Enhancing alcohol production with enzymes

novozymes®

Unlocking the magic of nature

Efficient alcohol production

Let Novozymes' enzymes bring your alcohol production more savings and increased efficiency. Enzymes allow you to benefit from the non-pressure cooking (NPC) process, which has maximum operating temperatures between 60°C and 95°C.

The high temperatures (150°C) and high energy consumption associated with standard alcohol production are now a thing of the past. The NPC process cost-effectively breaks down and gelatinises the starch of grain, potatoes or other raw materials, preparing them for subsequent enzymatic breakdown into fermentable sugars.

Look at all the benefits the NPC process gives you…

Energy savings

Avoid heating the mash to high temperatures, saving you considerable energy and money.

Infrastructure savings

Avoid installing expensive pressure-cooking vessels when renovating or constructing production plants.

Yield increase

Prevent the thermal breakdown of sugars and the subsequent formation of unwanted Maillard products.

Quality improvement

Improve the organoleptic properties of the distillates with the lower temperatures of the NPC process.

The NPC process…

- grinding or milling the raw material
- slurrying the raw material in water
- adding a liquefying enzyme
- heating the slurry
- observing a holding period
- cooling
- adding saccharifying enzyme
- cooling
- adding yeast
- fermenting
- distilling.

Process step	Product	Temperature (°C)	pH	Ca++ (ppm)	Dosage range (per t starch)
Liquefaction	Termamyl® SC Termamyl 120 L BAN 240 L BAN 480 L Fungamyl® 800 L	85-95 85-95 70-80 70-80 60-65	5-6 6-6.5 6-6.5 6-6.5 5-6	5 50 150 150 50	100-350 g 200-500 g 200-500 g 100-250 g 100-150 g
Saccharification	SAN Super 240 L SAN Super 360 L SAN Extra L	50-60 50-60 30-70	5-6 5-6 3-6	- - -	1000-1200 ml 600-800 ml 500-700 g
Fermentation enhancement	Neutrase® 0.8 L Alcalase® 2.4 L	40-45 40-60	5.5-6 5-7	- -	100-200 g 20-50 g
Viscosity reduction, HGF (high gravity fermentation)	Viscozyme® L Shearzyme® 500 L	45-65 45-65	4-6 4-6	- -	150-300 g 20-50 g

A complete solution suite

Novozymes has a complete suite of enzymes to facilitate all phases of the non-pressure cooking process!

Termamyl SC
Thermo-stable bacterial alpha-amylase
Declared activity: 120 KNU(S)/g

Termamyl 120 L
Thermo-stable bacterial alpha-amylase
Declared activity: 120 KNU/g

BAN 240 L / 480 L
Bacterial alpha-amylase
Declared activity:
BAN 240 L: 240 KNU/g
BAN 480 L: 480 KNU/g

Fungamyl 800 L
Fungal alpha-amylase
Declared activity: 800 FAU/g

SAN Super 240 L / 360 L
Amyloglucosidase with a balanced content of acid alpha-amylase and proteinase
Declared activity:
SAN Super 240 L: 240 AGU/ml
SAN Super 360 L: 360 AGU/ml

SAN Extra L
Amyloglucosidase with a balanced content of acid alpha-amylase
Declared activity: 400 AGU/g

Neutrase 0.8 L
Neutral bacterial proteinase
Declared activity: 0.8 AU/g

Alcalase 2.4 L
Bacterial proteinase
Declared activity: 2.4 AU/g

Viscozyme L
Fungal mixed carbohydrase: beta-glucanase, cellulase, etc.
Declared activity: 100 FBG/g

Shearzyme 500 L
Endo-xylanase
Declared activity: 500 FXU/g

Celluclast 1.5 L
Cellulase
Declared activity: 700 EGU/g

Dosage
Some of the products are available in various strengths and the enzyme dosage needs to be adjusted accordingly.

Helping you brew more efficiently…

The following table provides an overview of the non-pressure cooking process phases and how to apply Novozymes' enzymes for optimum results. We have also given some helpful tips (see Ⓐ to Ⓜ and the *Useful tips* section) to help you even more.

Raw material	Maize (corn), rice, sorghum	Wheat, barley, rye, oats
Equipment	• Mill, e.g. hammer mill with 1-2 mm sieve • Mash tun with heating, cooling and stirring • Saccharification tank with cooling equipment, fermenters	
Mill	Mill grain Ⓕ	
Water	Slurry the milled grain into water at max. 50°C: 300-350 l/100 kg grain Ⓖ Ⓗ	
pH/Ca^{++} Ⓐ	Check the pH; if below 5.6, adjust to pH 6 using lime or Termamyl® SC	
Enzyme Ⓑ	**Add:** Termamyl 120 L 200-500 g/t starch or Termamyl SC 150-450 g/t starch	**Add:** Fungamyl® 800 L 100-150 g/t starch or Ⓘ BAN 240 L 200-500 g/t starch or BAN 480 L 100-250 g/t starch **Add:** Ⓙ Viscozyme® L 100-200 g/t mash or Shearzyme® 500 L 50-100 g/t mash
Temperature	Heat to 85-95°C	Heat to 60-65°C Ⓘ
Hold	Hold this temperature for 30-60 minutes	
Cool Ⓔ	Cool to 55°C Ⓛ	Cool to 55°C using a cooling spiral, by adding cold water or a combination of the two Ⓛ
pH	Check the pH; if above 6, adjust to 5.5 with sulphuric acid	
Enzyme Ⓑ	**Add:** SAN Super 240 L 1.0 l/t starch, SAN Super 360 L 0.7 l/t starch or SAN Extra L 0.7 kg/t starch	
Cool	Cool to 30°C after holding for 30-120 minutes	
Yeast Ⓓ	**Add:** Inoculum yeast mash 8-10% or baker's yeast 1 kg/m^3 mash	
Cool	Cool to setting temperature	
Ferment Ⓒ	Transfer to fermenter and ferment for 48-72 hours	

Raw material	Potatoes, manioc, cassava & other tubers	
Process	**Recirculation**	**Steam jet**
Equipment	• Hammer mill, 2 mm sieve • Tank with recirculation pump, pipes and heating equipment • Mash tun with stirring and cooling • Saccharification tank with cooling equipment • Fermenters	**Steam jet** • Hammer mill, 2 mm sieve • Pump • Steam jet • Mash tun with heating, cooling and stirring • Saccharification tank with cooling equipment • Fermenters
Water K	Fill hot water (85-95°C) into circulation tank, approx. 5-10% of batch volume. Same amount of water and same high temperature	Fill hot water (85-95°C) into mash tun, approx. 5-10% of batch volume. Same amount of water and same high temperature
Start mill and pump	Start recirculation pump Start milling potatoes into tank	Start milling potatoes M
Enzyme B	When 10% of potatoes are milled, add Termamyl® SC 150-300 g/t starch to the tank	Start dosing Termamyl SC 150-300 g/t starch into the mill
Start jet		Pump milled potatoes through steam jet into mash tun, heating them to 85-95°C. Start stirrer in mash tun M
pH A	pH should be 5.2-5.8; if necessary, adjust by adding lime solution to the mill: approx. 0.5 kg lime/t potatoes	
Temperature	Hold temperature at 85-95°C by steam injection	
Hold	Continue recirculation for 15-30 minutes after milling is completed. Transfer batch to mash tun	Keep batch in mash tun for 30-60 minutes after filling is completed. The mash has to be moved constantly with slow stirring using strong stirring equipment
Cool E	Cool to 55°C using a cooling spiral, by adding cold water or a combination of the two	
pH	Check the pH; if above 6, adjust to 5.5 with sulphuric acid	
Enzyme B	Add SAN Extra L 0.7 l/t starch, SAN Super 240 L 1 l/t starch or SAN Super 360 L 0.7 l/t starch	
Cool	Cool to 30°C after holding for 30-120 minutes at 55°C	
Yeast D	**Add:** Inoculum yeast mash 8-10% or baker's yeast 1 kg/m^3 mash	
Cool	Cool to setting temperature	
Ferment C	Transfer to fermenter and ferment for 48-72 hours	

	pH 5.0	pH 5.3	pH 5.6	pH >6
Termamyl® SC	80°C	85°C	90°C	95°C
Termamyl 120 L	70°C	75°C	80°C	85-95°C
BAN	60°C	65°C	70°C	75°C
Fungamyl®	60°C	60-65°C	60-65°C	60-65°C

Useful tips

The processes described will work in the vast majority of cases. The following tips may, however, help to optimise the process or solve any problems that may arise. (Letters Ⓐ to Ⓜ refer to pages 4 and 5)

Ⓐ The stability and the performance of the liquefying enzyme are influenced by

- pH
- temperature
- calcium concentration.

The closer to the optimum conditions given above, the lower the required enzyme dosage. Guidelines for the relationship between pH and highest advisable temperature are as follows:
With Termamyl 120 L or BAN, it is always advisable to make sure that the pH is within the range 5.6-6.5. This can be achieved by adding lime. This will also add calcium, which stabilises the amylases.

For grain and when using hard water, both pH and calcium concentration will normally be adequate. If soft water (<5° dH, corresponding to 35 ppm Ca) is used, the addition of lime – $Ca(OH)_2$ – is recommended. A starting dosage of 0.5 kilograms per ton of raw material is suggested. It may then be adjusted according to experience.

For potatoes, the addition of lime is often necessary to adjust pH and calcium level (0.5 kilograms per ton of raw material).

When using new Termamyl SC, Ca adjustment is not needed and the optimum pH range is 5.2-5.8.

Ⓑ It is advisable to dilute the enzyme with *cold* water before addition, e.g. 1 litres of enzyme with 10 litres of water.

Ⓒ A reduction in the fermentation time of 10-20 hours may be achieved by adding Fungamyl 800 L (50-100 g/t starch) together with SAN Super (not necessary when Fungamyl is used as the liquefaction enzyme) after cooling to 55°C.

The yeast dosage must be increased by at least 25% and the fermentation temperature increased by 2°C. (For baker's yeast, the maxium temperature is 35°C; for propagated yeast, the maximum temperature is 38°C). Another option is to use Alcalase 2.4 L at 20-50 g/t starch.

Ⓓ In 24 hour yeast propagations, add 10 ml SAN Super 240 L or 7 ml SAN Super 360 L to each 100 litres of yeast mash.

Ⓔ In the event of viscosity problems with mash and stillage, we recommend adding the broad carbohydrase Viscozyme L at 100-200 g/t mash or Shearzyme 500 L at 50-100 g/t mash during cooling at around 55°C. Ask for our latest product developments and recommendations.

Ⓕ Alternatively, mill the grain with warm water (50°C) or cold water (20°C). The liquefying enzyme can then be added to the mill advantageously.

Ⓖ A two-tank system might be advantageous. The slurry could be prepared in one tank while the previous batch is processed in the other tank. The capacity of the unit would thus be increased.

Ⓗ Alternatively, prepare the slurry at 15°C the day before and keep it overnight without heating.

Ⓘ At 60-65°C, Fungamyl is recommended, in which case pH 5.0-5.3 is sufficient. If 70-75°C is considered necessary, BAN must be used.

Ⓙ For viscosity reduction, we recommend using Viscozyme L or Shearzyme in combination with BAN, Fungamyl or Termamyl. Ask for our latest product developments and recommendations.

Ⓚ The amount of water depends on the starch content of the potatoes. The lower the starch content, the less water is needed.

Ⓛ Problems with deposits on heat surfaces can usually be solved by adding Neutrase 0.8 L at 50-150 g/t starch or Alcalase 2.4 L at 25-75 g/t starch. This will often also improve fermentation.

Ⓜ The mill, pump and jet are started in close succession.

Novozymes - Unlocking the magic of nature

Novozymes is the biotech-based world leader in enzymes and microorganisms. Using nature's own technologies, we continuously expand the frontiers of biological solutions to improve industrial performance everywhere.

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