**Talk Overview**

1. Sweet Taste perception to preference

2. Sweetness in the Diet: evidence from ITT5 on infant and child sugar intakes (US and Mexico)

3. Differences in Sweetness perception, diet and T2D risk

4. Non-nutritive Sweetness and implications for energy balance (with some future focus from CNRC)

5. Beyond palatability: How sensory properties can help regulate energy intake

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**Sweet Taste Detection and Preference**
Sweet Taste Preference

**Sweetness / Sugars:**
- Improves the sensory properties of virtually every food if added to
- Improves other positive attributes including texture, thickness, body, mouthfeel, fullness, overall balance
- Food preservative / indicates safety
- Blocks or masks non-preferred flavors
- Dietary learning – through postingestive reinforcement
- Preferences: Within hours of birth, infants exhibit a strong preference for sweet tastes

Sweeteners:
- **Saccharin**: Artificial sweetener
- **Aspartame**: Artificial sweetener
- **Mannitol**: Natural sugar alcohol

![Sweet Taste Preference](Image)

Rosenstein and Oster, 1988

Hedonics of Sweetness – Adults vs. Children

- **Children like higher concentrations of sugar than adults** (DeGraaf & Zandstra 1999)
- **Heightened preference persists into adolescence** (Mennella et al 2011, 2014)
- **0.54mol/L sucrose: 11 tsp (44g) sugar**
  - Twice the sugar of a typical Coke!!
- **Children’s biological predisposition to liking higher sweetness makes them vulnerable to a modern food environment rich in sugar**


Sweets are more soothing for a child than for an adult

Sweet things are often used to soothe an upset child

This could lead to associations between using sweet things to soothe distress (Birch & Doub 2014)


Sweetness Detection: Acceptance/intake of Fruits & Veg.

Children with moderate SDT consumed more non-astringent fruit than children with low or high SDT

Children most sensitive to sweet taste eat fewer cruciferous vegetables than children with lower sensitivity

(Fogel & Blissett, 2014)
Does Sweetness Satiate to the same extent as Savoury?


No difference in intake
No difference in subjective fullness and hunger ratings

Early preference and liking for sweet things – but what about sweetness in the diet?

Nestlé FITS 2008 Sample Sizes by Age

- Dietary interviews completed for 3,274 infants, toddlers, and preschoolers from birth to 4 years:
  - 0 to 5 months: 382 younger infants
  - 6 to 11 months: 505 older infants
  - 12 to 23 months: 925 toddlers
  - 24 to 35 months: 737 preschoolers
  - 36 to 47 months: 725 preschoolers

- Nationally representative

- One day with 2nd day for 25% (data here is from one day intake)

Sweetness in Children's Diets


Dr. Kathleen Reidy, Dr. Denise Deming in - FASEB April, (2014)
Total Calorie intake increases by 600kcal between 6mths - 4 yrs

Dr. Kathleen Reidy, in FASEB April, (2014)

Over 70% of toddlers and 80% of preschoolers are consuming ‘any type of sweet’ during the day


Sweets Enter the Diet Early & Escalate Rapidly by 4 years

- A sharper rise in sweets in Mexico, but ~90% consuming in both countries by age 2.
- Sweetened beverages drive the increase, especially in Mexico - 78% by age 2 vs. 46% in USA.

Sweet Perception, Intake & T2D In Asia

Is sensitivity to Sweetness reflected in dietary intake?

The Association between Perceived Sweetness Intensity and Dietary Intake in Young Adults

Sara Cicereale, Lynnette J. Forde, and Russell S.J. Keast

Abstract: Individual differences in taste perception may influence dietary habits, nutritional status, and ultimately nutrition-related chronic disease risk. Individual differences in sweetness intensity perception and the relationship between perceived sweetness intensity, food behavior, and dietary intake was investigated in 150 adults. Subjects (age 15-35, BMI 21-35) completed a food and diet questionnaire, food variety survey, 24-h food records, and a

- Perceived sweetness intensity of a sucrose solution did not predict sweet food consumption or dietary sugar intake of young adults
- Although taste is an important consideration with regards to dietary choice, perceived sweetness intensity alone does not have a significant influence on food behavior and dietary intake

Is sensitivity to Sweetness reflected in dietary intake?

Maher and Duizer 2007

- People who frequently consume sweet things (LNCS and Natural sugars) – tend to show a preference for sweeter beverages when tested in the laboratory
- This is the same across sugars and non-nutritive sweeteners

Sweet Taste Perception Among Chinese Males & Females

Aim: Compare dietary & body composition as a function Sweet Intensity & Preference

<table>
<thead>
<tr>
<th>Measure</th>
<th>Chinese (N=100)</th>
<th>BMI &lt; 23 (n=71)</th>
<th>BMI ≥ 23 (n=29)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity</td>
<td>Mean</td>
<td>4.81</td>
<td>4.83</td>
<td>0.95</td>
</tr>
<tr>
<td>Preference</td>
<td>Mean</td>
<td>4.43</td>
<td>5.03</td>
<td>0.02*</td>
</tr>
</tbody>
</table>

Overall: There is little relationship between taste intensities and preferences of sucrose, with dietary intake and dietary patterns.

Sweet Perception Between Chinese and Indians

Conclusions:
- Indians had significantly higher sweetness recognition threshold compared to the Chinese
- This was not reflected in the dietary intakes of total or added sugars in the current data


2. Korean values from The relationship between PTC taster status and taste thresholds in young adults (Hong, et al., 2005).

Cross-Cultural Susceptibility to Diabetes

Chiu et al 2011 Diabetes Care

Rate of diabetes (%)

BMI

24 25 26 30

South Asian
Chinese
African American
Caucasians

Post-Prandial Responses to Glucose in Chinese, Indian & Caucasians

Insulenic and glycaemic responses are higher in Indians and Chinese compared to Caucasians

Between Indians have an even weaker response than Chinese

Combine higher Sweetness thresholds with higher sugar/CHO intakes = ‘Diabetes’

What if there was a way to have the sweetness without a strong caloric or glycaemic effect?

Dickinson et al 2002
J Nutr. 132:2574-79
Low Calorie and No-Calorie ‘Sweetness’

Dissociating Sweetness from Energy

Concerns about Consumption of LCNS / NNS:

- Interrupts normal learned associations & may undermine the usefulness of sweetness in the control of energy balance (Pepino 2015)

- Interferes with physiology of energy homeostasis

- Weaker CPR / reduced thermic effect (Blundell & Hill)

- Potential ‘appetitive’ effect of NNS (Swithers 2013)


Rats that had the saccharin-sweetened yogurt consumed more calories, put on more weight, gained more body fat, & did not cut back on their calorie consumption in the longer term

"Need for more vigilance of where the calories are coming from in case you overcompensate for those calories later"

Systematic Review; Rogers, P.J. et al (2015) IJO

- Animal Studies (N=90):
  - (N=90), 62/90 animal studies - exposure to LES did not affect or decreased BW.

- Prospective cohort studies in humans (N=12):
  - (N=12) showed no consistent associations between LES use and BMI

- Short RCTs in Humans (N=129)
  - Reduced total EI for LES vs. sugar-sweetened food or beverage consumption before an ad libitum meal (-94 kcal, 39 95%CI -122 to -66), no difference versus water (-2 kcal, 95%CI -30 to 26) – no compensation

- Sustained Intervention RCTs (N=10)
  - (N=10). Meta-analysis of RCTs (4wks - 40 mnth) LES vs. sugar led to reduced BW (-1.35 kg, 95%CI –2.28 to -0.42).

“The balance of evidence indicates that use of LES in place of sugar, in children & adults, leads to reduced EI & BW & possibly also when compared to water.”

Perceptual Differences: Artificial & Natural Sweetness

Orange Juice

<table>
<thead>
<tr>
<th>Sweetener</th>
<th>Sweetening power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>1</td>
</tr>
<tr>
<td>Acesulfam-K</td>
<td>100-200</td>
</tr>
<tr>
<td>Aspartame</td>
<td>100-200</td>
</tr>
<tr>
<td>Cyclamates</td>
<td>25-30</td>
</tr>
<tr>
<td>Saccharin</td>
<td>300-400</td>
</tr>
<tr>
<td>Sucralose</td>
<td>600</td>
</tr>
<tr>
<td>Thaumatin</td>
<td>2500</td>
</tr>
<tr>
<td>Neotame</td>
<td>7000-13000</td>
</tr>
</tbody>
</table>

from Bellisle & Drewnowski 2007

Do LCS or NNS – influence Energy intake?


Natural & Artificial Sweeteners: Impact on Energy Intake & Glycaemia

Anton et al 2010, Appetite

Do LCS or NNS – influence Body weight?


Natural Non-Nutritive Sweeteners: Impact of Sweeteners on Energy Intake and Glycaemia

<table>
<thead>
<tr>
<th>Name (Year FDA Approved)</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stevia (2008) (steviol glycosides, rebaudioside A, stevioside)</td>
<td>Extracted from the leaves of the Stevia rebaudiana Bertoni plant, South America</td>
</tr>
<tr>
<td>Truvia, PureVia, Sweet Leaf</td>
<td>200 – 300 times sweeter than sucrose</td>
</tr>
<tr>
<td>Luo Han Guo (2009) (cucurbitane glycosides, mogroside II, III, IV, V, VI)</td>
<td>Extracted from monk fruit, China</td>
</tr>
<tr>
<td>LuoSweet TM, Magou-V TM</td>
<td>150 – 300 times sweeter than sucrose</td>
</tr>
</tbody>
</table>

- Estimated daily intake: 1.3 – 3.4 mg/kg body weight
- Estimated daily intake: Not determined
- Estimated daily intake: 6.8 mg/kg body weight

*CGMS Study 1

Lau Han Guo (Monk fruit) Stevia Aspartame Sucrose

Liquid Solid

Study 2
A role for ‘Sweetness’ Beyond Palatability?

Could perceived sweet intensity be used to moderate food intake beyond its impact on palatability?

Sensory Enhanced Satiation

- The sensory properties of a food or beverage inform far more than likes/dislikes — **Portion size, Eating Rate, Nutrient density, Prospective consumption, Learning**
- Sensory quality and intensity can be used to signal calorie arrival based on learned associations — while successfully concealing the a judicious reduction in total calories

Independent effect of Taste Intensity on Food Intake

- Participants consumed most of their preferred salt concentration (IS)
- But between the similarly liked low and high intensity soups, participants consumed the least of the more taste intense version

Conclusions

- **Sweetness perception and preference plays an important role in food choice, energy intake regulation and habitual dietary behaviours**
- Early introduction of sweetness is a significant risk factor for weight gain and may be particularly problematic among Asian populations with a predisposition to T2D
- LCS and NNS — provide an opportunity to maintain sweetness levels while reducing calorie’s
- ‘Beyond Liking’ — Sensory quality and intensity should be considered for the impact they have on energy intake and dietary learning
Thank You

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The Sensory Ingestive Behaviour Team