Linking conservation to local use: Maize bread from LRs

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From the kernel to the bread

1 - Diversity

2 – Yield components

3 - Quality

4 - Socio-economic aspects
1 - Diversity
Hallauer (1994) proposed distinct four stages for maize breeding:

1) domestication process

2) development of more than 250 or less distinct races of corn by native American civilization till 16th century

Shamel, 1905; East (1908) and Shull (1908); Shull (1909, 1910) and Jones (1918)

3) development of distinct varieties from original races by American and European colonists (1500 to 1925)

4) development of the concept of inbreds and hybrids (1909 till present).

Columbus (1492)

PPB
Stage three (more than 500 years relationship)
• “Portuguese Agricultural Revolution” in the XVII/XVIII Cent.

• Adaptation led to a bigger expansion of the crop lead to a different types of maize adapted to a diversified number of microclimates (Northwest and Algarve), according to the sequence of valleys and mountains.

• The population diet was improved directly with maize bread (“Broa”), and indirectly due to the increase of meat consumption.
Adaptation do Portugal conditions versus adaptation to Portuguese farmers needs

American hybrids

Monocropping technology

No success

Poor grain quality for human use as bread

National breeding stations

Estação Agrária de Braga (NUMI)

Portuguese hybrids

ADAPTATION TO FARMER’s NEEDS

Grain quality for human use as bread

Early-maturing varieties adapted to highly intensified cropping systems

Success
Genetic resources \rightarrow On-farm conservation

Ex-situ (BPGV) \rightarrow PPB

Hybrids program

Conservation needed for specificities of germplasm
New needs new challenges, (re)newal uses

PPB

Germplasm for:

Niche market

OF and LIF,

Climate changes

On farm conservation

Study also some interesting traits (e.g. fasciation)
Participatory Maize Breeding (Breeding on-farm)
PPB – VASO started in 1986
The main question

• “How to solve the problem of the small Portuguese farmers where the land is scarce and the high demographic density exists”

  i.e.

• where the American model do not fit and where the multinationals do not have market to operate?
Important decisions for project success

Location
- traditional maize area
- Agro/sociologic/economics data availability
- Support of a local elite farmers’ association (CGAVS)
- Test the efficiency of an alternative project supposed to improve the local germplasm in order to be competitive, at least in certain specific circumstances, side by side with the local hybrids production

Germplasm
- 1 - Local Germplasm (e.g. ‘Pigarro’, ‘Amiúdo’)
- 2 - Exotic germplasm ‘FANDANGO’

Farmer
- The right people to work with, work side by side with the farmer, to whom the decision power will be allowed
- Their initial acceptance and enthusiasm
VASO Project (breeding methodologies)

Farmer selection
(A-B-C selection process)

Breeder selection
(S2 selection process)
Mr Meireles as winner of Sousa Valey Best Ear contest (14 years)
On farm conservation
Collecting missions in 2005
Helping to keep this long legacy...
Collecting the system with all their seed components
Organization of collecting missions
Collecting missions in 2005
-Serra da Estrela, National Park was included

other crops (cabagges, pumpkins,...)

Yellow maize landraces
29

White maize landraces
21

Beans
102

Rye
53

Number of landraces seed samples collected on the field expeditions

Studies
• Agronomic
• Molecular
• Quality

Vaz Patto MC, Moreira PM, Carvalho V and Pego S 2007 Collecting maize (Zea mays convar. Mays) with potential technological ability for bread making in Portugal. Genetic Resources and Crop Evolution
Biodiversity conservation so as traditions and empirical knowledge, i.e., collective memory
2 – Yield components
Material and Methods

- Trials in 2007 and 2010
- 39 maize entries from PPB and on-farm, plus population hybrids
- 9 locations in Portugal
- 3 Replications

- Plots
  - $9.6 \text{ m}^2$ (2 rows $\times$ 7.00 m length $\times$ 0.75 m between rows);
<table>
<thead>
<tr>
<th>Material and Methods Traits</th>
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<tbody>
<tr>
<td><strong>Yield, mg ha⁻¹</strong></td>
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<tr>
<td><strong>Moisture %</strong></td>
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<tr>
<td><strong>Days-to-silk, n° †</strong></td>
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<tr>
<td><strong>Days-to-silk, n° † end</strong></td>
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<tr>
<td><strong>Days-to-anthesis, n° †</strong></td>
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<tr>
<td><strong>Days-to-anthesis, n° † end</strong></td>
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<tr>
<td><strong>Plant height, m (x10) ‡</strong></td>
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<tr>
<td><strong>Ear height, m (x10) ‡</strong></td>
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<tr>
<td><strong>Ear Lenght, cm</strong></td>
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<tr>
<td><strong>Ear Diameter 1, cm (x10) ‡</strong></td>
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<td><strong>Ear Diameter 3, cm (x10) ‡</strong></td>
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<td><strong>Ear Diameter 2, cm (x10) ‡</strong></td>
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<td><strong>Ear Diameter 4, cm (x10) ‡</strong></td>
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<td><strong>Kernel-row number 1, n°</strong></td>
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<td><strong>Kernel-row number 2, n°</strong></td>
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<td><strong>Fasciation</strong></td>
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<td><strong>D/I %de Ind</strong></td>
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<td><strong>Convulsion</strong></td>
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<td><strong>F/D</strong></td>
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<td><strong>Ear weight, g</strong></td>
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<tr>
<td><strong>Kernel weight, g</strong></td>
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<td><strong>Kernel dept, cm (x10) ‡</strong></td>
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<td><strong>Kernel number, n°</strong></td>
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<td><strong>Thousand kernel weight, g</strong></td>
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<td><strong>Kernel per row, n°</strong></td>
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<td><strong>Cob diameter 1, cm (x10) ‡</strong></td>
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<td><strong>Cob diameter 3, cm (x10) ‡</strong></td>
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<td><strong>Cob diameter 4, cm (x10) ‡</strong></td>
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<td><strong>Medula 1, cm (x10) ‡</strong></td>
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<td><strong>Medula 2, cm (x10) ‡</strong></td>
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<td><strong>Raquis 1, cm (x10) ‡</strong></td>
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<td><strong>Raquis 2, cm (x10) ‡</strong></td>
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<tr>
<td><strong>Ear%Moisture</strong></td>
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<td><strong>Ear%Moisture</strong></td>
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Data treatment

- ANOVA and Multivariate Adaptive Regression Splines (MARS)

Results

- Yield range from 3.7 to 6.3 Mg/ha

Some population hybrid with - Pop Hib 1 – 7.1 Mg/ha

DATA treatment is on going
3 – Quality
End-use quality

- Viscosity profiles
- Rheological properties
- Breadmaking ability
Viscosity profiles: -Rapid Visco Analyzer (RVA)

- Viscosity profiles (maximum, minimum and final viscosity (cP units)

- Viscosities profiles express gelatinization and retrogradation phenomenon of starch that occur during heating/cooling and agitation of flour and water suspension

- (Brites et al. 2010)
Portuguese OPV

- Portuguese OPV exhibited significant higher protein, lower amylose contents and lower viscosity profiles than commercial hybrids varieties
  - Categorization on three distinct clusters:

  **A**
  - High oil and amylose content/low viscosity profiles

  **B**
  - High protein content, high viscosity profiles/low oil and amylose content

  **C**
  - Low protein content

Vaz Patto et al. (2009)
Breadmaking ability
Carla Brites

• Volume (cm³), Weight (g), Specific volume (polyethylene spheres displacement method)
• Crumb firmness, compression test (Texture analyser TA Hdi)

Greater dietary fiber and resistant starch, lower volume and denser loaf matrix in maize than in wheat bread (Brites et al., 2010)

• Sensory analysis
• **Viscosity**
  
  \( V_{\text{max.}} > 2000 \ \text{cP} \)

• **Collor** \( b > 30 \)

• **Protein** > 12.5%
4 - Socio-economic aspects
Farmers participation
Using

- Agronomic field data
- VASO experience
- Engage more farmers
  - Some of them where contacted by us, based on the collection mission
  - Others contact us, because they where interested in maize for OF and also to use these landraces for maize bread

Meetings, at 16th April (in Social Farm Institution – APCC)
Socio economic aspects
## Reasons for variety choice

<table>
<thead>
<tr>
<th>Traits</th>
<th>Tomato</th>
<th>Cabbage</th>
<th>Broccoli</th>
<th>Beans</th>
<th>Faba beans</th>
<th>Maize</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Organoleptic features</td>
<td>23</td>
<td>7</td>
<td>5</td>
<td>10</td>
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<td>3</td>
<td>53</td>
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<tr>
<td>Cooking and processing qualities</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>7</td>
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<td>9</td>
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<td>Rusticity</td>
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<td>5</td>
<td>4</td>
<td>7</td>
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<td>Plant morphology and crop architecture</td>
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<td>Speed and length of crop maturation</td>
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<td>5</td>
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<td>5</td>
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<tr>
<td>Suitability as livestock feed</td>
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<td>Resistance to diseases and pests</td>
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<td>1</td>
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<td>0</td>
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<td>Others</td>
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<td>1</td>
<td>3</td>
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<td>13</td>
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<tr>
<td><strong>Total respondents</strong></td>
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<td>21</td>
<td>18</td>
<td>23</td>
<td>18</td>
<td>18</td>
<td>28</td>
</tr>
</tbody>
</table>

Dinis et al, 2011
Pre-breeding, breeding, PPB
Pedro Mendes Moreira
ESAC

FCT (PTDC/AGR-ALI/099285/2008)
«Exploiting antioxidants, flavours and aromas diversity on ‘broa’ bread maize breeding »
http://www.solibam.eu

A new collaborative project on organic and low input breeding and management!!

SOLIBAM will develop specific and novel breeding approaches integrated with management practices to improve the performance, quality, sustainability and stability of crops adapted to organic and low-input systems, in their diversity in Europe and taking into account small-scale farms in Africa.

SOLIBAM will:

1. Identify traits specific for adaptation to low-input/organic conditions over a wide range of agro-climatic conditions in Europe
2. Develop efficient phenotyping, genotyping and molecular tools to monitor heritable variation during selection. Molecular analysis of functional polymorphisms will increase accuracy in breeding methodologies and
3. Improve disease resistance and productivity of crops adapted to organic and low-input conditions in Europe.
Conclusions

- They are (Negri, 2011):
  - widely used in breeding (e.g. pest and disease, **quality traits**)
  - used in developing typical and atypical (niche) products
  - useful in developing new farming systems (e.g. **environmentally friendly, organic, polycrop systems**)
  - promote landscape conservation
  - and maintaining local traditions

See Valeria Negri, presentation
References


• DINIS, I.; BRITES, C.; SANTOS, D.; MENDES-MOREIRA, P. (2011). On-farm seed production practices of organic and low-input farmers in Portugal. 20th meeting of the EUCARPIA Section Genetic Resources. April 5-7, Wageningen, The Netherlands


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