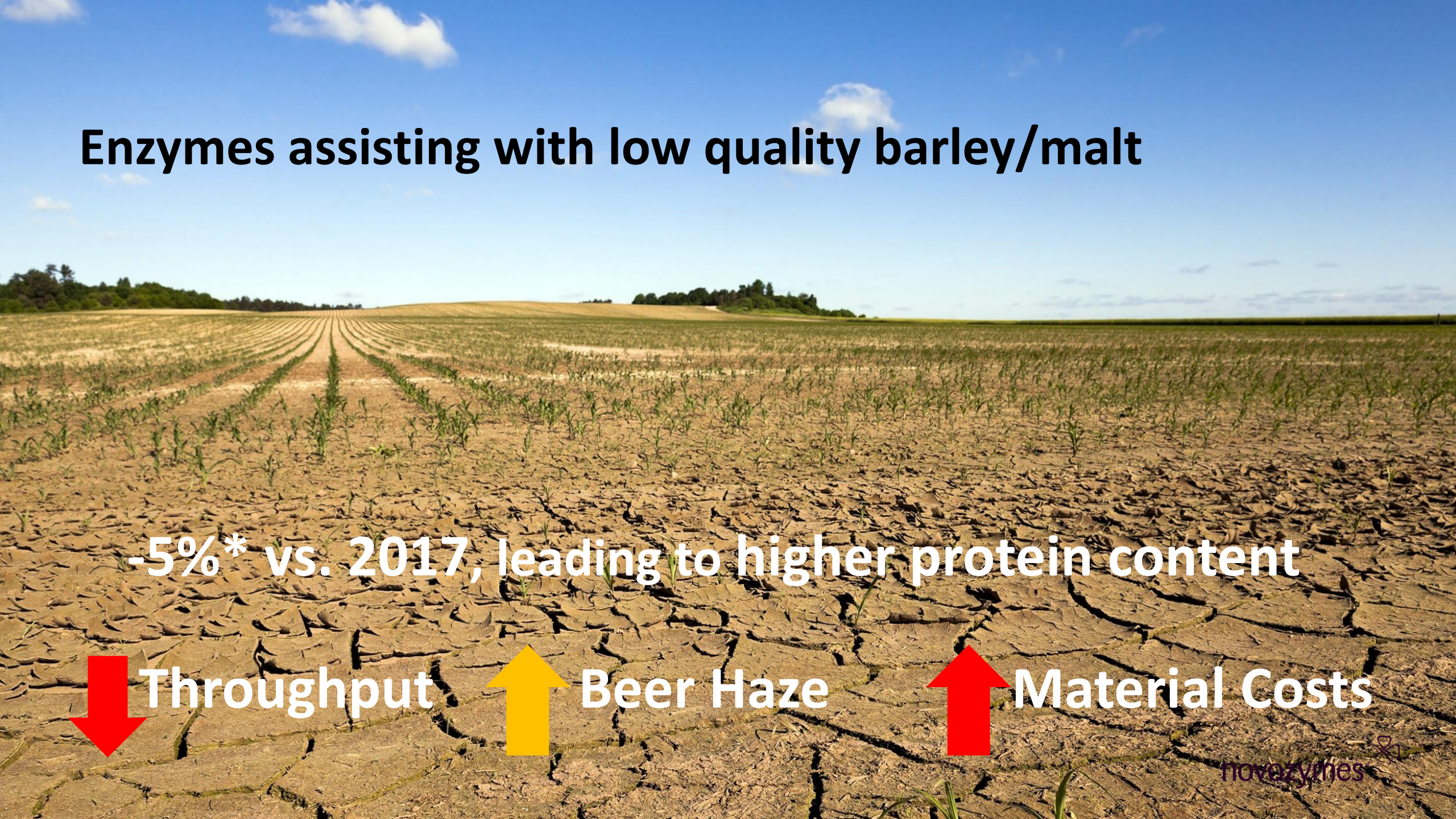
MASH VESSEL/

CEREAL COOKER

at the beginning of the process.



Enzymes assisting with low quality barley/malt



-5%* vs. 2017, leading to higher protein content

Throughput

Beer Haze

Material Costs

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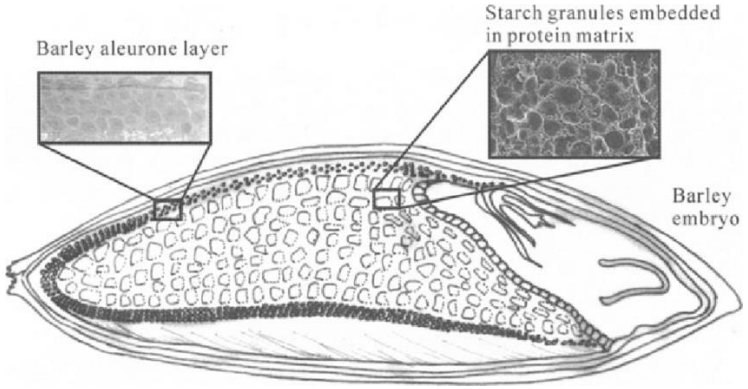
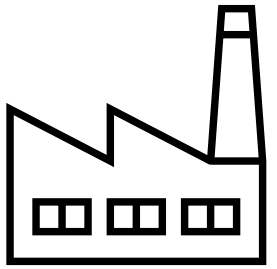
The weather impact on brewing& impact on raw material quality

Barley

High Protein contents



Malt



Harder to malt
Increased extract losses

Less extract / ton of grist
Potential filtration issues
Haze and turbidity risk

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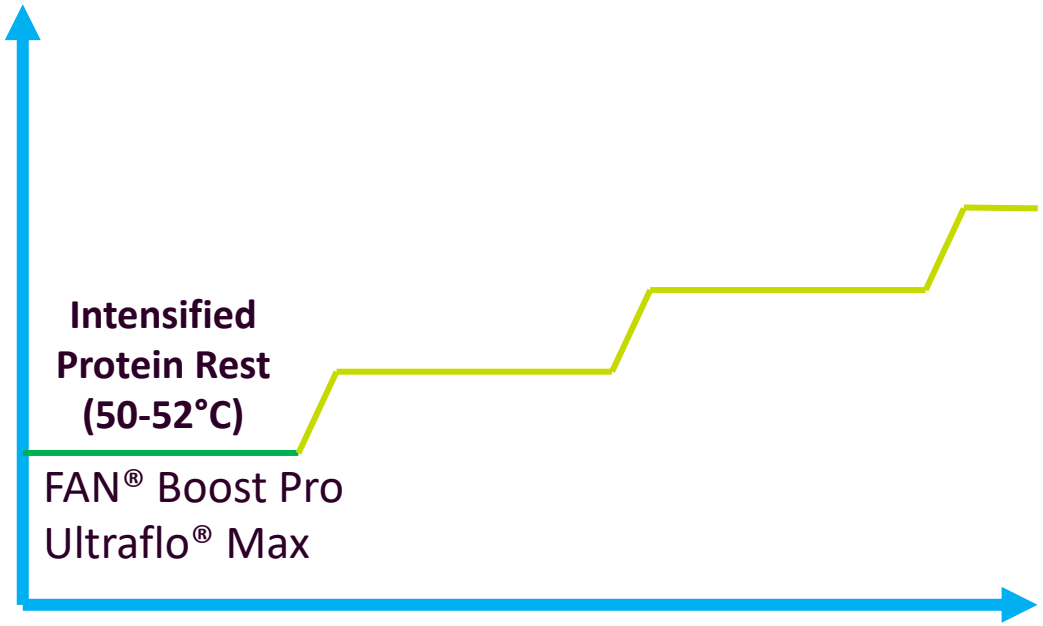

Malt

High Protein contents

Impact: Filtration / Haze Issues due to poor breakdown of proteins

Solution:

Integrate additional protein rest. Allow time for endogenous proteases to act.

Optimise with FAN® Boost Pro to maintain capacity and prevent gel formation.

Optimising the Ultraflo® or Ceremix® applications will aid in improving filtration by reducing other carbohydrates.

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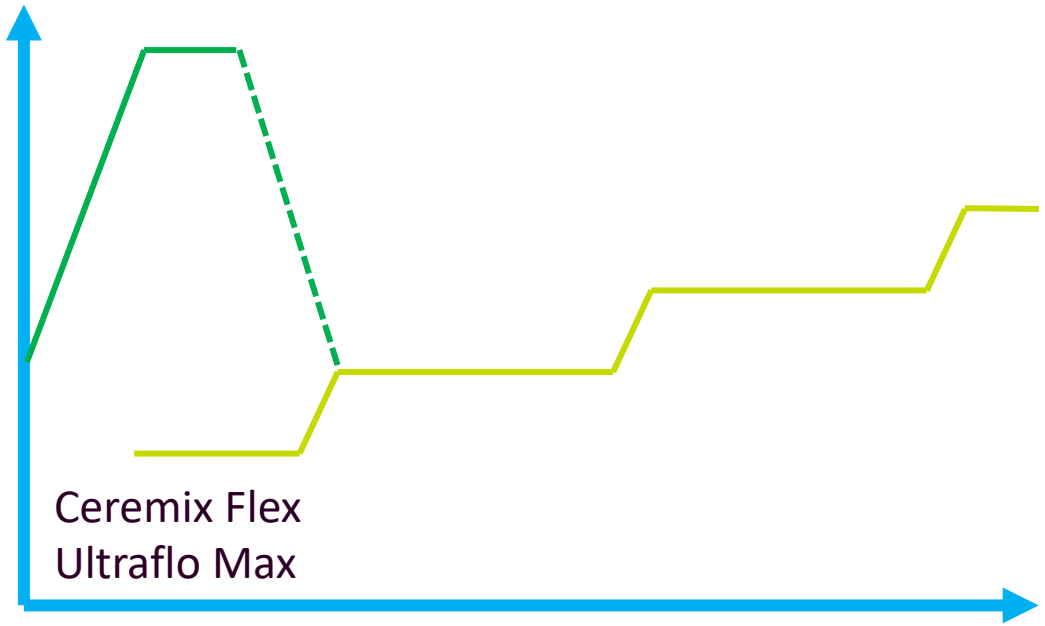

More Extract = Less starch
Impact: lower yields due to less starch content per kernel

Solution:

Optimise Ceremix Flex to ensure effective, maximum degradation of starch in the mash-tun.

If Termamyl (Ceremix Flex) only added to Cereal Cooker review whether necessary to add into the mash-tun (-> transfer-temperature).

(Addition of Ultraflo Max has shown an overall increase in extract yield due to lower viscosity)

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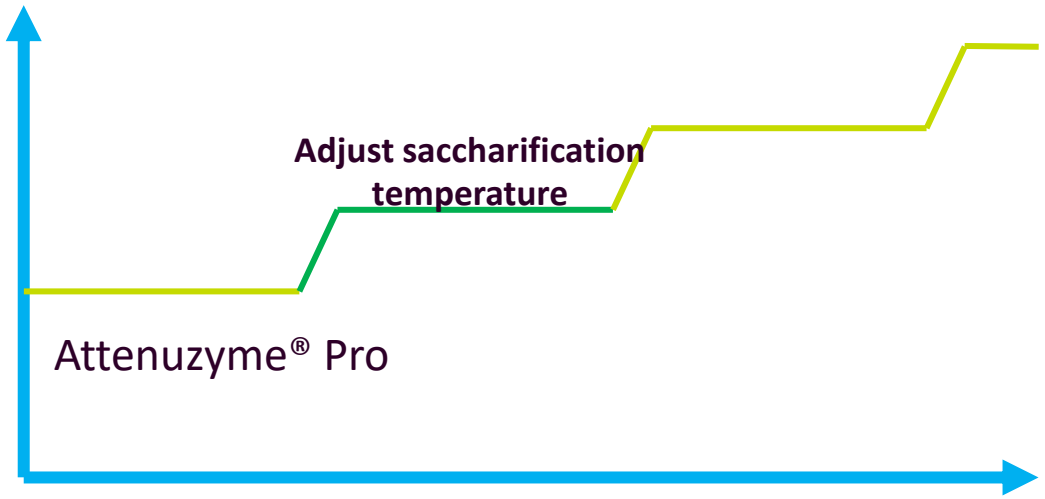
Cont’



Raw material	Barley	Barley malt	Wheat	Maize/ corn	Rice	Sorghum	Cassava
Gelatinization temperature (°C)	60-65	61-65	55-65	64-82	68-84	68-75	64-76

Small Kernels

Impact: Increased gelatinization temperature due to higher amount of amylopectin (α-1,6 linkages). This can be above deactivation temperature of the endogenous β-amylase lowering the RDF

Solution

Adjust saccharification rest to higher gelatinisation temperature.

Support endogenous β-amylase with more heat robust Attenuzyme Pro.

Pullulanase in Attenuzyme Pro will breakdown the alpha 1-6 linkage additionally increasing the RDF and yields.

	T_{opt} [°C]	pH_{opt}	Substrate	Product
α-Amylase	65 – 75	5.6 – 5.8	High- and low molecular α-glucans	Oligosaccharides
β-Amylase	60 – 65	5.4 – 5.6	α-glucans	Maltose

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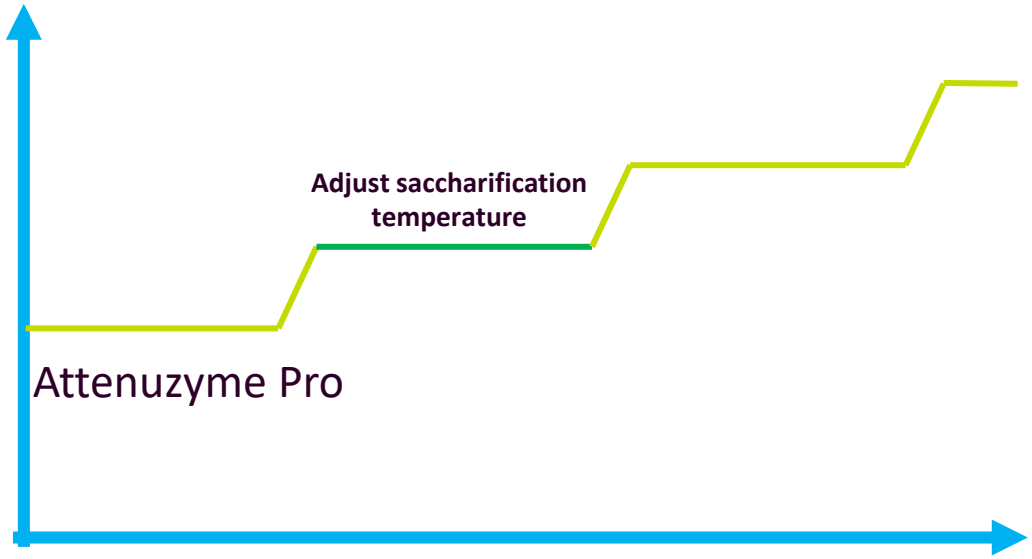

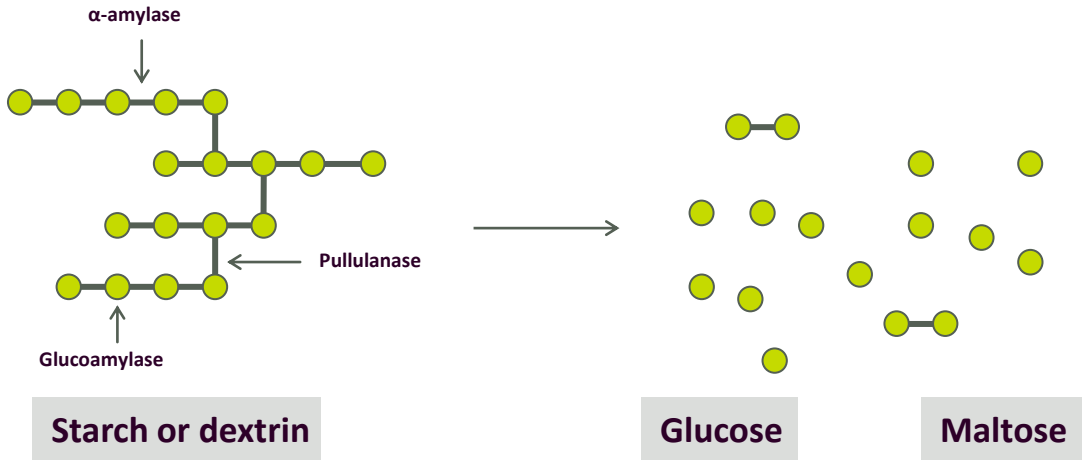

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Solution:

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Support endogenous β-amylase with more heat robust Attenuzyme Pro.

Pullulanase in Attenuzyme Pro will breakdown the alpha 1-6 linkage additionally increasing the RDF and yields.

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Summary: Enzymes assisting with low quality barley/malt

High Protein Content

Impact: Filtration / Haze Issues due to poor breakdown of proteins

Solution

Integrate additional protein rest. Allow time for endogenous proteases to act.

Optimise with **FAN® Boost** Pro to maintain capacity and prevent gel formation. *

Optimising **the Ultraflo® Max or Ceremi® Flex** applications will aid in improving filtration by reducing other carbohydrates.

Less starch

Impact: lower yields due to less starch content per kernel

Solution

Optimize **Ceremix® Flex** to ensure effective, maximum degradation of starch in the mash-tun.

If **Ceremix® Flex** only added to Cereal Cooker review whether necessary to add into the mash-tun (-> transfer-temperature).

(Addition of **Ultraflo® Max** has shown an overall increase in extract yield due to lower viscosity)

Small kernels (grain size)

Impact: Increased gelatinization temperature due to higher amount of amylopectin (α-1,6 linkages). This can be above deactivation temperature of the endogenous β-amylase lowering the RDF.

Solution

Adjust saccharification rest to higher gelatinisation temperature.

Support endogenous β-amylase with more heat robust **Attenuzyme® Pro**.

Pullulanase in **Attenuzyme® Pro** will breakdown the alpha 1-6 linkage additionally increasing the RDF and yields.

Enzymes lowering high energy costs

Brewing enzymes in a market with elevated prices and uncertainty

Global malting barley prices has been trending upwards for some time and world barley stocks are at the lowest level in almost 40 years.

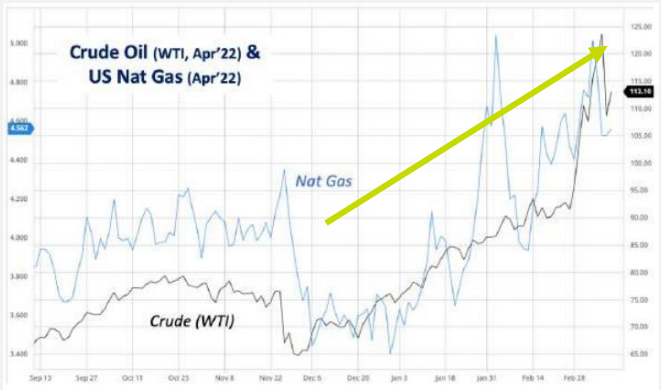
Increasing energy prices impacts the entire value chain: maltsters, breweries, packaging, logistics.

Enzymes can create even more value for the breweries:

- In a market with elevated raw material price market and uncertainty around availability and quality
- In a market with rising utility prices

Global Malting Barley Prices (USD/mt)

Crude Oil and US Natural Gas price



Sources: RMI Analytics

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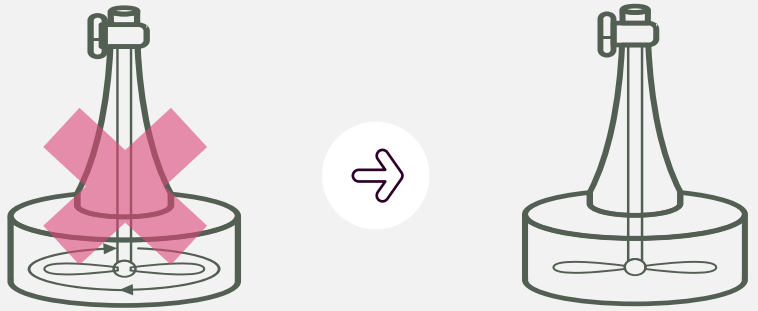
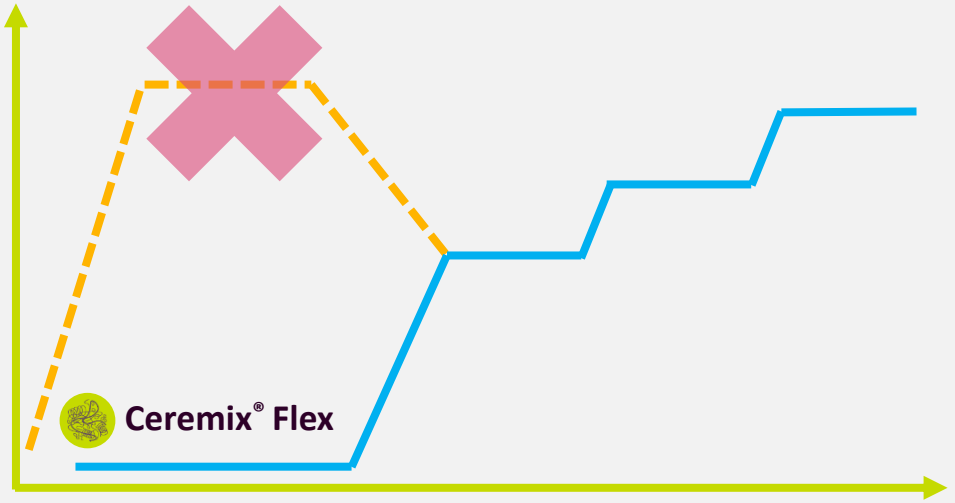
Save time and energy with Ceremix® Flex

Process high gelatinizing raw materials in an infusion process



Ceremix® Flex

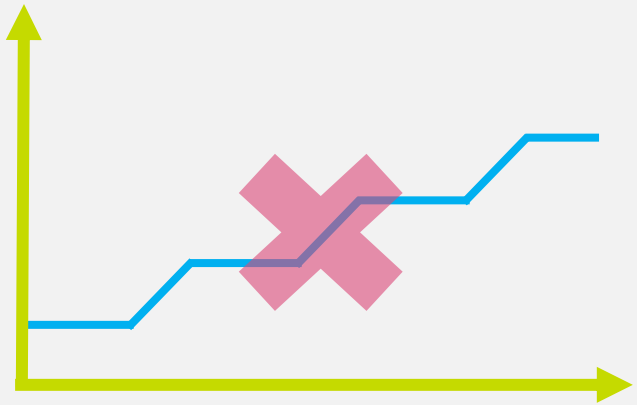
Enables processing of high gelatinizing raw material in an infusion process avoiding the boiling step



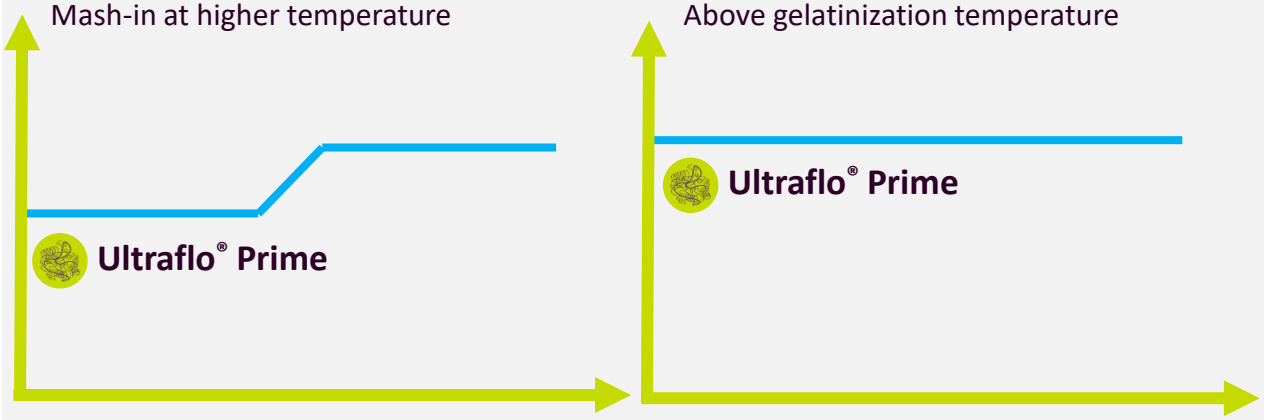
Simplify your mashing process

From step mashing to iso-thermal mashing?

Ultraflo® Prime
Ceremix® Flex
Enables high-temperature mashing



Today’s Mashing Regime



Simplify your mashing process

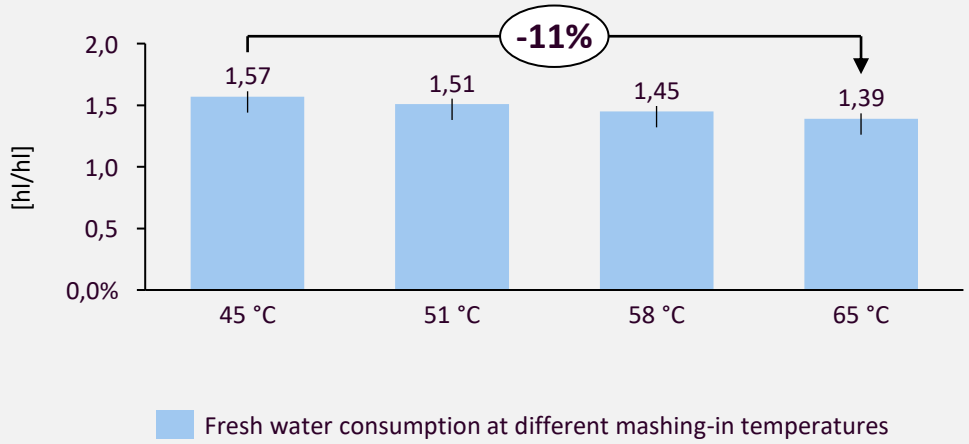
Studies confirms the benefits of high temperature mashing

A simplified mashing regime can have a significantly positive impact on the energy balance and water consumption.

Higher temperature = less fresh cold water consumption, less steam heating, and less surplus hot water consumption.*

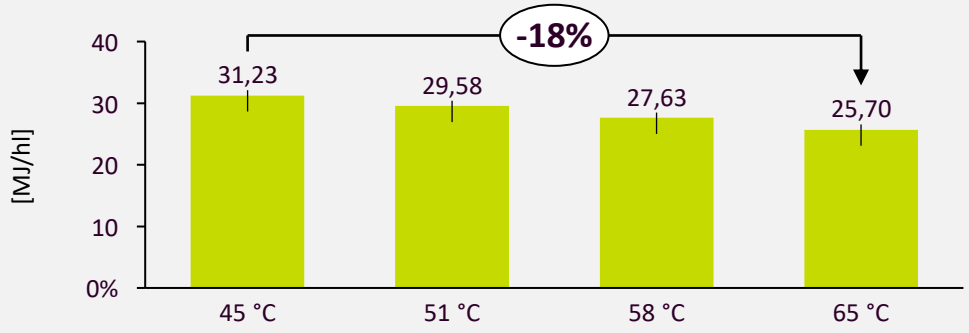
Brewers now have greater flexibility when choosing the mashing-in temperature.

Fresh water consumption*



Fresh water consumption at different mashing-in temperatures

Thermal energy (steam) consumption*



Thermal energy consumption at different mashing-in temperatures

Sources: *Brauwelt International 4-2014 / 20.08.2014 / Topics: Filling, Water / Author: Jaap Risselada

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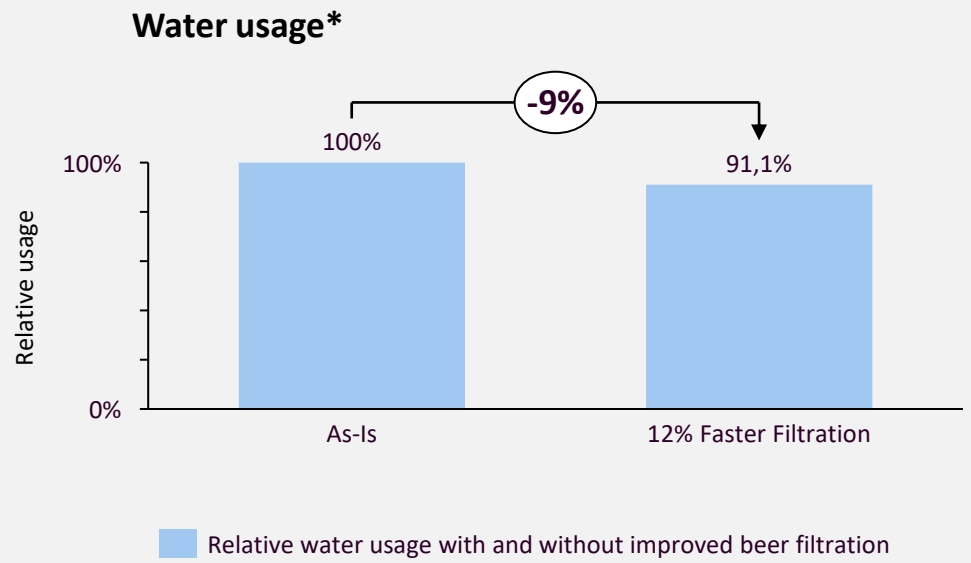
Simplify your mashing process

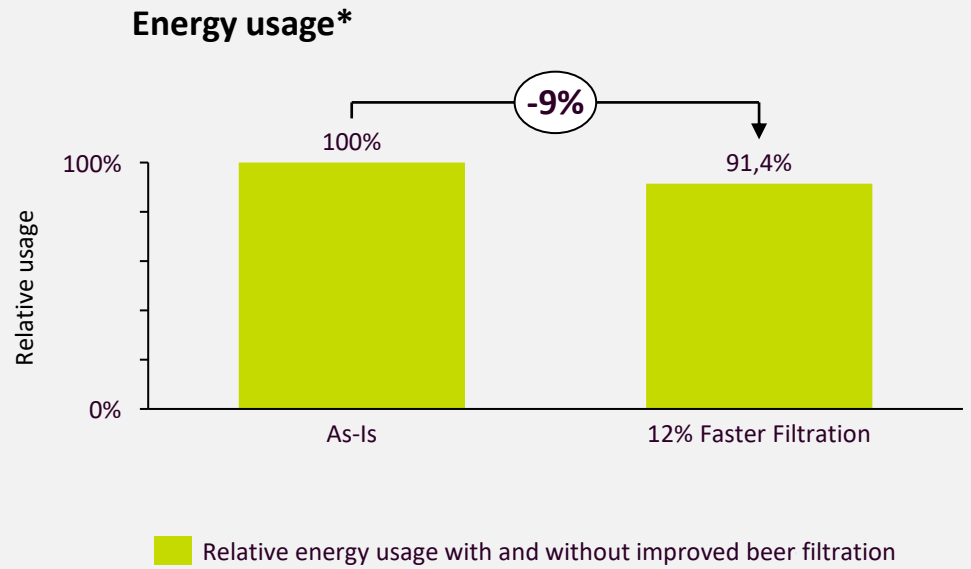
Case study: Faster Beer filtration can reduce water and energy usage by nearly 10%

Superior beer filtration performance with as much as **12%** higher throughput.

Faster filtration at same Kieselguhr consumption = more volume per cycle
= improved water and energy usage.

Water usage and energy consumption in the beer filtration step is reduced as much as **9%** by faster filtration.*





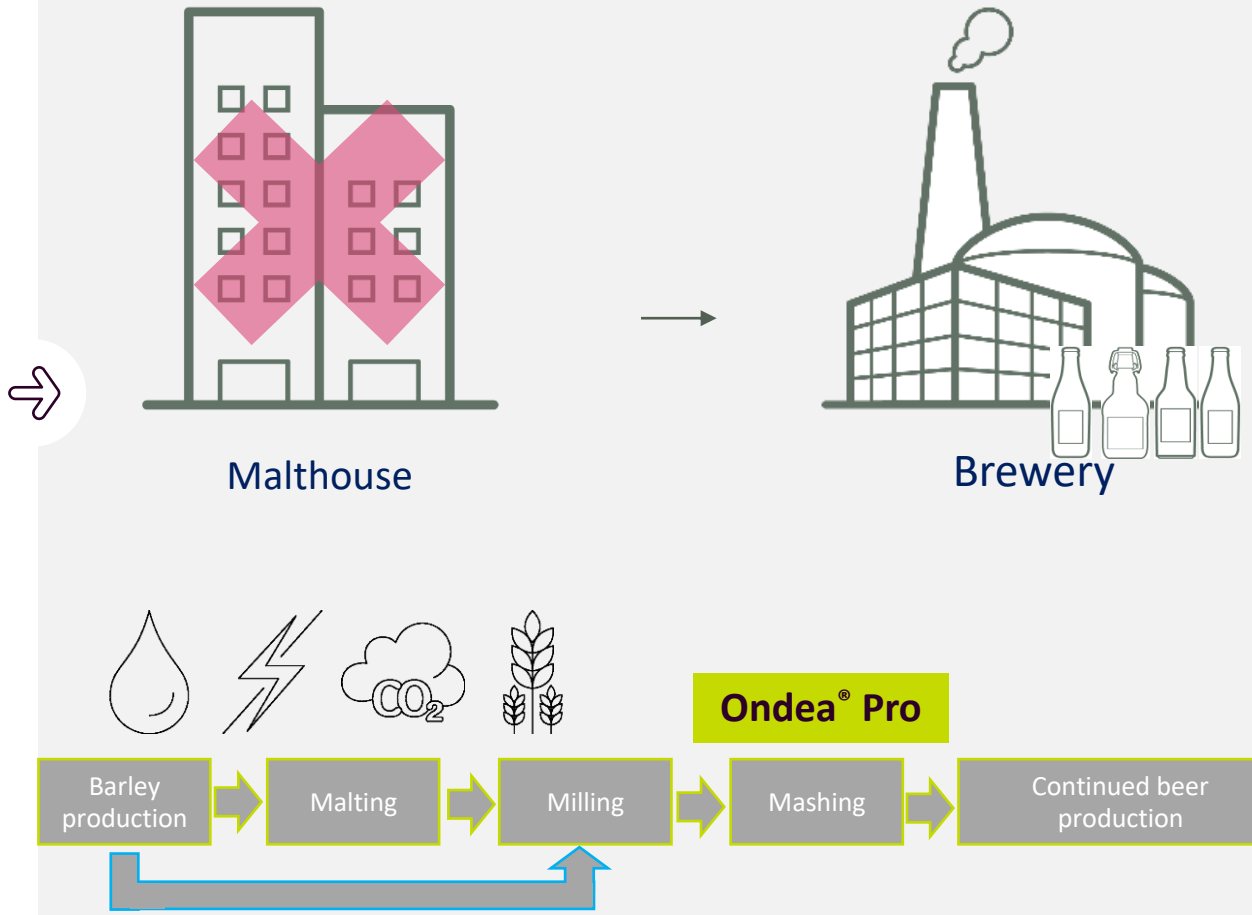
* Based on internal Novozymes data

Avoid energy intense malting with Ondea® Pro

Lower the energy requirements of the brewing process by increasing the amount of barley in your beers

Ondea® Pro

Enables brewing with barley and thereby avoiding the malting process



Summary: Enzymes lowering high energy costs

Brewing enzymes in a market with elevated prices and uncertainty

Ceremix® Flex

Enables processing of high gelatinizing raw material in an infusion process avoiding the boiling step

Ultraflo® Prime

Enables high-temperature mashing

Ondea® Pro

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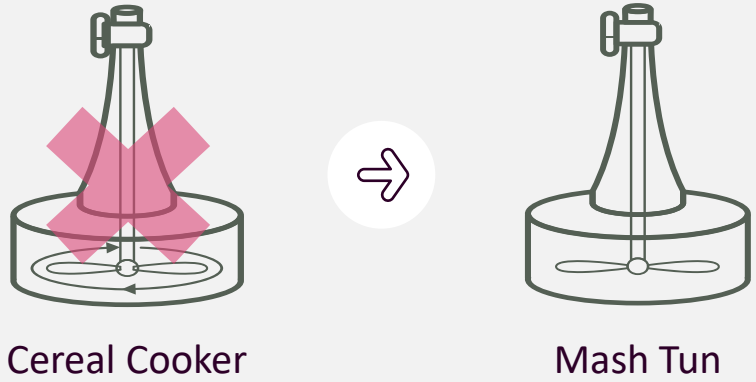

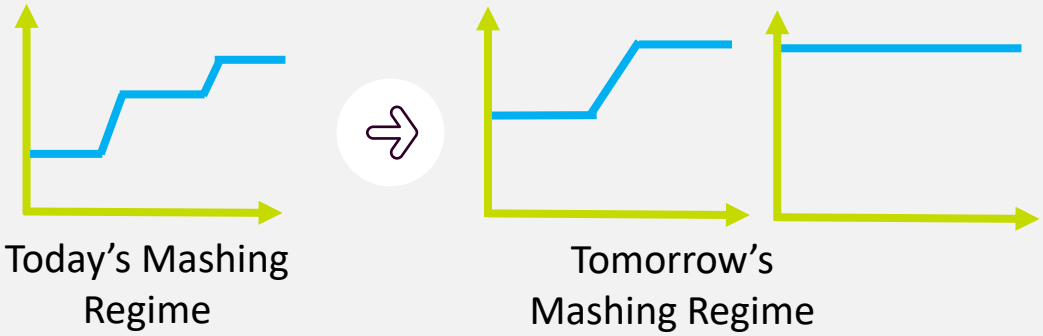

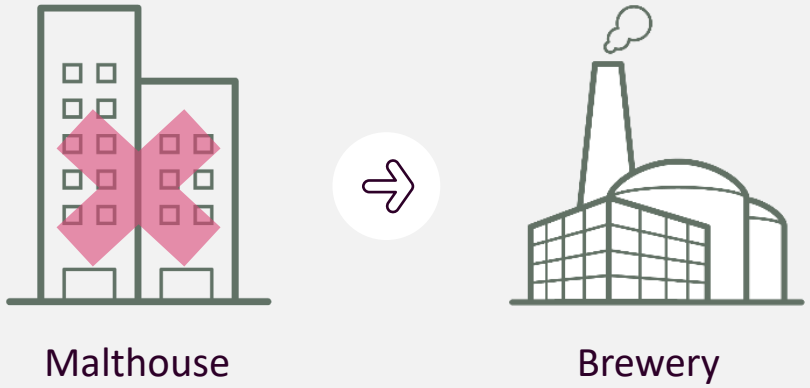

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Alex Merz

Brewing Engineer

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Brewing with Enzymes by NOVOZYMES

North America

DAUS@novozymes.com

Europe

ASMU@novozymes.com

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