Brewing With Enzymes

Brew Beer Better

Discover what enzymes can do for your craft brewery

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Brewingwithenzymes.com
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.
Agenda

- Enzymes 101
- Raw material optimization
- Cost effective cereal cooking
- Efficient wort separation and beer filtration
- Attenuation control and light beer production
- Diacetyl control
Enzymes truly come from nature

An example:
• Laundry with cold-water wash

The Science
• A rare mineral supporting microbial life
• Scientists identify the microorganism that express enzyme that we desire

These novel enzymes enable...
... cold-water wash
... significant savings of energy, CO₂ and money
Industrial scale enzyme production

RAW MATERIALS

FERMENTATION

MICRO-ORGANISMS

PURIFICATION

FORMULATION

MICRO-ORGANISMS TO BE INACTIVATED

READY TO SELL PRODUCTS

LIQUID PRODUCT

GRANULATED PRODUCT
Enzymes accelerate chemical reactions without a change in them.
Enzymes need specific conditions to perform.

**Universal factors**
- pH
- Temperature
- Time
- Enzyme dosage

**Situational factors**
- Solids level
- Oxygen
- Stabilizers
- Inhibitors
- Water quality

![pH effect graph](image)

- Activity peak at pH 5.2
- Effect from pH 5.0 to 6.0

![Temperature effect graph](image)

- Activity peak at 55 °C
- Effect from 50 °C to 75 °C

Why use enzymes in brewing?
Malt quality defined by

**Extract:** 75-80% yield of soluble (up to 70% starch)

Low **protein** (<12%)

Sound **husk**

High **enzyme activity** is desired, especially amylases

- Most enzyme activity is during mashing
- Mash off- most enzyme activity stops (75-80 °C)
- Wort boiling-enzymes are inactivated

Inherent enzyme activity affected by climate, variety, grain damage etc.

**Challenge: consistent activity NOT achieved**

Adapted from Arendt et al. Brewers' spent grain: A review with an emphasis on food and health
Most enzymatic reactions occur during mash/lauter tun

**Protein degradation**
- Proteases

**Starch degradation**
- $\alpha$-amylases
- $\beta$-amylases
- Glucoamylases

**Hemicellulose degradation**
- $\beta$-Glucanases
- Arabinoxylanases

![Graph showing enzymatic reactions over time and temperature](image-url)
Serving 600 craft breweries in US

Growing 20 breweries/a month
Onda® Pro is a pretty exciting development for gluten-free brewing, and over at Otherwise Brewing, we've been experimenting with it a lot.

- Aaron Gervais, Cofounder and Head Brewer of Otherwise Brewing (3.11.2020)

Onda® Pro: Adjuncts, no Problem!
A blend of 6 different enzyme products & used in high adjunct/gluten free/new raw material brewing
Non-standard raw materials brewing -with Odea® Pro

Amylases, proteases, lipases, hemicellulases
Ondea\textsuperscript{(R)} Pro

Enables;
- Use of non-traditional raw materials, including unmalted barley
- High adjunct loading
- High Gravity Brewing with up to 26\textdegree P (first wort)
- Gluten-free brewing with Ceremix\textsuperscript{®} Flex

Improves;
- Foam stability and body
- Starch conversion at a broader temperature range
- Lautering/filtration with mash filter
- Control of FAN and fermentability

Similar fermentation profile:
100\% barley wort and 100\% malt wort
Ceremix® Flex: Boost your starch degradation

A blend of thermostable maltogenic amylase, pullulanase, and alpha-amylase, simplifies brewing like never before.

I can say that your product gave far better results and I will prefer to use yours for my future brews.
(Regarding the use of Ceremix Flex)

- Ethan, Founder and brewer at The Highway Brewing Co. (6.15.2020)
Cost-effective cereal cooking
-with Ceremix® Flex

*α-amylase* randomly cleaves starch (large dextrins) to form a mixture of smaller dextrin chains (polymers of glucose)
Eliminate the cereal cooker for high gelatinizing adjuncts with Ceremix® Flex.

Recommended infusion mashing diagram when working with Ceremix® Flex to process a high-gelatinizing adjunct.

A specific cocktail of enzymatic activities degrades the starch granules of high gelatinizing raw materials below their natural gelatination temperature.

- α-amylase
- Pullulanase
- Maltogenic amylase
- Maize/Rice/Sorghum/Cassava

Eliminates the capital investment in a separate cereal cooking vessel and reduces energy costs.
With Ceremix® Flex

- Avoid the cereal-cooking process
- Eliminates costs spent on a cereal cooker
- No need for cooling in case of very high adjunct inclusions
- Energy savings
- Process high-gelatinizing adjuncts
- Flexible adjunct inclusion
- Run liquefaction of adjunct starch below gelatinization temperature through native starch de-branching enzymes
UltraFlo Max has exceeded all of our expectations. We have increased our average brewery efficiency from ~75% to ~91% since using this product. It has become a MUST have during brew days!

-Skylar Reed, Tradition Brewing Company

Ultraflo® Max: Faster filtration

A blend of β-glucanase and an arabinoxylanase that makes it possible to degrade both major cell wall components to ensure minimum viscosity and get **the best** wort separation and beer filtration.
Efficient time in wort separation and beer filtration - with Ultraflo® Max

*Breaking up complex carbohydrate structures into smaller, more soluble oligomers leads to lower viscosity and better filterability.*
With Ultraflo® Max

• Increase brew house efficiency/extract and save on material costs
• Reduce mash viscosity to avoid stuck mashes and sparges
• Control production variations due to raw material quality fluctuations
• Enable high gravity and high adjunct brewing
Attenuzyme® Pro: Higher attenuation

A blend of glucoamylase and pullulanase that makes it possible to hit high attenuation targets in short reaction times. Achieve Low-Calorie/Low-Carb and Light Beers

I had a significant jump in attenuation 20%, time saved 150 to 120 min mash, and wort returned from mash 20%. You have a happy customer!

- Matthew Williamson, Owner & Brewer at Williamson Mead and Brewing (9.27.2020)
Attenuation control and light beer production - with Attenuzyme® Pro

- Attenuzyme®
  Added into main mash

- α-amylase
- Pullulanase
- Glucoamylase

Malt, Barley, Wheat

Mash Tun
Decoction vessel
Lauter tun

Starch or dextrin

Glucose
Maltose
With Attenuzyme® Pro

- Obtain desired level of fermentable sugars every time
- Increase Real Degree of Fermentation (%RDF)
- Reach desired maltose and glucose ratios
- Produce Strong Beers or Brut IPAs

Dosage response (real degree of fermentation [%]) of Attenuzyme® Pro at 64°C after 60 minutes
Maturex® Pro: Diacetyl be gone!

An Acetolactate-Decarboxylase (ALDC) enzyme which prevents the formation of diacetyl and 2,3-pentanedion

“Maturex® Pro has streamlined our production process by ensuring that we consistently and reliably clear VDK tests on schedule to not only get beer out on time but to maximize the capacity of our cellar by reducing lengthy maturation times.”

- Tony Tielli, Head Brewer, Roughtail Brewing Co. (4.15.2021)
Fermentation

After cooling down the wort to temperatures <10°C yeast is added.

The yeast will typically ferment the vast amount of available sugars within 7 days providing Alcohol and Carbon dioxide (CO2).

Another side product formed by yeast is Diacetyl – an off-flavor. The addition of Maturex(R)Pro will prevent its formation saving maturation time in the next process step.
Diacetyl control
-with Maturex\textsuperscript{(R)}Pro

\textbf{Maturex\textsuperscript{®}}
After wort cooling in the fermenter

\begin{center}
\begin{tikzcd}
\text{Wort} \arrow{r} \& \text{Beer} \arrow{r} & \text{Filtration} \\
\text{Fermentation tank} & \text{Lager tank} \\
\end{tikzcd}
\end{center}

\begin{center}
\begin{tikzcd}
\text{CH}_3 - C - C - C - O \arrow{r}[swap]{\text{Spontaneous oxidative decarboxylation}} & \text{CH}_3 - C - C - O^- \arrow{r}[swap]{\text{(Slow reaction)}} & \text{Diacetyl} \\
\text{OH} & \text{o-acetolactate} \arrow{r}[swap]{\text{o-acetolactate decarboxylase}} & \text{Acetoin} \\
\end{tikzcd}
\end{center}
With Maturex® Pro

- Eliminate diacetyl rests
  - Prevent the formation of diacetyl and 2,3-pentanedione in beer (butterscotch/buttery off-flavor)
- Shorten maturation time leading up to higher-capacity utilization
- Reduce/eliminate Dry Hop Creep
- Create leaner process conditions for low-alcohol beers
- Reduce energy consumption
- Beer maintains high quality index
YES!, you can use them all together!

"I've now used Maturex and Ultraflo in a few beers and I've been very impressed with the results. I've also brewed several times with Ultraflo Max. It really helped with a high wheat beer (a gose) and now that I've got the dosage right, it helps pretty significantly with my New England IPAs (pretty wheat and oat heavy). So, cheers to you all at NovoZymes, I'm a pretty happy brewer over here."

- Matt White, Owner & Brewer at Beachcrest Brewing Company

"We recently used both Ultraflo Max and Ceremix Flex in our seasonal hefeweizen, Banana Hammock. The combination of enzymes allowed us to use a locally grown wheat in place of a pre-gelatinized national brand. We saw an increase in body from the raw wheat, as well as a slight rise in overall mash efficiency while using the enzymes when compared to previous years."

- Brandon Ridings, Ono Brewing Company (4.19.2021)

"The primary reason we are interested in enzymes is to maximize the potential quality of our product. Efficiency is somewhat of a byproduct of that."

- J. D. Angell - Head Brewer at White Street Brewing Co. (3.19.2020)
Brewingwithenzymes.com

Brew Beer Better
Discover what enzymes can do for your craft brewery

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QUESTIONS?

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Book a Brewmaster | Novozymes

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