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

With the financial support of General Direction of agriculture, Walloon Region
Project strategy

Known sample production (Unité de Phytotechnie FUSAGx)

3 variability sources:
• varieties
• phytotechny
• harvest dates

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:

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

- + water (100% flour weight)
  - Mix: 20 min

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

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

- Freeze-drying and storage

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

Batter procedure:

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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

B-type granules < 10 µm (%vol)

<table>
<thead>
<tr>
<th>Variety</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
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<tr>
<td>Agami</td>
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<td>Cubus</td>
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<td>Deben</td>
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Starch Granules size distribution (harvests 2002–2005): means of the varieties under study

Sowing date influence

B-types granules (% vol)
Amylose content: minimal, mean and maximal values, harvests 2002–2005

Maximum variations: 2–4% of the apparent amylose

### Variety effect

The table below shows the apparent amylose content of various varieties over the years 2002 to 2005. The data indicates a lower apparent amylose content in the years 2002 and 2005 compared to 2003 and 2004.

<table>
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The graph visually represents the same data, providing a clearer comparison of the apparent amylose content across the different years and varieties.
Amylose / amylopectin (harvests 2002–2005) : means of the varieties under study

(⇔ associated with higher A-granules content in December starches)
Starch yield (% starch): minimal, mean and maximal values, harvests 2002–2005

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


![Starch yield graph]

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

Starch yield (% total starch)

- 2002
- 2003
- 2004
- 2005
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

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

(associated with higher A-granules and amylose contents in starches from December seedlings)
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
Starch: Pic of viscosity at 95°C (with AgNO₃) :
minimal, mean and maximal values, harvests 2002–2005

Maximum variations at 95°C : 60 to 100 BU
Starch pic of viscosity at 95°C (with AgNO₃) harvests 2002 to 2005
Starch pic of viscosities at 95°C and final viscosity at 50°C (with AgNO₃) harvest 2005

Variety effect

Viscosity at 95°C
Viscosity at 50°C
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: $R^2 = 0.61$

$R^2 = 0.75$

$R^2 = 0.68$

$R^2 = 0.72$

$R^2 = 0.82$
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

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Delta Koch (2) - Agami (2) = 1097 cP
Delta Deben (3) - Agami (2) = 1605 cP

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**Pic de viscosité en présence d'inhibiteur**

- Phytotech 1
- Phytotech 2
- Phytotech 3

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**Species**

- Koch
- Mercury
- Cubus
- Deben
- Meunier
- Dream
- Agami
- Corvus

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**Pic de viscosité**

- 2250
- 2500
- 2750
- 3000
- 3250
- 3500
- 3750
- 4000
- 4250
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

(PV AgNO3 – PV water)/PV water VS AAA ceralpha

\[ R^2 = 0.96 \]
\[ n = 91 \]
Starch sensitivity to enzymatic hydrolysis

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

- Pic of viscosity vs added activities

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

- Linearisation by using pic ratios

\[ y = 1.16x - 0.07 \]

\[ R^2 = 0.99 \]
Starch sensitivity to enzymatic hydrolysis

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

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 négligeable !!!

• 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
Many thanks for your attention
Composante amidon: résultats obtenus

- Influence importante de la variété et de la date de semis sur les propriétés intrinsèques et techno-fonctionnelles de l’amidon
- Relations entre les caractéristiques intrinsèques de l’amidon et ses propriétés de viscosité
- Relations entre les propriétés de viscosité des moutures intégrales et celles des amidons
- Méthode d’extraction de l’amidon à l’échelle du laboratoire et à l’échelle semi-pilote
Composante enzymatique

Alternative à l’indice de chute de Hagberg : conclusions

- Double protocole : estimation précise et rapide de l’AAA endogène des moutures intégrales
- Multiples informations : AAA et propriétés intrinsèques de gélification
- Valider le principe sur les farines blanches (augmenter la base de données) et les amidons extraits (adapter la méthode de dosage spectrophotométrique)

- N’intègre pas les aspects « cinétique d’hydrolyse/liquéfaction » càd que la méthode considère que les amidons ont la même sensibilité à la hydrolyse enzymatique

Investigation de cette sensibilité
Composante enzymatique

Investigation de la sensibilité des amidons à l’hydrolyse enzymatique

2 aspects

- Étude de la liquéfaction des amidons (Ajouts croissants d’AAA)
  - Mesures viscosimétriques
  - Applications : filière meunerie–boulangerie, IAA utilisatrices des amidons pour propriétés de texture
  - En relation avec composition et structure de l’amidon

- Étude de la cinétique d’hydrolyse partielle et complète des amidons
  - Applications : Production de sirop de glucose (Amidonnerie) et bioéthanol
  - En relation avec composition et structure de l’amidon