NIEUWE TRENDS IN SUIKERVERVANGING

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LEAD-UP

2014: 13% of world population = obese

obesity + sedentary life style vs metabolic diseases

governmental agencies vs added sugars

consumer awareness vs sweet sins
RESEARCH OBJECTIVE

Linking the physicochemical properties of bulking agents to the mouthfeel of fat-based suspensions

Reference sweetener = sucrose

Alternative bulking agents

- Isomalt ST ($\alpha$-D-glucopyranosyl-1-6-sorbitol/ $\alpha$-D-glucopyranosyl-1-6-mannitol dihydrate)
- Fructo-oligosaccharides (FOS) : DP 2-8
- Inulin 1 : DP : 2 - 70
- Inulin 2 : DP $\geq$ 32
FAT-BASED SUSPENSION

Delbaere et al. (2017)
MODEL SUSPENSION

~ white compound chocolate

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Conc. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>46.01</td>
</tr>
<tr>
<td>CBS</td>
<td>33.39</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>20.00</td>
</tr>
<tr>
<td>Lecithin</td>
<td>0.60</td>
</tr>
</tbody>
</table>
FAT-BASED SUSPENSIONS

Main quality defects in fat-based suspension following sugar replacement

ADHERENCE = stickiness in mouth

GRITTINESS = perception of particles in mouth
ADHERENCE

~ (apparent) viscosity

Factors influencing suspension viscosity (Servais et al., 2002)
- Particle volume fraction $\phi$
- Particle size distribution PSD
- Particle shape
- Surface roughness
- Wetting properties of suspended particles in continuous phase
- Adsorbed agents on the particle surface
- Aggregation
- Continuous phase viscosity
ADHERENCE

Sugar replacement on mass basis by an alternative with $\neq \rho$

$\neq \phi$

$\neq$ viscosity

Sugar replacement on volume basis

Fig. 1. Relative viscosity vs. solid volume fraction for best multimodal systems (Farris, 1968).
# ADHERENCE

~ suspension viscosity

<table>
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<tr>
<th>Parameter</th>
<th>Sucrose</th>
<th>Isomalt ST</th>
<th>FOS</th>
<th>Inulin 1</th>
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<tbody>
<tr>
<td>$\eta^*$ (Pa.s) @ 50 s$^{-1}$</td>
<td>1,86$^B$</td>
<td>3,92$^C$</td>
<td>1,50$^A$</td>
<td>1,46$^A$</td>
<td>1,66$^B$</td>
</tr>
<tr>
<td>Adherence (0-15) by trained panel</td>
<td>0$^A$</td>
<td>2$^B$</td>
<td>8$^C$</td>
<td>12$^D$</td>
<td>15$^D$</td>
</tr>
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</table>

$R_{\eta^*-adherence} = -0,55$

“The overall sensory perception only becomes obvious when the fat-based suspension liquefies and the dispersed phase interacts with saliva”

(Zumbé et al., 2001)
## ADHERENCE

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**Property of bulking agent in water**

| Solubility (g/100g)                      | 65-70   | 20-25      | 75-80  | 30-35    | insoluble |
| $\eta_{20\%}$ solution (mPa.s)          | 1,43    | 1,52       | 1,57   | 1,65     | -         |

$R_{\eta}$ solution-adherence = 0,96

$\sim$ viscosity of bulking agent in solution
GRITINESS

~ particle size of suspensions

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<tr>
<td>( D_{v,90%} ) (( \mu m ))</td>
<td>33.1(^\text{A})</td>
<td>68.2(^\text{C})</td>
<td>33.8(^\text{A})</td>
<td>40.1(^\text{B})</td>
<td>39.5(^\text{B})</td>
</tr>
<tr>
<td>Grittiness (0-15) by trained panel</td>
<td>0(^\text{A})</td>
<td>3(^\text{B})</td>
<td>7(^\text{C})</td>
<td>6(^\text{D})</td>
<td>8(^\text{D})</td>
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\( R_{D_{v,90\%}-\text{grittiness}} = -0.17 \)

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<tr>
<td>( \Delta D_{v,90%} ) (%) following sonication</td>
<td>-5</td>
<td>-24</td>
<td>-8</td>
<td>-5</td>
<td>-23</td>
</tr>
</tbody>
</table>

High reduction in particle size following sonication is an indication of particle agglomeration (Saputro et al., 2017)
GRITINESS

Sucrose

Isomalt ST

FOS

Inulin 1

Inulin 2
SOLID STATE OF BULKING AGENTS

Crystalline solids

Glassy solids

dehydration

glass transition, incl. enthalpic relaxation

DP ↑ ⇒ T_g ↑
glass transition

Sucrose  Isomalt ST

Fructo-oligosaccharides  Inulin 1  Inulin 2
SOLID STATE OF BULKING AGENTS

**Moisture level**
- crystalline solids < glassy solids

**Particle density**
- crystalline solids > glassy solids

**Particle shape**
- crystalline ~ angular vs glassy ~ spherical

**Fragmentation during refining**
- crystalline
- glassy

Ziegler & Hogg (2009)
GRITTINESS

Sucrose

Isomalt ST

FOS

Inulin 1

Inulin 2
## Grittiness

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<tr>
<td>$D_{v,90%}$ (µm)</td>
<td>33.1&lt;sup&gt;A&lt;/sup&gt;</td>
<td>68.2&lt;sup&gt;C&lt;/sup&gt;</td>
<td>33.8&lt;sup&gt;A&lt;/sup&gt;</td>
<td>40.1&lt;sup&gt;B&lt;/sup&gt;</td>
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<td>7&lt;sup&gt;C&lt;/sup&gt;</td>
<td>6&lt;sup&gt;D&lt;/sup&gt;</td>
<td>8&lt;sup&gt;D&lt;/sup&gt;</td>
</tr>
<tr>
<td>Moisture (g/100g)</td>
<td>0.8&lt;sup&gt;A&lt;/sup&gt;</td>
<td>1.3&lt;sup&gt;B&lt;/sup&gt;</td>
<td>2.0&lt;sup&gt;C&lt;/sup&gt;</td>
<td>2.2&lt;sup&gt;C&lt;/sup&gt;</td>
<td>2.1&lt;sup&gt;C&lt;/sup&gt;</td>
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$R_{\text{moisture-grittiness}} = 0.91$

~ solid state property
CONCLUSIONS

Main quality defects in fat-based suspension following sugar replacement

ADHERENCE = stickiness in mouth
  ➔ Solubility / viscosity in solution

GRITTINESS = perception of particles in mouth
  ➔ Moisture level / solid state
CONCLUSIONS

Ideal sugar replacer for application in fat-based suspensions with respect to mouthfeel

Crystalline
Anhydrous
Moderately to highly soluble in water
Low to moderate viscosity in solution
## VALIDATION

<table>
<thead>
<tr>
<th>Confectionery product</th>
<th>Reference</th>
<th>Sugar-reduced (-30%)</th>
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</thead>
<tbody>
<tr>
<td>Hazelnut spread (liking: 1-9 by consumers)</td>
<td>6.6 ± 1.4&lt;sup&gt;A&lt;/sup&gt;</td>
<td>7.0 ± 1.3&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dark compound coating (liking: 1-9 by consumers)</td>
<td>6.4 ± 1.1&lt;sup&gt;A&lt;/sup&gt;</td>
<td>6.3 ± 1.2&lt;sup&gt;A&lt;/sup&gt;</td>
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