Efficient Conversion of Wheat Starch into Bioethanol Using the Low Energy Intensive STARGEN™ Technology

4th European Bioethanol Technology Meeting
Detmold
April 15-16, 2008
Introduction to STARGEN™

STARGEN™ process for whole grains

Why Processing Wheat Starch

Considerations when Processing Wheat Starch

STARGEN™ process for (wheat) starch

Conclusions
Optimized blend of amylases to hydrolyze raw (granular) starch

Produces glucose from uncooked grains during yeast fermentation

Superior performance in SSF of dry milled grains without cooking

Available in two versions

- **STARGEN™001** for the conversion of corn
- **STARGEN™002** for the conversion of rye, wheat, triticale and barley

Optimal pH is pH 3.8-4.5.
The STARGEN™ Process
Whole ground wheat

Milled Grain

Fresh water

Thin stillage

Proc. Cond.

ACTIVATION
30-60 minutes

FERMENTATION
48-72 hours

pH 3.5
56°C

STARGEN™ 002

Acid Alpha-amylase
Viscosity reduction
Protease

pH 3.5
56°C

pH 3.5
32°C
Why processing wheat starch?

- High value by-products
  - Gluten
  - Fiber
- Additional benefits for ethanol production:
  - Lower viscosity: No fibers
  - High DS processing
  - Higher ethanol yield in fermentation (>16% v/v)
  - Energy efficiency in Distillation
  - Sustainability
- Disadvantage of wet-milling
  - High investment
  - High yeast nutrient demand
Do we need protease and/or viscosity reducing enzymes?

What is the use of the activation step?

Which nutrients can/should be used?

What are the optimal conditions
Need for additional enzymes?

**STARGEN™ 002 Fermentation without Protease or Viscosity reducing enzymes**

![Graph showing fermentation time vs. ethanol percentage](image)

Wheat starch 25% DS, pH 5.0
0.29 kg/MT dss GC626
1.8 kg/MT dss STARGEN™ 002
STARGEN™ in a wet-mill process

STARCH MILK

pH 4.0-5.0  
53-56°C

pH 4.0-5.0  
32°C

"ACTIVATION"  
30-60 minutes

FERMENTATION  
48-72 hours

Fresh water

Thin stillage

Proc. Cond.

*Acid Alpha-amylase

STARGEN™
The activation step

- Temperature 53-56 °C is easily reached by addition of
  - Thin stillage
  - Process condensate

- Temperature > 53 °C reduces lactic acid bacterial growth

- Addition of Acid Amylase
  - Insurance against temperature excursions
  - Generate some fermentable sugars for yeast start
Yeast Nutrients
Heavy and Light corn steep water

Influence Steep Water on Ethanol yield

- Light steep
- Heavy steep

Influence Steep Water on residual glucose

Wheat starch 25% DS, pH 3.5
0.29 kg/MT dss GC626
2.0 kg/MT dss STARGEN™ 002
10% heavy or light steep water
Commercial yeast nutrients

Influence Yeast Nutrients on Ethanol yield

Influence Yeast Nutrients on residual glucose

Wheat starch 25% DS, pH 3.5
0.29 kg/MT dss GC626
2.4 kg/MT dss STARGEN™ 002
Optimizing yeast nutrients

Influence extra nutrients on Ethanol yield

Influence extra nutrients on residual glucose

Wheat starch 25% DS, pH 3.5
0.29 kg/MT dss GC626
1.8 kg/MT dss STARGEN™ 002
Optimal pH

Wheat Starch Fermentations with STARGEN™ 002 at various pH values

Wheat starch 25% DS, pH 3.5-5.0
0.29 kg/MT dss GC626
1.8 kg/MT dss STARGEN™ 002
Dose Response

Wheat Starch Fermentations with different STARGEN™ 002 dosages

- Ethanol (% v/v)
- Fermentation time (h)

- >1.8 kg/MT
  Starch negative at ± 60 hours

Wheat starch 25% DS, pH 4.5
0.29 kg/MT dss GC626
1.4-20 kg/MT dss STARGEN™ 002
Process recommendations

**STARCH MILK**

- **pH ~4**
- **30°C**

**pH 4.0-4.5**
- **53-56°C**

**pH 4.0-4.5**
- **32°C**

**“ACTIVATION”**
- 30-60 minutes

**FERMENTATION**
- 48-72 hours

- Acid Alpha-amylase
- GC626 at 0.29 kg/MT
- STARGEN™ 002
- At 1.8 kg/MT

Fresh water

Thin stillage

Proc. Cond.
Comparing Conventional and STARGEN™
on Wheat Starch

Wheat starch 25% DS, pH 4.5-5.0
0.29 kg/MT dss GC626
1.8 kg/MT dss STARGEN™ 002

Conventional
500g yeast / MT

Conventional
1000g yeast / MT

STARGEN™ 002
500g yeast / MT

Ethanol (% v/v)

Fermentation time (h)
Conclusions

STARGEN™ 002 on Wheat STARCH

➤ Reaches High ethanol yields in a simple process

➤ Allows high DS fermentations without viscosity issues

➤ Little pH adjustment is needed

➤ Yeast nutrients need to be controlled

➤ No additional yeast needed
Acknowledgements

- Pauline Teunissen
- Martien Bergsma
- Gerhard Konieczny-Janda
Thank You!!

Extract maximum value out of your grains!