Banana physicochemical & functional differentiation during ripening. A key study for understanding consumer preferences

O. Gibert, D. Dufour, M. Reynes, A. Giraldo, A. Escobar & A. González

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Introduction

Dessert bananas and cooking bananas:
- Highly diverse source of starch
- Staple food for millions of inhabitants

Rationale & objectives
- Standardization of the methods of evaluation
- Evaluation of physicochemical & functional properties
- Identification & hierarchization of quality traits among consumption subgroups to ensure consumer acceptability
Method

- Socio-economic surveys within communities of stakeholders for identification of consumer preferences
  (i) Visit and selection of “fincas” with largest diversity
  (ii) Cooking workshops/demonstrations

- Standardization of the methods & germplasm evaluation
  (i) Selection/isolation of the raw material
  (ii) Physicochemical and functional characterization
  (iii) Chemical characterization during ripening
Banana genotypes & consumption groups

Dessert bananas

AA  – Sucier, Samba,..
AAA – Cavendish, Gros Michel,..
AB   – Ney Poovan, Kunnan
AAB  – Silk, Pome, Mysore,..
ABB  – Pisang Awack
Dessert bananas

- Bocadillo (AA)
- Primitivo (AA)
- Gros Michel (AAA)
- Cavendish (AAA)
- Rollizo (AAA)
- Tafetán morado (AAA)
Banana genotypes & consumption groups

Dessert bananas

AA  – Sucier, Samba,..
AAA  – **Cavendish**, Gros Michel,..
AB  – Ney Poovan, Kunnan
AAB  – Silk, Pome, Mysore, ..
ABB  – Pisang Awack
AAAA  – FHIA hybrids, ..
AAAB  – FHIA hybrids
Dessert hybrids

FHIA 25 (AAAB)

FHIA 18 (AAAB)

FHIA 17 (AAAA)

FHIA 1 (AAAB)
Banana genotypes & consumption groups

**Dessert bananas**

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AAA – **Cavendish**, Gros Michel,..
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ABB – Pisang Awack
AAAA – FHIA hybrids, ..
AAAB – FHIA hybrids

**Cooking bananas**

EA-AAA – Lujugira
ABB  – Bluggoe, Pelipita, Saba,..
AAT/AT – Féhis
AAB  – Maia maoli,
Cooking bananas

Cachaco (ABB)

Guineo (EA-AAA)

Pelipita (ABB)

Hua moa (AAB)

Guayabo (AAB)
Banana genotypes & consumption groups

**Dessert bananas**

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– Sucrier, Samba, ..

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– Cavendish, Gros Michel, ..

**AB**  
– Ney Poovan, Kunnan

**AAB**  
– Silk, Pome, Mysore, ..

**ABB**  
– Pisang Awack

**AAAA**  
– FHIA hybrids, ..

**AAAB**  
– FHIA hybrids

**Cooking bananas**

**EA-AAA**  
– Lujugira

**ABB**  
– Bluggoe, Pelipita, Saba, ..

**AAT/AT**  
– Féhis

**AAB**  
– Maia maoli, **Plantains**
Plantains (AAB)

- Cubano blanco
- Dominico
- Hartón
- Maqueño
- África
- Dominico Hartón
Banana genotypes and consumption groups

Dessert bananas

AA  – Sucrier, Samba,..
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Cooking hybrids (AAAB)

FHIA 20

FHIA 21
Banana genotypes & consumption groups

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*Bakry et al., 2009; Lescot, Fruitrop 2010*
Socio-economic survey

- Identification of the varieties cultivated locally
- Cooking workshops to describe the consumption patterns & for hierarchization of preferences
# Few consumption preferences

<table>
<thead>
<tr>
<th>Process/use</th>
<th>D Harton</th>
<th>Guayabo</th>
<th>Guineo</th>
<th>Gros Michel</th>
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<td>Fried products</td>
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Moneditas
Tostadas
Patacón pisado
Tostones
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Empanadas
Masa precocida
Marranitas
## Few consumption preferences

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Adapted from Quintero et al. 2009 in Gibert et al. 2009
Consumption modes/preferences

- great diversity of cultivated varieties identified (> 30) ¹
- various consumption patterns (6 modes) ¹
- preferences based on the selection of varieties at a specific stage of ripeness for a use (4 stages)

Is it possible to identify some objective quality traits to:

- differentiate genotypes & banana subgroups?
- to justify the consumption patterns/acceptability at various stages of ripeness?

¹ Quintero et al. 2009, in Gibert et al. JAFC 2009
**Starch & flour Isolation: an accurate method**

- **Stage I**
  - Crushed pulp
  - Slurry filtration
  - Washed 3X & decantation
  - Centrifuged (10000rpm -4°C)
  - Starch oven-dried (50°C – 48h) & stored (4°C)

- **Stage II & III**
  - Cut in thin slices
  - Freeze-drying
  - N₂ Crushing
  - Flour ground
  - Flour stored (4°C)
  - Paint mixer grinding
Germplasm evaluation

» Morphological characterization

Bunch/finger dimension & weight distribution, edible fraction,...
Germplasm evaluation

➤ Morphological characterization
  Bunch/finger dimension & weight distribution, edible fraction,...

➤ Physicochemical characterization
  pH, TA, DM, specific gravity, ash, TSS, soluble sugars, organic acids,
  proteins, starch content, crude fiber, minerals, texture

➤ Functional characterization
  Pasting & thermal properties

Gibert et al., JAFC 57, 2009, err. 58, 2010
Dufour et al., JAFC 57, 2009
Gibert et al., JFE, 2010
Pasting properties by RVA

Viscosity (cP) vs. Time (s) and Temperature (°C)

- BD: Peak Breakdown
- SB: Settling Breakdown
- CA: Cool Down
Germplasm evaluation

➤ Morphological characterization
  Bunch/finger dimension & weight distribution, edible fraction, ...

➤ Physicochemical characterization
  pH, TA, DM, specific gravity, ash, TSS, soluble sugars, organic acids, proteins, starch content, crude fiber, minerals, texture

➤ Functional characterization
  Thermal & pasting properties

Gibert et al., JAFC 57, 2009, err. 58, 2010
Dufour et al., JAFC 57, 2009
Gibert et al., JFE, 2010
Functional properties by DSC

Onset
PCA illustration of the germplasm evaluation

Gibert et al., JAFC 57, 2009, err. 58, 2010
Dufour et al., JAFC 57, 2009
PCA illustration of the germplasm evaluation

Gibert et al., JAFC 57, 2009, err. 58, 2010
Dufour et al., JAFC 57, 2009
How to guaranty consumer acceptability?

- A specific firmness
  - A specific appearance
  - A « flavor profile »:
    - volatile compounds
    - taste ➔ Presence of starch
    - Sweetness: glu, fru, suc
    - Sourness: malic, citric & TA
    - Astringency: oxalic

Ripening influence on OA & soluble sugars? Any differences among genotypes?

Ripening stage definition

13 varieties harvested at optimal green stage

Stage I

13 varieties let to ripen until being fully-ripe

Stage II

13 varieties let to ripen until being over-ripe

Stage III
Soluble sugars & organic acids: *stage I*

- PC1: 42%
- PC2: 20%

- Raffinose
- Oxalic
- α-ketoglutaric
- Trans-aconititic
- Malic
- Total sugars
- Glucose
- Fructose
- DM
- Soluble sugars & organic acids:
  - Glucose
  - Fructose
  - DM

Legend:
- AA
- AAA
- AAAB
- AAAea
Soluble sugars & organic acids: stage II

PC1: 39%

PC2: 26%

DM
• R cit/mal
citric

AAA
• AAB
citric

AA
• AAB
citric

AAAea
• AAA

AAAB

sucrose

cis-aconitic
cis-aconitic R
fum/mal
total sugars
glucose
malic
fructose
citric
R cit/mal
DM
Soluble sugars & organic acids: stage III

PC1: 28%
PC2: 25%

- AAA
- AA
- AAB
- malic
- glucose
- TTA
- fumaric
- R fum/mal
- AAAea
- citric
- R cit/fum
- DM
- R cit/mal
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<th>Issue</th>
<th>Limitations</th>
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<tr>
<td>Hand w-finger w Finger d</td>
<td>Differentiation pl-cook. des. hyb.</td>
<td>Cooking behavior?</td>
</tr>
<tr>
<td>Edible food fraction</td>
<td>Yield &amp;productivity</td>
<td>Sensorial acceptability?</td>
</tr>
<tr>
<td>Spatial dimensions</td>
<td>Intra bunch variability (sampling strategy)</td>
<td>Edaphoclimatic conditions</td>
</tr>
<tr>
<td>Onset temp. Breakdown (BD)</td>
<td>Sensorial acceptability Prediction of cooking behavior</td>
<td>Environmental contribution &amp; interaction with genetic origin</td>
</tr>
<tr>
<td>Setback (SB)</td>
<td>Industrial formulation &amp; neglected var. valorization</td>
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</tr>
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<td>Cooking ability (CA)</td>
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## Quality traits: a hierarchization trial & limits

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<tr>
<td>DM- Starch Amylose</td>
<td>Differentiation between subgroups at stages I, II, III Potential for processing</td>
<td>• Environmental contribut. &amp; interaction with genetic origin</td>
</tr>
<tr>
<td>Ca$^{2+}$, K$^+$</td>
<td>Subgroup differentiation</td>
<td>• Farming practices</td>
</tr>
<tr>
<td>Pulp firmness</td>
<td>Sensorial acceptability Differentiation on consumption mode</td>
<td>• Dependence on stage of ripeness</td>
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<tr>
<td>Soluble sugars</td>
<td>Genotype differentiation Fermentation ability</td>
<td>• Dependence on stage of ripeness</td>
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<tr>
<td>Organic acids</td>
<td>pH or TA prediction</td>
<td>• Relationship with sensorial acceptability to established</td>
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Prospects..

- Validation of prioritized traits
- Environmental contribution to hierarchized traits
- Taste prediction (sweetness, taste & aroma dynamics) based on chemical attributes, with genotype/ripening stage

- “Full use of genetic diversity through consumer-oriented evaluation”:
  - adding value to neglected varieties
  - contributing to breeding strategy improvement
  - ensuring consumer acceptability
Thank you for your attention

Obrigado pela sua atenção

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