Oat-based beverages

Consumers around the world are embracing plant-based foods and beverages. Beverage processors are taking advantage of this trend and enjoying impressive growth. Oat based beverages is the fastest-growing segment among plant-based milk alternatives. Enzymatic treatment of oats is a critical enabling technology for creating these popular beverages, and the optimal selection and usage of enzymes is vital for meeting quality, nutrition and process efficiency demands. The Novozymes oat beverage toolbox will help you maximize your potential.

Benefits

- Ability to create differentiated oat drinks from simple raw materials
- Ability to adjust sweetness to match targeted consumer preferences
- Ability to adjust mouthfeel and beverage viscosity to match targeted consumer preferences
- Ability to optimize nutritional profile for desired claims
- Simple production
- Yield improvement
- Best-in-class or organic-compliant solutions

Products

The Novozymes oat beverage enzyme toolbox can be used to create an array of oat beverages with different properties. A typical oat beverage process will include a liquefaction step where an α-amylase and beta-glucanase solubilizes the starch and reduces viscosity during heat treatment, often followed by a saccharification step using a maltose or glucose producing amylase for sweetness and fine-tuning of mouthfeel. Optionally, a protease can be added to improve oat protein solubility, thereby increasing yield and protein content of the final beverage. Selection of the ideal enzymes depends on the desired product concept including sensory profile and nutritional profile as well as process efficiency goals time and cost.

Application	Product	Description	Function	Suitable for organic
Liquefaction	BAN® 480 L	Endo-acting α-amylase with significant beta-glucanase activity, liquid	Solubility with the lowest viscosity	✓
Saccharification	Fungamyl® 800 L	Exo-/endo- acting α-amylase with significant maltose generation, liquid	Mild sweetness generation	✓
	Amylase AG® 300 L	Exo-acting glucoamylase, liquid	Sweetness generation	✓
	Maltogenase® L	Exo-acting maltogenic-amylase with moderate thermal stability, liquid	High efficiency maltose generation	
Protein enhancement	Neutrase® 0.8 L	Endo-protease, liquid	Increase soluble protein content	✓
	Formea® Sol	Endo-protease, liquid	Best-in-class soluble protein content	

Table 1. Enzyme toolbox for oat beverage production, including steps of liquefaction (solubilization), saccharification (small molecular weight dextrins), and optionally protein solubilization. *More information about the products is available from Novozymes Market.*

Usage

Formula development
Oat beverage production steps can be mimicked on the benchtop during the product development phase using an experimental apparatus that can maintain agitation and mixing, consistent temperature control and realistic times for heating and cooling between steps. We recommend a Thermomix® for benchtop development, or for experiments requiring multiple simultaneous hydrolysis conditions - a multi-stage malt mashing bath apparatus.

Table 2 describes a simple oat base model system to use for enzyme hydrolysis optimization containing only the minimum ingredients needed. Once a hydrolyzed base formula is created that is optimized for mouthfeel, composition and flavor, additional ingredients such as flavors, hydrocolloids, vitamins and minerals, or emulsifiers and stabilizers can be incorporated into the formula to meet additional shelf-life or product concept requirements.

Ingredient	Mass (g)
Hydrolyzed oat beverage base (5-10% solids)	1000
Oil	8.0
Salt	0.8
Batch total	*1008.8*

Table 2. Oat base model system. Creation of the hydrolyzed base is summarized in Table 3.

Choice of oats raw material
Novozymes trials comparing oat seeds with husks, de-husked heat-treated oat seeds, oat flakes (rolled oats) and oat flour showed the best results are obtained with heat-treated oat flour. The smaller particle size of a flour as well as the stability and sensory quality from the heat-treatment yields the overall best enzyme performance, stable process, and a clean flavored product. Rolled oat flakes also yield excellent results. While the same enzyme selection and usage principles can be extended to any source of oats, the specific outcomes described below, such as

process efficiencies, process times, extent of hydrolysis and sensory properties are based on heat-treated oat flour and could vary according to raw material.

Optimizing sensory properties through enzyme selection

Three of the most common approaches for a hydrolyzed oat beverage base are (1) optimizing for enzyme usage, without sacrificing taste or mouthfeel, (2) optimizing for process simplification without sacrificing taste or mouthfeel, (3) a zero-sugar beverage. In this section, enzyme selection and usage for each of these concepts will be described in detail. The resulting composition and sensory properties associated with each of these three concepts can be found separately in the Performance section. Using these same tools in different combinations, temperatures and dosages, further differentiation and optimization can also be achieved.

Concept	Enzymes	Incubation conditions
2-step hydrolysis, optimized enzyme dosage	Liquefaction: 0.2% BAN® 480 L Saccharification: 0.2% Fungamyl® 800 L	Liquefaction: 70–80°C, 30 mins Saccharification: 50–60°C, 30 min
Efficient 1-step process, reduced process time	2.0% BAN® 480 L	70–80°C, 30 mins
Zero-sugar claims	0.2% BAN® 480 L	70–80°C, 30 mins

Table 3. Recommended enzyme selection and usage levels for 3 common oat beverage bases.

Concept #1 - Optimizing for enzyme usage. Among the most common oat beverage formulas is one based on maximizing the hydrolysis of the oat flour into glucose and small molecular weight sugar and dextrins for a balance of optimal yield (soluble solids), mouthfeel and mild sweetness. This concept is designed for minimum enzyme dosage by working close to the temperature optimums for the enzymes.

As shown in Figure 1, 0.2% BAN® 480 L is used for liquefaction at 70–80°C for 30 minutes followed by 0.2% Fungamyl® 800 L at 50–60°C for 30 minutes. In the liquefaction step, the high temperature gelatinizes the starch, allowing BAN® alpha-amylase to hydrolyze it into soluble low viscosity dextrins. In addition, the beta-glucanase activity present in BAN® 480 L hydrolyzes soluble oat beta-glucan into small dextrins for reduced viscosity. After cooling, Fungamyl® is then added in a separate saccharification step, where along with BAN®, these enzymes further breakdown the dextrins into glucose, maltose, and small molecular weight dextrins that yields a mild sweetness and pleasing mouthfeel (Figures 2 and 4).

One variant on this concept for a higher sweetness beverage is to use 1-2% Amylase AG 300 L rather than Fungamyl® to generate glucose rather than maltose during saccharification. In this variation, a higher dose of BAN from 0.5 to 2.0% is also recommended to compensate for the lack of α-amylase activity in AG 300 L. With increased sweetness, this option could be suitable for product concepts such as flavored oat beverages, a coffee whitener or as a base to a cultured product. An additional common variant is to include 0.1% Neutrase® 0.8 L for a boost in protein content of the base as outlined in the Performance section (Table 5).

Concept #2 Optimizing process efficiency. A second common concept is designed for greater process efficiency. This formula uses only Novozymes BAN® 480 L but at a high enough dose to generate the desired mild sweetness and mouthfeel in a single combined liquefaction and saccharification step. By eliminating a separate lower temperature saccharification step, processors can benefit from improved asset utilization and process time. BAN® is a more thermally stable enzyme than Fungamyl® or AG 300 L, and when used at a high dose can yield the same mouthfeel and sweetness with a different dextrin and sugar profile (Figures 3 and 4).

In this concept, a 2% dosage of BAN® 480 L in the oat flour slurry will yield the optimal results. The process in Figure 1 would be simplified such that the liquefaction, cooling and saccharification steps would be combined into a single hydrolysis step of 70–80°C for approximately 30 mins. Alternatively, if a single-step hydrolysis yielding maltose in the final product is desired, combinations of 0.1–2.0% BAN® 480 L and 0.05 –0.50% Maltogenase L (Table 1) can be used. The use of protease in this concept will be significantly less effective due to lower thermal stability of the proteases, but with experimentation could be explored at a one-step incubation temperature of 70°C.

Concept #3 Optimizing process efficiency. A third popular concept is an oat beverage with a zero-sugar nutrition profile. This can be achieved in a single hydrolysis step using only 0.2% BAN® 480 L and incubation at 80°C for 30 minutes. As shown in Figure 4, this treatment will yield a very low sweetness, lower than dairy-milk or the above concepts. However, with less than 0.2 g sugar per 100 g (Figure 2), this product can bear claims of zero sugar or sugar free to satisfy consumer demands (depending on country-specific labeling regulations). The relatively bland flavor in these products can be improved by formulating with added natural flavors and sweetness enhancers.

Based on these common principles, numerous additional product concepts and customizations are possible using the versatile Novozymes oat beverage toolbox. By selecting different combinations of thermostable alpha-amylases, exo-acting amylases, and proteases, many variations targeting yield, sugar or protein contents, viscosity, or other parameters can be explored. Novozymes Technical Service can support the design of these experiments with you.

Production of oat drinks

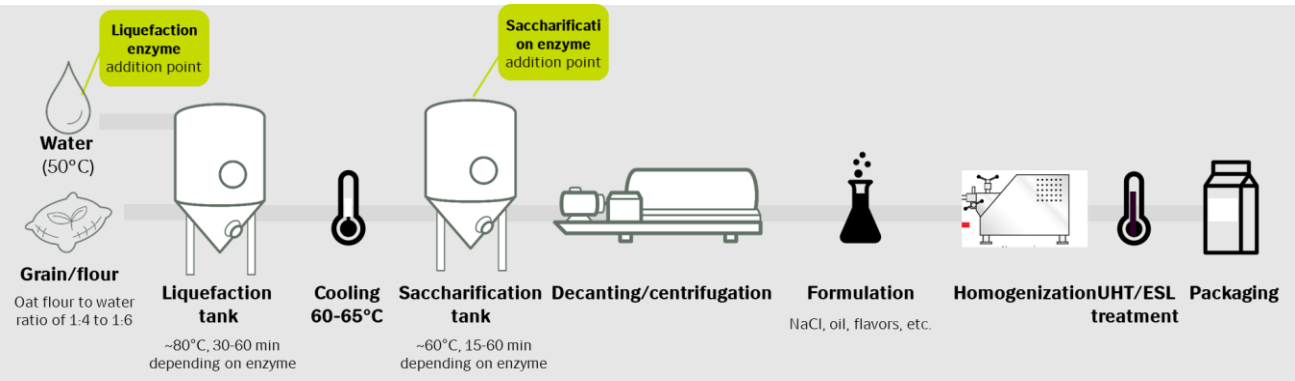

Figure 1. Typical process flow for production of oat beverages. Alternatively, liquefaction and saccharification can be combined into a single step without cooling for a shorter process time with adjustments to the enzymes.

Enzymatic treatment – liquefaction and saccharification

Liquefaction enzymes should be added at 50°C in the water phase prior to heating to the hydrolysis temperature so that during gelatinization, the increase in viscosity is mitigated. The specific oat starch gelatinization temperature range may vary depending on the oat variety, particle size and oat treatment (whole seed, flakes or flour) but will occur during the heating from the initial slurry condition of 50°C to the liquefaction step at ~80°C. Starch must be gelatinized to make it accessible to the enzyme and insufficient gelatinization will result in native starch that will be lost as waste during decanting and centrifugation.

Specific hydrolysis protocols are described in the previous section. Upon scale-up testing of these benchtop conditions, adjustments to time and temperature compared to benchtop development can be expected due to differences in thermal processing efficiencies at scale. To match the sensory properties of the validated benchtop formula, parameters such as viscosity and carbohydrate profile are critical benchmarks to target during scale-up optimization trials. The optimal endpoint of hydrolysis can be established as the point at which these parameters match the target and no longer change significantly with additional process time.

Decanting and centrifugation

To ensure good separation of the insoluble and soluble components, a decanting system or centrifuge is used. The decanting system must be adapted to the processing parameters depending on the scale of production. A product with inadequate decanting can have lower shelf-stability in both mouthfeel and off-flavor.

Formulation and homogenization

After decanting/centrifugation, the liquified phase is sent to downstream processing. The addition of salt at 0.1–0.2% will improve the flavor, and vegetable oil at 0.8–1.2% with high shear mixing and homogenization can sustain and stabilize a brighter opaque appearance and rich mouthfeel.

Thermal processing and enzyme inactivation

The finished formulated beverage should be thermally processed for microbial safety and stability according to common UHT (140°C for 3–4 sec) or ESL (90°C for 30–90 sec) heat treatments, then packaged for distribution.

Under these conditions, the activity of the amylases will be negligible throughout the shelf-life of the beverage due to both the denaturation of the enzyme from the thermal process as well as substrate-limitation, where the amylase will have low affinity for the small dextrins. However, it is important to note that if this hydrolyzed oat base were to be used as the basis of a formulated product downstream where additional starches are added (e.g. an oat-based cultured product), then a more extensive thermal processing would be needed to fully inactivate the enzyme. Alternatively, such products could be formulated with hydrocolloids other than starch to provide thickening and stability.

Oat concentrate process variation

Hydrolyzed oat concentrate can also be produced with an oat to water ratio of 1:4. The desired ±85° Brix can be reached by evaporation after decanting/centrifugation. As stated above, in an application where the oat concentrate will serve as the basis of a formulation where additional starch is added downstream, thorough testing of enzyme inactivation and more extensive thermal processing will be required.

Performance

Liquefaction

Table 4 shows the physical characterization of the beverages produced according to these three approaches. The important role that the dose of BAN during liquefaction has on soluble solids is evident. It is also notable that a similar viscosity can be obtained through these different routes of hydrolysis, illustrating the power that product developers have through enzyme selection and usage to deliver desirable results within ranges balancing multiple parameters of interest.

Concept	Enzymes	Dissolved Solids (%)	Viscosity (cP)	pH
1. 2-step hydrolysis, optimized enzyme dosage	Liquefaction: 0.2% BAN® 480L Saccharification: 0.2% Fungamyl® 800 L	8.5–10%	25–30	~6.5
2. Efficient 1-step process, reduced process time	2.0% BAN® 480 L	8.5–10%	25–30	~6.5
3. Zero-sugar	0.2% BAN® 480 L	4.5–5%	25–30	~6.5

Table 4. Physical characterization of 3 leading oat beverage concepts.

Increasing dosage of BAN increases the sugar content during liquefaction as shown in Figure 2, due both to the alpha-amylase action but also the hydrolysis of beta-glucan. Working within a dosage range of BAN from 0.2 to 2.0 as well as adjusting temperatures from 70-80°C are important levers for modifying the sugar and dextrin profiles leading into the saccharification step.

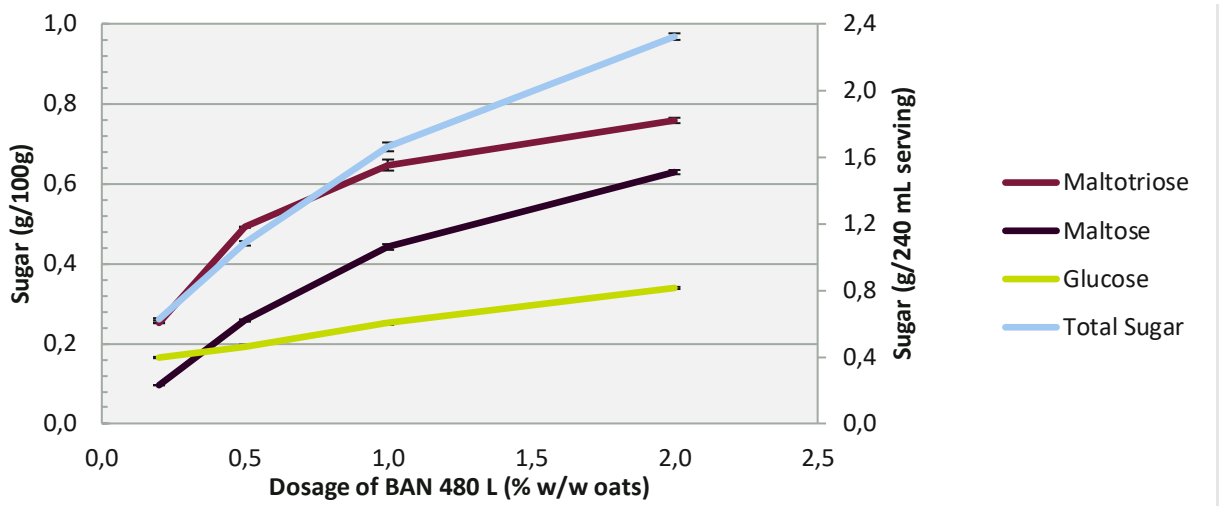

Figure 2. Sugar profile vs. dosage of BAN® 480 L incubated at 70°C for 30 min and inactivated at 90°C for 15 min. Values reflect the mean and std dev. of triplicate batches.

Sweetness adjustment (saccharification)

The sweetness of the beverage can be adjusted by applying different dosages of an endo-acting amylase to decrease the molecular weight of the starch phase of oats, in combination with an amylase which generates glucose or maltose. It is the complex interaction of combinations of both the α-amylase liquefaction enzyme and the saccharification enzyme, including the doses and temperatures used, that contributes to the resulting dextrin and sugar profile and sweetness.

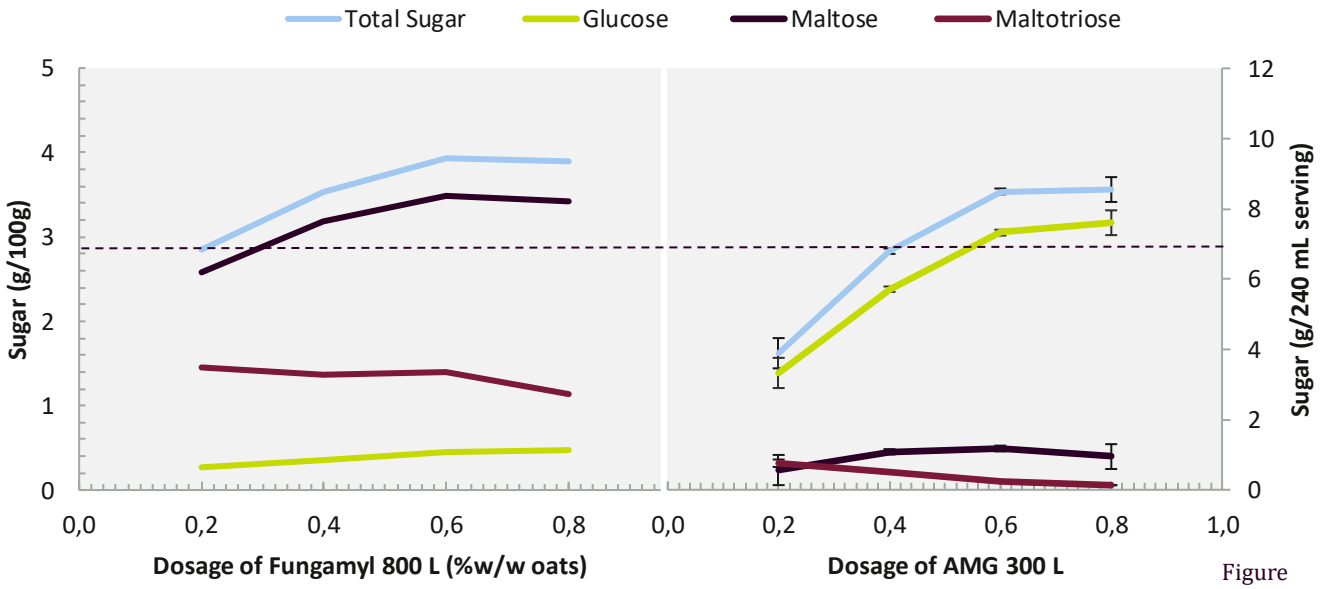

Figure 3. Sugar vs. dose of Fungamyl® 800L and AG 300 L in the presence of 0.2% BAN® 480 L. Hydrolysis was performed at 70°C for 30 min with BAN®, followed by 50°C for 30 min with Fungamyl® or AG and inactivated at 90°C for 15 min. Values reflect the mean and std dev. of triplicate batches. Typical sugar content of 7g per 250mL serving in a US oat beverage is denoted.

The effect of increasing saccharification enzyme dosages after a liquefaction step with 0.2% BAN® is shown in Figure 3. As predicted, the BAN + Fungamyl combination yields very low glucose and significant maltose, while the reverse is true for AG 300 L. Compared to AG 300 L, Fungamyl uniquely also produces significant levels of maltotriose and other larger dextrins from DP3-DP10 (data not included) which are perceived as sweet. As a result, despite the higher relative sweetness of glucose vs maltose, the net sweetness of BAN + Fungamyl® for saccharification under the conditions in Concept #1 make it a more effective tool for increasing net sweetness at the conditions studied.

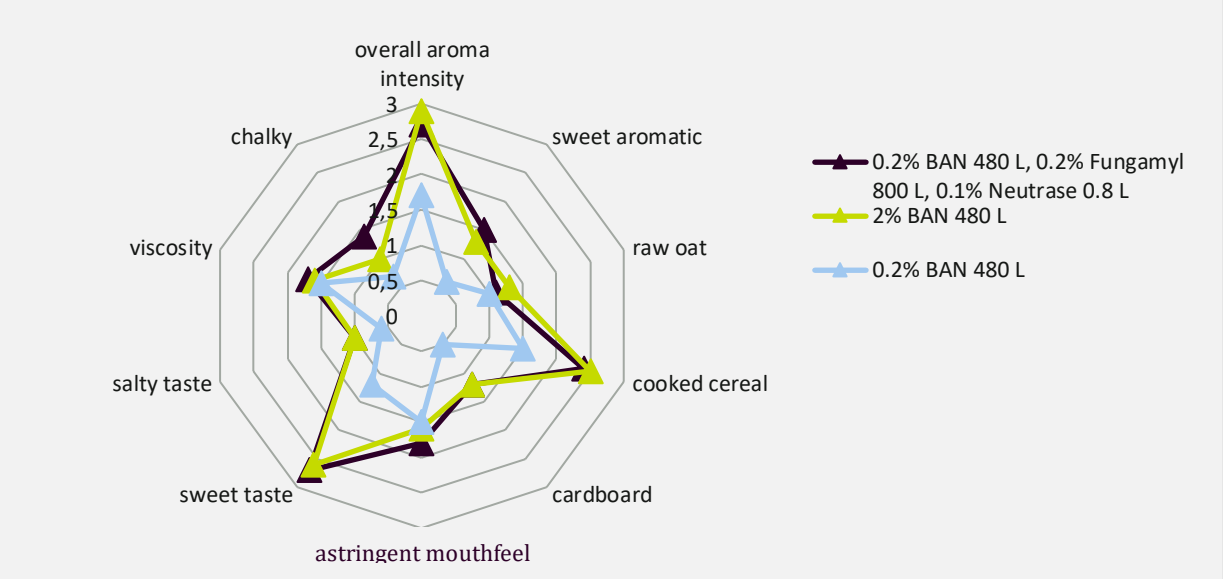

Figure 4. Sensory profiling results for three popular oat base concepts on an absolute sensory intensity scale from zero to 15. Pasteurized 1% and whole dairy milk is scored as 2.3 on sweet taste.

The three concepts in the previous section were characterized as summarized in Table 4 and profiled by a trained sensory panel at the North Carolina State University Sensory Service Center, as summarized in Figure 4. A notable observation is that despite the differences in sugar and dextrin profile and the enzymes selected in concepts 1 and 2 (dark purple and green lines), the sensory profiles are quite similar. There is a somewhat higher chalkiness, not objectionable, that resulted in concept 1, possibly from the higher oat protein dispersed in the product (Table 5). The sweetness of dairy milk at 2.3 was just below the sweetness score for these concepts. The overall bland flavor, lower solids and lower sugar content of the zero-sugar concept (blue line) is similar to leading zero sugar oat beverages in the marketplace (data not included).

Protein optimization

The addition of a protease during the saccharification step enables extracting more soluble protein from the oats, increasing the protein content of the oat beverage. Table 5 shows the maximum soluble protein achievable using Novozymes leading oat beverage proteases. Soluble protein is higher after treatment with protease due to the hydrolysis of the large insoluble oat protein to smaller more soluble peptides. However, the hydrolysis is overall mild, leaving a significant amount of protein within the insoluble oat cake co-product separated at the decanter, and not adding significant bitterness to the soluble oat phase.

Enzymes	Dosage (% oat basis)	Soluble Protein (g/100g)	Soluble Protein (g/240 mL serving)
No Added Protease	--	~0.5-0.6	~1.2-1.5
Formea® Sol	0.1%	~1.25	~3
Neutrase 0.8 L	0.1%	~0.8-1	~2-2.5

Table 5. Typical soluble protein with oat beverage proteases. Hydrolysis was performed with 0.2% BAN 480 L at 70°C for 30 min, followed by 50°C for 30 min. with and 0.2% Fungamyl® 800L and protease, and inactivated at 90°C for 15 min.

Safety, handling and storage

Safety, handling and storage guidelines are provided with all products.

Get ahead

It takes the best technology and expertise to stay ahead of the dynamic food and beverage market and become even more flexible, efficient and profitable. With our oat 360° toolbox and our knowhow, Novozymes can support you on that journey. Let's transform the quality and sustainability of your business together.

About Novozymes
Novozymes is the world leader in biological solutions. Together with customers, partners and the global community, we improve industrial performance while preserving the planet's resources and helping build better lives. As the world's largest provider of enzyme and microbial technologies, our bioinnovation enables higher agricultural yields, low-temperature washing, energy-efficient production, renewable fuel and many other benefits that we rely on today and in the future. We call it Rethink Tomorrow.

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