The expression of the apple in its fermented products

Rémi BAUDUIN – IFPC
21/11/2019 3ème Sagardo Forum
Presentation plan

French cider apple
Aroma
Color
Taste
## Short overview of IFPC: main figures

<table>
<thead>
<tr>
<th>Status</th>
<th>Technical Industrial Centre (law 1948) Qualified by MAAF “Agricultural Technical Institute” et “Agro-Industrial Technical Institute”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff</td>
<td>13 employees including 10 permanent people</td>
</tr>
<tr>
<td>Budget</td>
<td>1,4 millions €, 40% self-funding (CVE)</td>
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<tr>
<td>Missions</td>
<td>Elaboration of viable technical references:</td>
</tr>
<tr>
<td></td>
<td>- cognitive research with transfer of skills</td>
</tr>
<tr>
<td></td>
<td>- experiment programs</td>
</tr>
<tr>
<td></td>
<td>Coordination of partnership for common programs</td>
</tr>
<tr>
<td>Network</td>
<td>RMT (for instance Fermented and distilled beverages), GIS fruits, Chamber of Agriculture, cider makers</td>
</tr>
</tbody>
</table>
Short overview of IFPC: 2 localizations

**Station Cidricole - Sées (61)**
- 10 ha orchard organized in 1500 to 6000m² units (plots) – trials before producers validation
- An experimental network of 30 production plots
- A greenhouse de 340m² for cider apple species conservation (virus free)
- Laboratory for simple analyses

**Processing Pilot Plan - Le Rheu (35)**
- Located on INRA site
- Surface of 320m²
- Materiel for cider elaboration at a pilot level and with fermentation rooms (100L à 1L)
- 4 thermostatic rooms
- 2 Laboratory for analyses and microbiology
- Analytical plateau shared with INRA (HPLC, LC-MS, GC, GC-MS, GC-MS-MS, GC-MS-O)
Short overview of IFPC: main axes

**Sustainability and competitiveness**
*Apple cider production and cider production*
- Reducing inputs in production
- Improving health security

**Innovation, valorization & organoleptic qualities improvement**
- Improving organoleptic qualities
- Promote innovation and valorization

**Knowledge management and know-how of cider making**
- Electronic book of knowledge
Short overview of IFPC : Partnership

Recherche

Centres techniques et stations expérimentales

Enseignement supérieur et technique

Développement, associations et syndicats filière

Entreprises

Réseaux

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French cider apples
French cider apples

- A pool of cultivar with high polyphenol content:
  - Bitter (3g/L)
  - Bitter sweet (2 to 3 g/L)
  - Sweet (1 to 2 g/L)

- A pool of cultivar with high acidity:
  - Sharp (> 6 g/L H$_2$SO$_4$)
  - Sour (3 to 4 g/L H$_2$SO$_4$)
French cider apples

- Comparaison with desert apple
Impact on color

Fench cider apple

Color
Color impact: polyphenols in apples

- Native polyphenols:

  Colorless
  - Phenolic acids
  - Procyanidins
  - Catechin
  - Dihydrochalcones

  Colored
  - Flavonols
  - Anthocyanidins

  Apple skin
  Red flesh Apples
Color impact: oxydation of polyphenols

- In the fruit the 3 components are not in contact ... no oxydation

Microscopie tissus de pomme
(extrait de Gregory Glenn and Poovaiah (1987)
Post Harvest Pomology Newsletter,
5(1): 10-19

Polyphenol oxydase
Oxygen
Polyphenols
Cytoplasme
Vacuole
Plastes
Noyau
Paroi
Color impact : oxidation of polyphenols

- The milling/crushing of apple allows the oxidation of polyphenols

![Image of apple](image)

![Diagram](diagram)

© S. Guyot, INRA

Coloration of polyphenols is only one of the consequence of their enzymatic oxidation

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Color impact: varietal potential

- Coloration shift depends on the apple cultivar:
  - Concentration of enzyme (polyphenol oxidase (PPO)),
  - Activity of PPO (pH)
  - Balance between polyphenols chlorogenic acid and polymerized procyanidols

Sharp varieties

Bitter varieties

Bitter-sweet varieties
Color impact: modulation of color shift

- Technology has also a role to play
  - Inerting (CO2/N2)
  - Oxydation trap (SO$_2$, ascorbic acid ....)
  - pH decrease and/or thermal denaturation of PPO

Experimentation with *marie-menard* variety

Experimentation on *guillevic* variety
Color impact: case of red flesh apples

- Well suited for « rosé cider » ?
Color impact : case of red flesh apples

- levers for keeping a red/pink color :

  Few anthocyanes
  Large amount of PPO and chlorogenic acid
  High pH

  High concentration of anthocyanes
  Few amount of PPO and chlorogenic acid
  Low pH

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Apple impact: Taste

- Fench cider apples
- Color
- Taste

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Impact on taste : acidity

• Direct relationship with total acidity

• Large available panel :
  
  • “Super Sharp” (> 8 g/L H$_2$SO$_4$) : Avrolles
  • Sharp (4 to 8 g/L H$_2$SO$_4$) : Judor, Petit Jaune, Locart vert
  • Sour (3 to 4 g/L H$_2$SO$_4$) : Pomme de Moi, Blanchet
  • Sweet : Bedan, Bisquet, Rouge Duret
Impact on taste: bitterness and astringency

- Effect of procyanidins concentration and degree of polymerization (DP)

![Graphs showing the impact of procyanidins concentration and degree of polymerization (DP) on bitterness and astringency.]

- Distribution of DP is different for the apple cultivar

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Impact on taste: varietal potential

• Comparison of ciders (monovarietal) made from 3 different bitter cultivars:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Polyphenols Folin (g/L)</th>
<th>Avg DP of procyanidols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeanne Renard</td>
<td>5,9</td>
<td>4,3</td>
</tr>
<tr>
<td>Kermersien</td>
<td>3,7</td>
<td>5,7</td>
</tr>
<tr>
<td>Marie Menard</td>
<td>3,2</td>
<td>4,8</td>
</tr>
</tbody>
</table>

For the same level of bitterness (normalization) “Jeanne Renard” add the lowest amount of astringency.
Impact on taste: modulation of astringency

- Technology has also a role to play: oxidation of procyanidins and retention on pulp
Impact on taste: modulation of astringency

- Technology has also a role to play: oxidation of procyanidins and retention on pulp

Apple juice rich in high DP procyanidins

Apple juice with less procyanidins and lower DP

⇒ less astringency

Impact on taste: modulation of astringency

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**Impact on taste : effets of macroconstituents**

- **Direct effects and interactions :**

<table>
<thead>
<tr>
<th></th>
<th>SWEETNESS</th>
<th>ACIDITY</th>
<th>BITTERNESS</th>
<th>ASTRING.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar</td>
<td>+ + +</td>
<td>-</td>
<td>- - -</td>
<td>-</td>
</tr>
<tr>
<td>Malic Acid</td>
<td>-</td>
<td>+ + +</td>
<td>-</td>
<td>+ +</td>
</tr>
<tr>
<td>Polyph DP</td>
<td></td>
<td></td>
<td>DP4 - DPS</td>
<td>DP2 &lt; DP4 &lt; DP6 &lt; DP8</td>
</tr>
<tr>
<td>[Polyph]</td>
<td>- -</td>
<td>+</td>
<td>+ + +</td>
<td>+ + +</td>
</tr>
</tbody>
</table>
Aromatic impact

Fench cider apples

Color

Taste

Aroma
Aromatic impact: introduction

- Bipolar, dichotomous Distribution of French Ciders

- Pasteurised
  - Few Polyphenols
  - Sweet; Slightly acids

- Non Pasteurised
  - Rich in Polyphenols
  - Hard Ciders

- Fruity
- Cooked Apple

- Animal-like Aromas
- Evolved Aromas

Le Quéré et al (2006). LWT - Food Science and Technology, 39, 1033-1044

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Aromatic impact: introduction

• Bipolar, dichotomous Distribution of French Ciders

Pasteurised
Few Polyphenols
Sweet; Slightly acids
Fruity
Cooked Apple

Acetic acid Esters (Acetate)
Ethyllic Esters
Phenyl ethanol

Non Pasteurised
Rich in Polyphenols
Hard Ciders
Animal-like Aromas
Evolved Aromas
H2S
Volatile phenols

Le Quéré et al (2006). LWT - Food Science and Technology, 39, 1033-1044

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Aromatic impact: volatiles from fermentation

⇒ Production of phenyl ethanol & phenylethyl acetate

S. uvarum
H. valbiensys

Low YAN
Anaerobic conditions + Keeving

Brettanomyces
Free hydroxycinnamic acids

⇒ Production of volatile phenols
Aromatic impact : work on progress !!

• Hard to find a strong link with varieties
  • Blend of varieties
  • Fermentation with native flora

• Work on progress : volatile compounds from the fruit :
  • Precursors of varietal thiols (some varieties have high concentrations)
  • Terpenes
In conclusion

• Strong organoleptic impact of French apple varieties ...
  ... mainly related to the polyphenols!

• But ....
  • technology and microbiology could also play a significant role
  • climate and orchard cultural practices
Thanks for your Attention

UMT Nova²Cidre (IFPC & INRA BIA PRP)