Wheat starch variability in characteristics and Rheological properties: the influence of varieties, harvest years and phytotechny


CRA-W : Walloon agricultural Research Centre
Quality of agricultural products Department

FUSAGx : Faculty of Agronomy
Unité de Technologie des Industries agro-alimentaires
Unité de Phytotechnie des Régions tempérées

GEMBLOUX - BELGIUM

58 Starch convention, Detmold - Germany, 25-27/04/2007
Project strategy

3 variability sources:
- varieties
- phytotechny
- harvest dates

Known sample production
(Unité de Phytotechnie FUSAGx)

Enzymatic aspects
(Dpt Qualité CRA-W)
- Caracterisation of ground wheat
- Evaluation of α-amylase activities
- Starch sensitivity to enzymatic hydrolysis

Starch (Unité de Technologie des IAA FUSAGx)
- flour characterisation
- Starch extraction
- Starch Characterisation

Common interpretation of the results

Possible specific end-uses according to the starch
Starch isolation:

**Starch isolation:**

- Flour + water (60% flour weight)
- Kneading: 2 min
- Rest: 8 min
- + water (100% flour weight)
- Mix: 20 min

**Batter procedure**

- + water (400% flour weight)
- Stirring to agglomerate the gluten: 35 min
- Filtration
- Gluten
- Fibers

**Filtration**

- Gluten suspension
- (stored 24h at 4°C)

**Freeze-drying and storage**

- 3 cycles of starch centrifugation and re-suspension in water
- Starch suspension

Starch: methods and analyses

Batter procedure
Starch characterisation

- Dry matter (ISO n°712)
- Starch Damaged (amperometry determination by the Chopin-Dubois SD4 method, NF ISO 5530-1)
- Starch contents (polarimetry method of Ewers, ISO 10520)
- Starch viscosity (micro visco-amylograph Brabender)
  - in water suspensions
  - in a 2 mM AgNO₃ water solution (alpha-amylase inhibitor)
- Granule size distribution (laser light scattering using a Malvern granulometer)
- Amylose / amylopectin content (modified iodometric method of Morrisson et Laignelet, 1983)
Starch granules: size distribution
Starch granules: size distribution
(minimal, mean and maximal values, harvests 2002-2005)

Maximum variations (B-type granules < 10 μm): 15 to 20 % vol
Variety effect

Starch granules size distribution (harvests 2002-2005)

B-type granules < 10 µm (%vol)

- Agami
- Cubus
- Meunier
- Mercury
- Folio
- Corvus
- Robigus
- Deben

2002 2003 2004 2005
Sowing date influence

Starch Granules size distribution (harvests 2002-2005): means of the varieties under study

<table>
<thead>
<tr>
<th>Year</th>
<th>October (%)</th>
<th>December (%)</th>
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<tbody>
<tr>
<td>2002</td>
<td>22.9</td>
<td>20.4</td>
</tr>
<tr>
<td>2003</td>
<td>20.8</td>
<td>19.1</td>
</tr>
<tr>
<td>2004</td>
<td>23.0</td>
<td>23.3</td>
</tr>
<tr>
<td>2005</td>
<td>21.7</td>
<td>21.1</td>
</tr>
</tbody>
</table>
Amylose content: minimal, mean and maximal values, harvests 2002-2005

Variety effect

Maximum variations: 2-4% of the apparent amylose
Amylose / amylopectin (harvests 2002-2005)

Variety effect

2002 et 2005 : lower apparent amylose content
Amylose / amylopectin (harvests 2002-2005): means of the varieties under study

Sowing date effect

**Amylose content**: October < December (2002, 2003, 2005) (associated with higher A-granules content in December starches)
Starch yield (% starch): minimal, mean and maximal values, harvests 2002-2005

Variety effect

Maximum variations: 6 to 17% of the total starch
Variety effect

Starch yield (harvests 2002-2005)

![Graph showing starch yield for different varieties across years 2002 to 2005.]

- Cubus
- Agami
- Folio
- Mercury
- Corvus
- Meunier
- Dream
- Deben
- Robigus

Starch yield (% total starch)
Sowing date effect

Starch yield (harvests 2002-2005): means of studied varieties

Yield values similar in October and December (except in 2005)
A higher damaged starch is correlated with a higher water absorption of flours and more sensitive to enzymatic hydrolysis.

Varieties from harvests 2002-2005

$R^2 = 0.81$
Starch Damaged: minimal, mean and maximal values, harvests 2002-2005

Year effect

Very high

Weak

Maximum variations: 5 to 6 CDU
Starch damaged (harvests 2002-2005)

Variety effect

Damaged starch (CDU)

- Agami
- Robigus
- Deben
- Meunier
- Corvus
- Mercury
- Dream
- Folio
- Cubus

Legend:
- 2002
- 2003
- 2004
- 2005
Viscosity of starch and ground wheats
RVA (Newport), ICC method N°162

Time of analysis: 13 minutes
Viscosity properties

Dissociating the enzymatic and the starch contribution to viscosity (starch, ground wheat)

Brabender Micro-visco amylograph
Newport Rapid Visco Analyser
Maximum variations at 95°C: 60 to 100 BU

Starch: Pic of viscosity at 95°C (with AgNO₃):
minimal, mean and maximal values, harvests 2002-2005

Year effect

Graph showing starch viscosity at 95°C with AgNO₃ (BU) for years 2002 to 2005.
Starch pic of viscosity at 95°C (with AgNO₃) harvests 2002 to 2005
Variety effect

Starch pic of viscosities at 95°C and final viscosity at 50°C (with AgNO$_3$) harvest 2005

![Graph showing viscosity at 95°C and 50°C for different varieties](image-url)
Starch : pic of viscosity at 95°C (with AgNO₃) : mean values for the varieties under study (harvest 2002 to 2005)

Sowing date influence

October > December
Correlations between the pic of viscosity at 95°C (with AgNO₃) measured on ground wheat and on the corresponding starch (harvest 2002 to 2005)

Overall: $R^2 = 0.61$

- 2002: $R^2 = 0.75$
- 2003: $R^2 = 0.68$
- 2004: $R^2 = 0.72$
- 2005: $R^2 = 0.82$
Combined effects of the phytotechny on the pic of viscosity (95°C) ground wheats

**Phyto 1**: October seedlings, No fungicide, N fertilisation: 50-60-0
**Phyto 2**: October seedlings, fungicide, N fertilisation: 50-60-75
**Phyto 3**: December seedlings, fungicide, N fertilisation: 0-60-155

Delta Koch (2) - Agami (2) = 1097 cP
Delta Deben (3) - Agami (2) = 1605 cP
Enzymatic effects (alpha- amylase activities)

• Indirect methods

  *Hagberg Falling Number*

  *Rapid Visco Analyser (ICC method N°162)*

• Direct methods for AAA

  *Ceralpha Method (Megazyme, ICC N°303)*

  *Amylazyme Method (Megazyme, AACC 22.05)*
Endogenous enzymes

2 contribution: the starch, the enzymes

RVA (water- 2 mM AgNO₃)

2 varieties with similar AAA
Endogenous enzymes

Ground wheats from 2002 to 2005

$(\text{PV AgNO}_3 - \text{PV water})/\text{PV water}$ VS AAA ceralpha

**Résultats moutures intégrales 2002-2005**

$R^2 = 0.96$

$n = 91$

Activité alpha-amylasique (unités Ceralpha/g)
Starch sensitivity to enzymatic hydrolysis

Addition of growing activities of an amylase from *Bacillus sp.*

- Pic of viscosity vs added activities

Linearisation by using pic ratios

\[
\frac{(PV_{\text{initial}} - PV_{\text{after adding AA}})}{PV_{\text{after adding AA}}}
\]

\[
y = 1.16x - 0.07 \quad R^2 = 0.99
\]
Starch sensitivity to enzymatic hydrolysis

Addition of growing activities of an amylase from *Bacillus sp.*

\[ y = 4.85x + 0.28 \]

\[ R^2 = 1.00 \]

\[ y = 7.39x - 0.28 \]

\[ R^2 = 0.99 \]

\[ y = 5.91x - 0.46 \]

\[ R^2 = 0.99 \]

\[ y = 5.78x - 0.67 \]

\[ R^2 = 0.98 \]

\[ y = 1.16x - 0.07 \]

\[ R^2 = 0.99 \]

Slope of the regression = sensitivity to enzymes
Conclusions and further prospects

There is a variability in the intrinsic properties of starch
We may not neglect it!!!

- Genetic and phytotechny have an influence on the characteristics of the ground wheat and the corresponding starches
- Major influence of the harvest years
- Variety is of a major concern
- It can be reinforced by the phytotechny

Goal: Orientation of wheat lots according to the applications
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Many thanks for your attention