Chemosensory Changes in Obesity and after Metabolic Surgery

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Food preferences and diet choices are fundamentally affected by how food tastes.

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Modified from Aggarwal, Rehm, Monsivais, Drewnowski, Prev Med 2016

Gut-brain nutrient signaling
Chemosensory perception and body weight: is there a link?

Disclosure:

• Psychophysical measurements of human taste function: changes associated with obesity and with weight-loss surgeries

• Review of the literature shows discrepant results: Inappropriate sensory methods?
The psychological attributes of taste

Taste Perception

Quality
- Sweet
- Sour
- Bitter
- Salty
- Umami (Savory)

Intensity
- Barely detectable
- Weak
- Moderate
- Strong
- Very strong

Hedonics
- Like / Dislike

Modified from Breslin & Spector, Current Biology, 2008
Obesity and taste function

Modified from Breslin & Spector, Current Biology, 2008
Taste perception range

- **Detection threshold** (DIFFERENT!) ~8 mM (1/7 tsp in 8 oz)
- **Recognition threshold** (SWEET!) ~35 mM (1/2 tsp in 8 oz)
- ~300 mM (6 tsp in 8 oz)
- ~5,800 mM (saturated solution)

Undetectable: no perception (below-threshold)

Maximal intensity

adapted from Keast & Roper; Chem Senses 2007
Sucrose thresholds do not predict perception of intensity of above threshold concentrations

Webb, Bolhuis, Cicerale, Hayes and Keast, Chemosens Percept. 2015
(Consistent with Bartoshuk, AJCN, 1978; Jayasinghe et al., Nutrients 2017)

Pepino et al., unpublished
Methods

- Using “sip-and spit” technique:
  - Taste sensitivity (glucose, sucrose, NaCl, MSG)
    b. Intensity at above-threshold concentrations general Labeled Magnitude Scale (Bartoshuk et al., Phil Trans R. Soc. B., 2006)
  - Hedonic value of sweetness
    a. Sucrose preferences (Monell tracking technique)
    b. Sweet taste reactivity taste: changes in hedonic value with repeated experience (Pepino and Mennella, Appetite, 2012)

Obesity: Absence of Satiety Aversion to Sucrose
Cabanac & Duclaux, Science 1970
Obesity is not associated with changes in perceived sweetness of sucrose or sucrose preferences.

Pepino et al., Obesity (2010)

P=0.43

Pepino et al., Diabetes (2016)
Compared to lean peers, women with obesity perceive more pleasure when repeatedly tasting sweetness.

**Pepino & Mennella, Appetite, 2012**

**Obesity: Absence of Satiety**

Aversion to Sucrose

“highly sensitive to external stimuli”

“relatively insensitive to internal stimuli”

**Cabanac & Duclaux, Science 1970**
Brain activation to palatable food (and in resting state) in subjects with obesity is different from lean subjects

Somatosensory Areas

Taste Area

Reward Area

“highly sensitive to external stimuli”

“relatively insensitive to internal stimuli”

Wang et al., Neuroreport, 2002

Stice et al., J Abnorm. Psychol. 2008
Summary (1):
Obesity and taste perception

- Pleasure derived from sweetness
- Brain reactivity to calorically dense food pictures/taste
- Motivation to “work” for calorically dense food
- Salivation to repetitive food cues

(*Consistent with: Epstein et al., 1996; Wang et al., 2002; Stice et al., 2008; Epstein et al., 2008; DelParigi et al., 2004)
Bariatric surgery and taste perception

- People lose ~30% body weight, ~60-70% excess body weight and keep it off in the long term (Chang et al., JAMA Surgery, 2014)
Following RYGB and SG, the majority of patients report changes in “taste”.

Makaronidis et al., Appetite, 2016

Pre-clinical data: Sclafani et al., Physiol. & Behav. 1985; Hajnal et al., AJPGLP, 2010; Shin et al., IJO, 2011; Berthoud et al., Ann N Y Acad Sci, 2012; Mathes et al., AJPREG 2015

Olbers et al., Annals of Surg 2006
Studies on RYGB and taste sensitivity

<table>
<thead>
<tr>
<th>Study</th>
<th>Subjects</th>
<th>Methods</th>
<th>Finding</th>
</tr>
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<tbody>
<tr>
<td>Scruggs et al., Obes Surg, 1994</td>
<td>6 before-after RYGB, 10 lean</td>
<td>Taste thresholds</td>
<td>Increased bitter and sour sensitivity after RYGB</td>
</tr>
<tr>
<td>Burge et al., J Am Diet Assoc, 1995</td>
<td>14 before - after RYGB, 4 in very-low-calorie diets</td>
<td>Taste thresholds</td>
<td>Increased sweet sensitivity after RYGB</td>
</tr>
<tr>
<td>Bueter et al., Physiol Behav, 2011</td>
<td>9 before-after RYGB, 9 lean</td>
<td>Taste thresholds</td>
<td>Increased sweet sensitivity after RYGB</td>
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## Studies on SG and taste sensitivity

<table>
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<th>Study</th>
<th>Subjects</th>
<th>Methods</th>
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<tr>
<td>El Labban et al., Nutrition, 2016</td>
<td>9 RYGB; 12 SG (post surgery)</td>
<td>Detection thresholds</td>
<td>~ sweetness, saltines, bitterness sensitivity (sourness &lt; in RYGB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sucrose acceptability</td>
<td>~ sucrose acceptability</td>
</tr>
<tr>
<td>Altun et al., Ann Otol, Rhin &amp; Laryng., 2016</td>
<td>52 SG (pre-, 1m &amp; 3 m post- surgery)</td>
<td>Taste strip test</td>
<td>Improvement in taste acuity</td>
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Study Design

20-70 year old scheduled to undergo bariatric surgery

Taste Test + Eating Behavior (3 separate visits)

Individual supervised weight management program (20% weight loss)

6 to 12 months

Taste Test + Eating Behavior (3 separate visits)

Nance et al., Nutrients, 2017

Pepino et al., Obesity, 2014
Taste detection thresholds: unchanged

Pepino et al., Obesity, 2014

Before surgery (LAGB + RYGB)

After surgery (LAGB + RYGB)

<table>
<thead>
<tr>
<th>Substance</th>
<th>Before Surgery</th>
<th>After Surgery</th>
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</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>(32.0 mM)</td>
<td>(29.0 mM)</td>
</tr>
<tr>
<td>Sucrose</td>
<td>(8.9 mM)</td>
<td>(7.9 mM)</td>
</tr>
<tr>
<td>NaCl</td>
<td>(2.6 mM)</td>
<td>(2.1 mM)</td>
</tr>
<tr>
<td>MSG</td>
<td>(1.6 mM)</td>
<td>(1.2 mM)</td>
</tr>
</tbody>
</table>

Nance et al., Nutrients, 2017
Taste intensity remained unchanged

- **Sweetness**
  - Sucrose (mM)
  - Glucose (mM)

- **Saltiness**
  - NaCl (mM)

- **Savoriness**
  - MSG (mM)

*Before surgery (LAGB + RYGB)*

*After surgery (LAGB + RYGB)*

Pepino et al., Obesity, 2014; Nance et al., Nutrients, 2017; Consistent with Hubert et al., Nutrients, 2019
Sweet taste pleasantness decreased after both SG and RYGB but not after LAGB

Pepino et al., Obesity, 2014
Nance et al., Nutrients, 2017
Summary (II): Metabolic surgery and taste perception

Taste Perception

Quality

Intensity

Hedonics

"Affective component"

Pleasure derived from sweetness
Brain reactivity to pictures of calorically dense food
Motivation to “work” for calorically dense food

"Sensory-discriminatory component"

*Consistent with: Ochner et al., Ann Surg, 2011; Miras et al., AMJCN, 2012; Scholtz et al., Gut, 2013; Goldstone et al., JCEM, 2016; Hubert et al., Nutrients 2019*
Future studies

• Patients report dramatic changes in “taste” perception: changes in “flavor” perception? Retronasal smell? Texture? Fat sensory perception?

• Do the observed changes in the affective component of sweetness last beyond the first-year post surgery? Can this sweetness response explain variation in weight-loss/regain trajectories?

• **Potential mechanisms?**
  
  Changes in gut-brain nutrient signaling
Potential mechanisms

- **Enhanced conditioned satiety?** (Asarian and Geary, Appetite 2019)
- **Condition avoidance?** (Mathes et al., AJPR 2015)

Bradley et al., Obesity, 2014
Potential mechanisms (II)

- Decreased “appetition”? Preclinical data suggest the gastrointestinal rerouting plays a critical role for sugar-induced dopamine release in dorsal striatum (Han et al., Cell Metabolism, 2016)

“It intestinal sugar sensing has an appetite-stimulating action that enhances preferences for sweets” (Sclafani, Cell Metab. 2016)
The dark side of metabolic surgeries

- 2-fold increase in likelihood to develop an alcohol use disorder (AUD) after RYGB compared to banding procedures (King et al., 2012, JAMA; Ostlund et al., JAMA Surg, 2013, King et al., SOARD 2017).

SG and RYGB convert 2 drinks to ~4

Pepino et al., JAMA Surgery, 2015; Acevedo et al., SOARD, 2018
Thanks

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