

High Gravity Fermentation

Correct gelatinization, liquefaction and saccharification of starch-based raw materials can still result in highly viscous mashes. The extraction and solubilisation of highly viscous non-starch polysaccharides (NSP) such as cellulose, pentosans, xylans and beta-glucans during the process is highly dependent on the type of raw material used. To reduce energy and water consumption and effluent by running the process at a high DS level, viscosity-reducing enzymes are needed for mainly “small grains” such as wheat, barley, rye and triticale.

Benefits

The reduction in the viscosity of mashes and liquids in all stages of the process using Novozymes Viscoferm® will open the door to:

- Higher output by running at higher DS
- Reduced costs for energy, water and operations
- Reduced fouling, cleaning and wear of equipment
- Flexibility in choice of raw materials

Products

Viscoferm® is a balanced blend of xylanase, beta-glucanase and cellulase produced by submerged fermentation of a *Trichoderma* sp. and a genetically modified *Aspergillus* microorganism.

Novozymes Viscozyme® L is a multi-enzyme complex containing a wide range of carbohydrases, including arabinase, cellulase, beta-glucanase, hemicellulase and xylanase. The enzyme preparation is produced from a selected strain of *Aspergillus aculeatus*.

There is more information about the products available at the Customer Center.

Performance

Wheat

Wheat (as well as rye) is a major raw material for distillers in Europe and Canada. The relatively high amount of water-soluble pentosans is remarkable. These pentosans, primarily consisting of the two pentoses arabinose and xylose, are polysaccharides that create compounds of a very high viscosity.

In the modern plant, only Viscoferm® achieves maximum viscosity reduction, highest DS, increased output and smooth downstream processing.

Enzymatic degradation of the pentosans with xylanases such as Viscozyme® L can also reduce viscosity, but to a much lesser extent than with Viscoferm®.

Viscosity reduction on 100% wheat

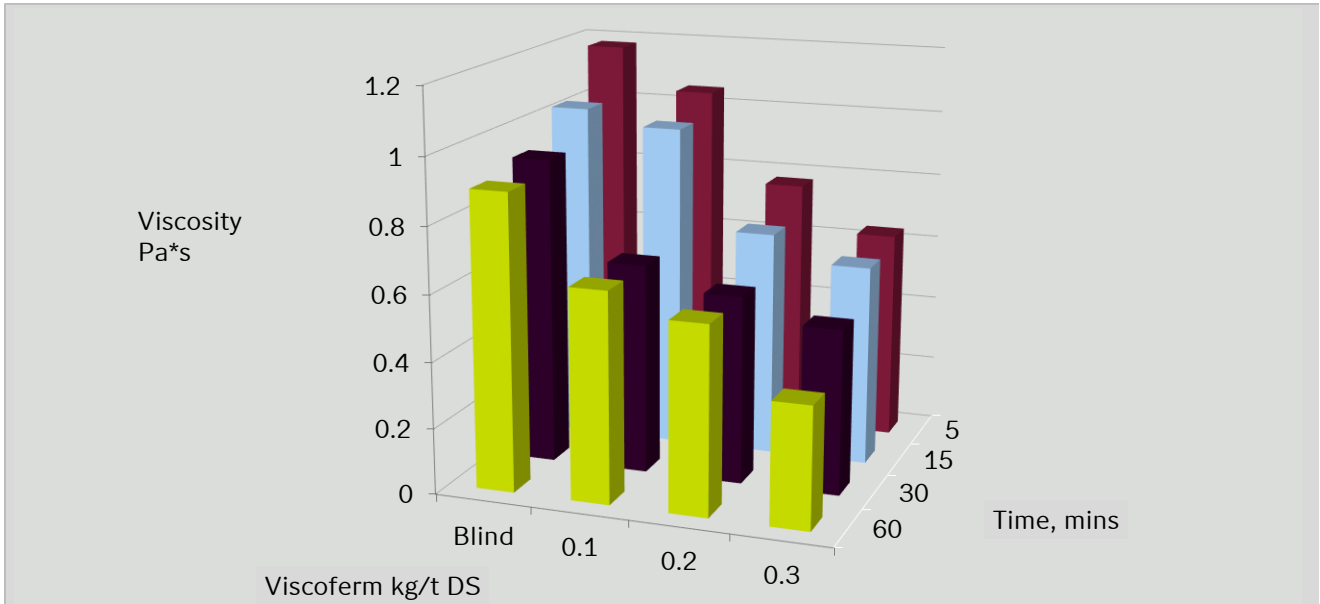


Fig. 1. Viscoferm® performance on 100% wheat mash in the laboratory. Time: 5-60 min., Dry substance: 30%, pH: 5.0

Industrial tests on 100% wheat show that over 70% more fermentation capacity was obtained in a distillery by using Viscoferm® (see table 1 below). A high-alcohol-tolerant yeast strain was used in order to ensure fermentation and achieve the high alcohol content.

100% wheat	Control	Viscoferm®
Enzyme dosage	No viscosity reducing enzyme	0.1 kg/ton
DS achieved	14.5-16.5°Bx	> 26°Bx
Alcohol content of mash (v/v)	8-9%	> 14.5%
Capacity increase	Control	> 70%

Table 1. Industrial test results on 100% wheat

Rye

Rye contains the same viscosity-increasing polysaccharides as wheat and barley, but the problems with viscosity are even more serious. In this case, it is necessary to use viscosity-reducing enzymes such as Viscoferm®.

In the modern plant, only Viscoferm® achieves maximum viscosity reduction, highest DS, increased output and smooth downstream processing.

Viscosity reduction on rye

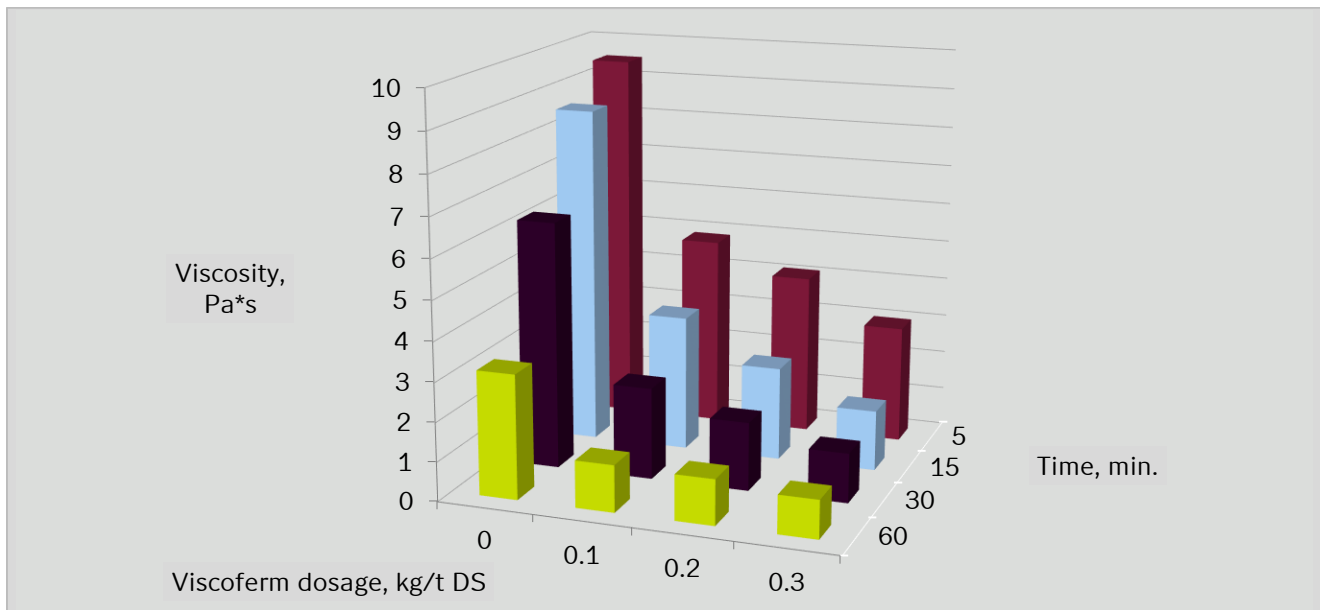


Fig. 2. Viscoferm® dosage and viscosity reduction performance on rye in the laboratory

Industrial tests on 100% rye show that 90% more fermentation capacity was obtained in a distillery by using Viscoferm® (see table 2 below). A high alcohol tolerant yeast strain was used in order to ensure fermentation and achieve the high alcohol content.

100% rye	Control	Viscoferm®
Enzyme dosage	No viscosity reducing enzyme	0.15 kg/ton
DS achieved	13-15°Bx	> 26°Bx
Alcohol content of mash (v/v)	6-7.5%	> 14.5%
Capacity increase	Control	> 90%

Table 2. Industrial test results on 100% rye

Triticale

In the modern plant, only Viscoferm® can achieve maximum viscosity reduction, highest DS, increased output and smooth downstream processing.

Viscosity reduction on 100% triticale

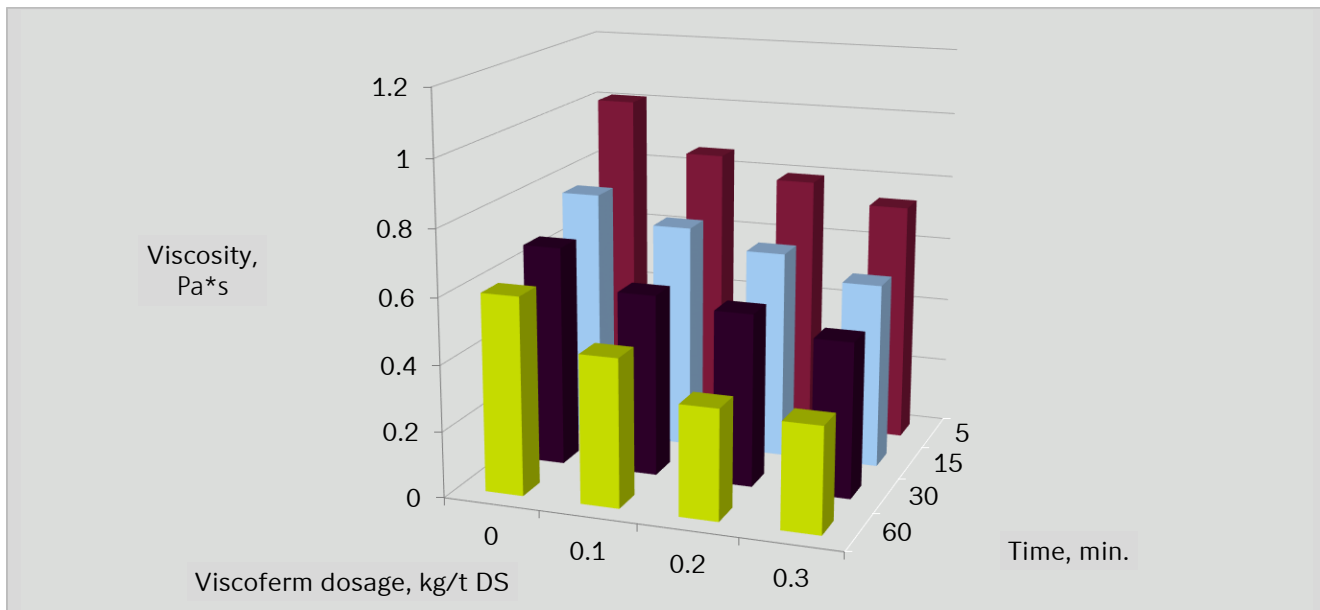


Fig. 3. Performance of Viscoferm® on triticale mash. Time: 5-60 min., Dry substance: 30%, pH: 5.0

Barley

Xylans and beta-glucans are responsible for processing problems with barley. In the modern plant, Viscoferm® achieves maximum viscosity reduction, highest DS, increased output and smooth downstream processing.

Viscosity reduction on 100% barley

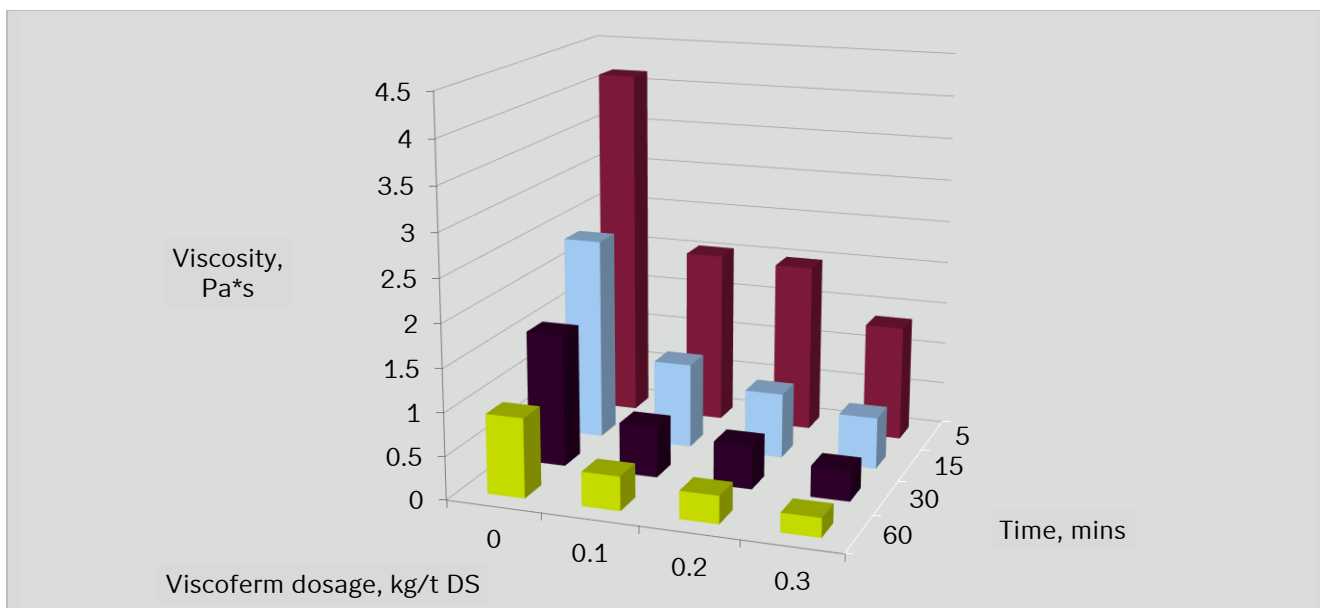


Fig. 4. Effect of Viscoferm® on barley. Time: 5-60 min., Dry substance: 30%, pH: 5.0

Corn

High DS can be run without using extra viscosity-reducing enzymes. Sometimes the use of Viscoferm® can help to achieve the required DS level even on stale or difficult maize.

Sorghum and millet

As in the case of corn, high DS can be run without using extra viscosity-reducing enzymes. Sometimes sorghum can be difficult to process, and the use of Viscoferm® can help to achieve the required DS level.

Potato, tapioca, manioc, cassava

On fresh manioc/tapioca/cassava, the use of Viscoferm® or Viscozyme® L is recommended to achieve the required DS level.

Usage

Viscoferm® can be added either at mashing prior to liquefaction at 50°C or after liquefaction at 60-65°C during saccharification.

Dosage

Raw material	Viscoferm® dosage	Viscoferm® dosage	pH	Time (min.)	Temperature (°C)
	Kg/ton grain 20-25% DS	Kg/ton grain 30-35% DS			
Barley	0.04-0.07	0.12-0.22	5-6	30	50
Rye	0.05-0.10	0.15-0.25	5-6	30	50
Wheat	0.03-0.07	0.10-0.20	5-6	30	50
Triticale	0.03-0.07	0.10-0.20	5-6	30	50
Oats	0.05-0.10	0.15-0.30	5-6	30	50
Fresh manioc, cassava, tapioca*	0.03-0.08*	0.10-0.25*	5-6	30	50

Table 3. Recommended dosages of Viscoferm® for viscosity reduction at HGF.

*For fresh cassava, manioc or tapioca Viscozyme® L can be used alone or in combination with Viscoferm®

Viscoferm® - pH performance

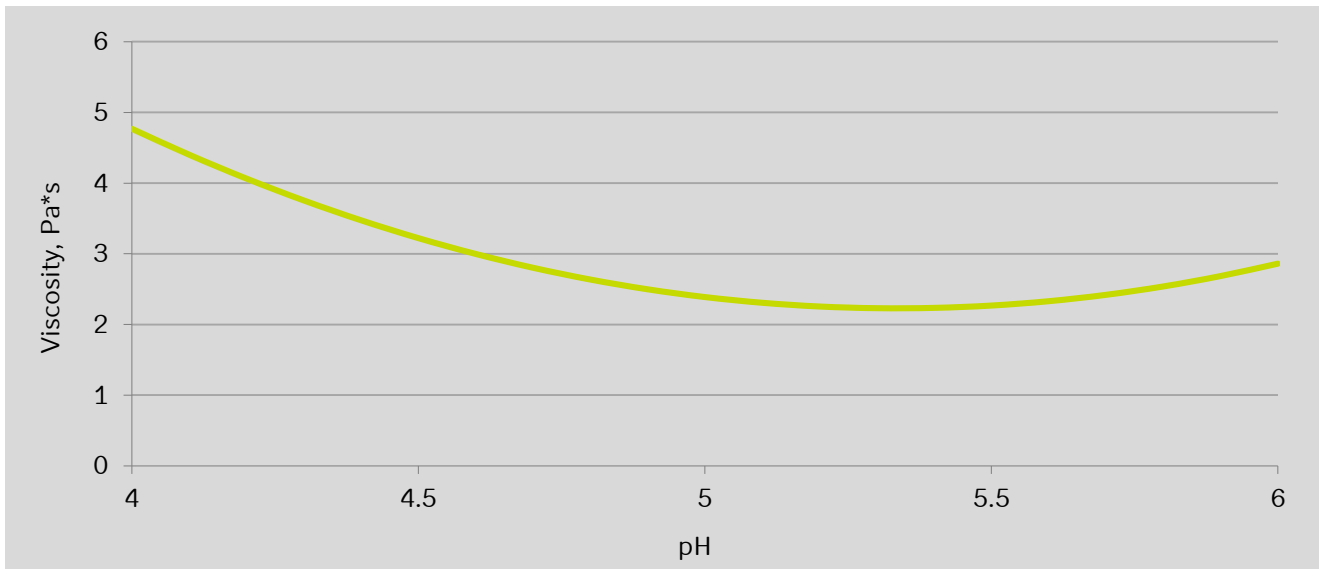


Fig. 5. Performance of Viscoferm® at different pH levels. Viscoferm® is stable over a broad pH range from 4 to 6. The optimum pH is between 4.8 and 5.8.

Trial conditions: Dosage: 0,2 kg/t DS, Time: 30 min.

Viscoferm® - temperature performance

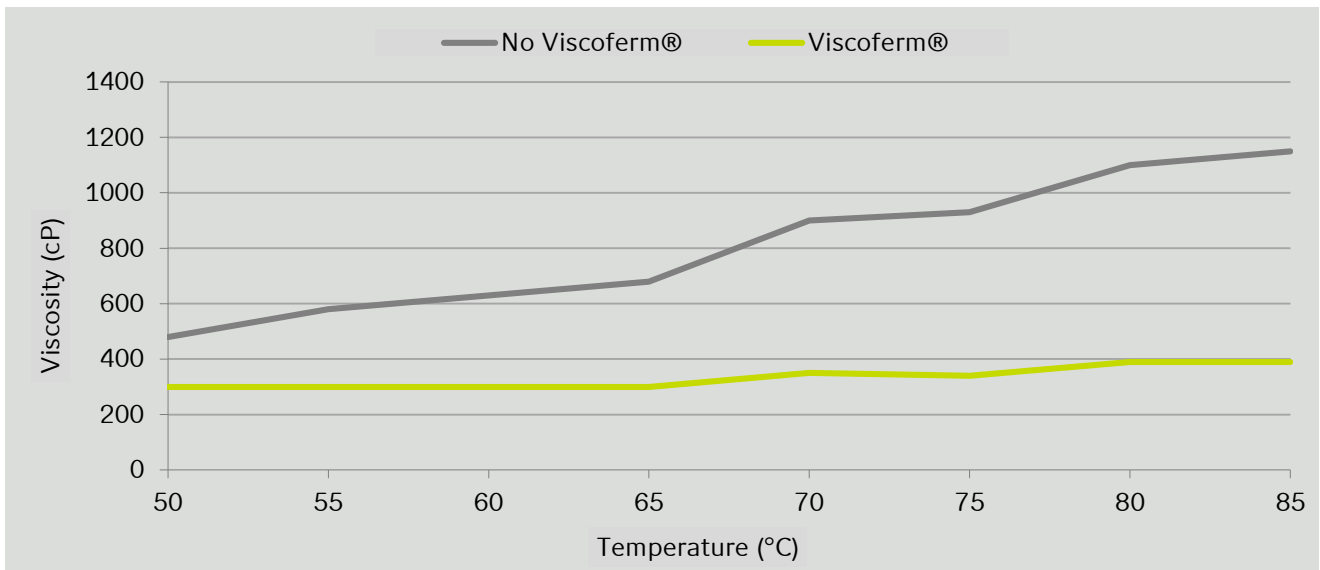


Fig. 6. Stability of Viscoferm® at different temperatures. Trial conditions: Rye, 24% DS Temperature: 50°C during 30 minutes with 150 ppm Viscoferm®

Figure 6 shows the viscosity of rye mashes treated with and without Viscoferm® in the temperature range 50-85°C. The reason for higher viscosity levels at higher temperatures in mashes without Viscoferm® is the increased hydrolysis of NSP (Non-starch Polysaccharides), which is responsible for the viscosity in mashes from rye, wheat, barley, triticale and others.

The curve for the viscosity of rye mashes treated with Viscoferm® shows very little difference between 50-85°C, indicating how robust Viscoferm® is even at high temperatures of 80-85°C.

Detailed application information

For more information on the use of Novozymes' products, please contact our Global Technical Service team.

Storage

Ideal storage conditions are 0-10°C (32-50°F) in sealed packaging in a dry environment protected from the sun. The products have been manufactured for optimum stability. However, enzymes gradually lose activity over time. Extended storage and/or adverse conditions such as higher temperatures or increased humidity may lead to a higher dosage requirement.

Safety, handling and storage

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

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.

Novozymes Switzerland AG

Neumattweg 16
4243 Dittingen
Switzerland

Novozymes A/S

Krogshøjvej 36
2880 Bagsvaerd
Denmark