naturally citrus
orange juice modulation
Orange Juice Modulation

presentation agenda

1. Endangered citrus availability
2. Consumer view: flavor preferences
3. Industry view: rationale for orange juice flavor modulation
4. HLB impact on juice flavor
5. From understanding to solutions
6. A way forward
Citrus Availability & Symrise Reaction

Future supply endangered, volumes shrinking

Citrus Availability 2010
- Fresh fruit market is biggest “competition”, processing = leftovers
- Less juice & nectar consumption: less citrus trees re-planted
- Shift to competing cash crops: sugar cane for ethanol / fuel

continuously declining

Devastating diseases: Citrus Greening (HLB) in USA, Mexico, …
- Climate instability: hurricanes, droughts, flooding, lost harvests
- NFC trend in orange juice: no essence oil & water phase derived

Citrus Availability 2018

Citrus Availability 2025

naturally citrus
- truly sustainable and future-proof citrus taste solutions to create long-term value for money

Key Consequences:
- Shortage / less availability
- Price & quality fluctuation
- Long-term cost increase
Consumer View: flavor preferences
focus on intrinsic factors of OJ liking

- **Taste**
  - Bitter, sweet, sour, sodium, umami, fat...

- **Smell**
  - Orthonasal, retronasal

- **Calorie content**
  - [−]

- **CONSISTENCY**

- **FLAVOR PERCEPTION**

- **Preference**
  - [+] Healthy routine
  - Chemesthesia
    - Warm, cold, pungent, itching, stinging, burning, tingling...
  - Mouth Feel
    - Astringency, richness, fullness...
Industry View: Modulation Rationale

major drivers of juice flavor

balance of different flavor components is vital for good orange juice flavor

Sugars for **sweetness**
sucrose, glucose, fructose

Acids for **tartness**
citric acid, malic acid

Volatile for **aroma**
esters, aldehydes, ketones, alcohols, terpenes etc.

Secondary Metabolites for **bitterness, astringency**
flavones, limonoids, etc.
Industry View: Modulation Rationale

Juice flavor fluctuation is natural but controlled

Provenance
(chosen cultivar, soil, climate, processing)

Weather
(sun, draught, humidity, frost, natural disasters)

Seasonality
(early, mid, late)
Industry View: Modulation Rationale
measures to control juice flavor fluctuations

Measures are limited by
- availability of desired sensory qualities
- storage capacities
- additional costs (incl. cost of bound capital)
- negative sensory impact
- regulatory compliance
- shelf life

special treatment
(debittering, deacidification, enzymes …)

blending of juice qualities along and across two seasons

ONE quality

add-back systems
(FTNF solution)
Industry View: Modulation Rationale
orange juice inventory management

Little late season high-ratio juice overlap =>
little volume to blend with low-ratio early season juice!
Understanding of HLB Impact
construction areas: juice & peel oil

volatile + non-volatile = juice

volatile + non-volatile = peel oil
Impact of HLB on Valencia Orange Juice

major sensory & analytical differences

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HLB</th>
<th>Healthy</th>
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<tbody>
<tr>
<td>Brix</td>
<td>9.88</td>
<td>13.48</td>
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<tr>
<td>% Acid</td>
<td>0.57</td>
<td>0.61</td>
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<tr>
<td>Brix/Acid</td>
<td>17.33</td>
<td>22.26</td>
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<tr>
<td>Limonin [mg/kg]</td>
<td>2.75</td>
<td>0.54</td>
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<tr>
<td>Nomilin [mg/kg]</td>
<td>0.22</td>
<td>0.10</td>
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</tbody>
</table>

comparison

[Flavor profile diagram showing taste & mouth feel and flavor aromatics]
Mitigation of HLB Impact
selective enrichment and masking (non-volatiles)

MASKING
Bitterness
Harshness
Acidity
Off notes

[ - ]

OPTIMIZING
Sweetness
Body
Mouthfeel

PMFs
limonoids
acids
sugar
flavanoid glycosides
ununsaturated aldehydes
limonoid glycosides

[ + ]
Mitigation of HLB Impact
research on HLB flavor masking (non-volatiles)

• Phase 1: Building up a robust sensory test method
• Phase 2: Screening of (natural) molecules with potential taste modifying properties
• Phase 3: In depth research on fractions derived from orange processing streams (FTNF)
Mitigation of HLB Impact
research on HLB flavor masking (non-volatiles)

Test of Single Molecules & Benchmarks

Phase 2. Screening of non-volatile molecules
58 materials tested on HLB juice. List of top five performing candidates

<table>
<thead>
<tr>
<th>#</th>
<th>Material</th>
<th>Sweet</th>
<th>Sour</th>
<th>Bitter</th>
<th>Astringent</th>
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<tbody>
<tr>
<td>1</td>
<td>FD</td>
<td>+0.49</td>
<td>-0.50</td>
<td>-1.05</td>
<td>-0.70</td>
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<tr>
<td>2</td>
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<td>3</td>
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<td>4</td>
<td>SYM B4</td>
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<td>-0.85</td>
<td>-0.22</td>
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<tr>
<td>5</td>
<td>ND</td>
<td>+0.32</td>
<td>-0.27</td>
<td>-0.83</td>
<td>-0.19</td>
</tr>
</tbody>
</table>

- Proof of principle done
- A range of molecules showed significant masking of HLB off-taste
- Already developed FTNF balancing flavors (SYM XX) showed good performance as well

various potent fractions identified and made commercially available
Mitigation of HLB Impact

research on HLB flavor upgrade (volatiles)

Volatiles and HLB decoded

- Lack of esters and (unsaturated) fatty aldehydes compensated
- No formation of specific HLB off-note molecules
- Solid understanding on molecular level about how to balance the overall flavor
- FTNF and natural solutions for mitigation composed
A Way Forward
keeping consumers delighted about orange juice

**Living with HLB**
the disease is not likely to go away soon, so continue fighting its spreading

**GMO? Listen to your global consumers!**
people in the US & overseas will demand transparency

**Great Taste Matters**
even with continuous doubts about its health benefits, orange juice is delicious!

**Flavor compensation**
negative volatile & non-volatile HLB impact can be mitigated to get usage up

**Fruit Juice Matters**
the global campaign starts to get traction but needs more unbiased media penetration

**Regulatory hurdles?**
juice requires recoveries but other drink segments allow more flexibility – use it!

**Sector resilience**
advances in agriculture and processing efficiency must keep orange profitable

**No way around more sustainability**
becoming future-proof is our joint challenge – so let’s go!
refreshingly different

naturally citrus