Sweetness and diet quality

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Sigrid Gibson: Disclosures

(past 3 years)

Research funding:

Honoraria/ travel
International Sweeteners Association, PepsiCo, UNESDA
Review

Public Health England
Sugar Reduction: The evidence for action
Literature Review in 2015 (Annex 5)

- There is evidence for an innate preference for sweet taste, but not that this is addictive.

- Further research is required to determine whether taste preferences or food choices would change in response to a gradual reduction in sweetness/sugar content, as seen in salt.
Sweetness could affect diet quality 2 ways:

1. If sweet-tasting diets were nutrient-poor

2. If appetite/preference for sweetness drove consumption towards less nutritious foods
Sweetness and diet quality

1. Are sweet diets poor in nutrients?

2. Is sweetness (without calories) associated with poorer dietary choices or a lower diet quality?

3. What is the effect of reducing or maintaining sweetness on food choice and consumption?

4. Research needs
What do we mean by Diet Quality?

- “good vs. bad foods”?
- macronutrient composition
- micronutrient density
- % of RDA

Composite indices eg.
- NQI
- RRR
- NNR
- MAR
- DDS

Many defined relative to energy content
Nutrient Density Scores of Selected Fruits, Vegetables, Snacks and Convenience Foods

Watercress
Chinese cabbage
Spinach
Leaf lettuce
Kale
Red pepper
Broccoli
Cauliflower
Strawberry
Orange
Pepperoni pizza
Cheeseburger
Potato chips
Strawberry Thickshake
Blueberry muffin
Muesli Bar
Chocolate Cake
Oreos
Kit Kat
Jelly beans
1. Are sweet diets poor in nutrients?

Sugars are the major source of sweetness- hence most data relate to high-sugar diets

- Diets high in added sugars/free sugars have lower nutrient density (mg/MJ) (Louie & Tapsell, 2016); (Gibson et al. 2016)
- They score lower on diet quality (Lluch et al. 2017)

**BUT**

- associations are relatively weak, vary by nutrient and may be non-linear
- not seen for total sugars, suggesting sweetness *per se* is not main cause
- intrinsic sugars are positively associated with diet quality (Kaartinen et al., 2017)
Is there a sweet dietary pattern?

- No single sweet pattern - different foods have different associations (*Gazan 2016*).

Food choices are the key

- breakfast cereals, yogurt, smoothies
  - vs... biscuits, ice-cream, soft drinks.

Food choices determine intake of all nutrients, including sugar...
2. Is sweetness (without calories) associated with poorer dietary choices or a lower diet quality? (Observational studies)

LCS users tend to have more health-conscious behaviours and better scores on Healthy Eating Index than non-users (Drewnowki & Rehm, 2014).
Consumption of Low-Calorie Sweeteners among U.S. Adults Is Associated with Higher Healthy Eating Index (HEI 2005) Scores and More Physical Activity

Adam Drewnowski * and Colin D. Rehm
Consumption of low calorie beverages is associated with energy and nutrient intakes and diet quality

- UK data (NDNS 2008-2011)
- Detailed 4-day dietary records
- 1590 adolescents (16+) and adults
- Classified into one of four groups

<table>
<thead>
<tr>
<th>NO SOFT DRINKS</th>
<th>SSB only (250ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCB only (250ml)</td>
<td>Both LCB and SSB (500 ml)</td>
</tr>
</tbody>
</table>

**LCB consumers** had lowest sugar intakes

Gibson, Horgan et al. (2016), *Nutrients*

*No difference in sugar intake between LCB and NC*
### NC and LCB groups consumed more fruit and vegetables and fish than SSB consumers,

<table>
<thead>
<tr>
<th>Beverages group</th>
<th>mean consumption (g/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no soft drinks (NC)</td>
</tr>
<tr>
<td>NC and LCB groups consumed more fruit and vegetables and fish than SSB consumers,</td>
<td>598</td>
</tr>
<tr>
<td>Meat And Meat Products</td>
<td>167</td>
</tr>
<tr>
<td>Fish</td>
<td>46</td>
</tr>
<tr>
<td>Fruit</td>
<td>110</td>
</tr>
<tr>
<td>Vegetables</td>
<td>147</td>
</tr>
<tr>
<td>Sugary foods:</td>
<td>73</td>
</tr>
<tr>
<td>Puddings and ice cream</td>
<td>21</td>
</tr>
<tr>
<td>Biscuits and cakes</td>
<td>34</td>
</tr>
<tr>
<td>Confectionery, sugar, jam</td>
<td>18</td>
</tr>
</tbody>
</table>
Diet soda drinkers more likely to binge on junk food: study

Just because it's diet doesn't mean it's good for you.

New York Daily News

‘Diet soda is a gateway drug’.
Drinkers of the no-calorie beverages are more likely to gorge on sugary, salty and fatty treats like cookies, French fries and pastries than people who drink regular soda, says a new study from the University of Illinois.

NHANES within-person day 1 vs day 2
Beverage consumption in relation to discretionary food intake and diet quality among US adults 2003 to 2012 (An Ruopeng, 2015 JADA)

• Diet-beverage consumption was associated with +69 kcal. 49 kcal of this was discretionary (high sugar/fat)
  
- 30 kcal for SSB consumers
- 60 kcal for coffee consumers

Beverages are commonly paired with foods
Beverage consumption in relation to discretionary food intake and diet quality among US adults 2003 to 2012

Increase in total daily calorie intake by beverage type:
- Alcohol: 384 k calories
- Sugar Sweetened Beverages: 226 k calories
- Coffee: 108 k calories
- Diet Beverages: 69 k calories
- Tea: 64 k calories

NO CHANGE IN HEALTHY EATING SCORE WITH DIET BEVERAGES
2. Conclusions from observational studies on sweetness without calories (via NNS/LCS)

- Use of LCS/LCB is a component of common weight control strategies that may include healthier food choices.

- In most studies LCB consumption is not associated with higher consumption of sugary foods
  - Study weaknesses- comparator, measurement, correlation, selective reporting.

- These studies cannot tell us about causality or mechanisms
3. What is the effect of reducing or maintaining sweetness on food choice and consumption? (RCTs)

- Maintaining sweetness (via LCS)
- Reducing sweetness via sugar reduction
- Reducing sweetness by sugar replacement with starch/fat/protein
Maintaining sweetness in the CHOICE trial

Does LCB intake affect dietary consumption patterns?
Piernas, Tate et al. 2013

• Subjects were all regular consumers of caloric beverages, who swapped them for either LCB or water for 6m

• Both intervention groups showed beneficial changes in energy and sugar intakes and dietary patterns.

• LCB group reduced desserts more than the water group

• Maintaining sweetness by using LCBs, compared with water, did not increase preferences for sweet foods and beverages

## CHOICE TRIAL

Diet beverage (DB) and Water groups achieved similar reductions in energy and sugar intake but DB group reduced desserts *more* than the Water group.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Change 0-6m</th>
<th>Change from baseline</th>
<th>Difference between water and LCB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total energy intake (kcal)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>-539</td>
<td>***</td>
<td>ns</td>
</tr>
<tr>
<td>DB</td>
<td>-682</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td><strong>Energy from beverages (kcal)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>-200</td>
<td>***</td>
<td>ns</td>
</tr>
<tr>
<td>DB</td>
<td>-256</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td><strong>Added sugar (kcal)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>-158</td>
<td>***</td>
<td>ns</td>
</tr>
<tr>
<td>DB</td>
<td>-198</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td><strong>Desserts (kcal)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>-38</td>
<td>ns</td>
<td>0.007</td>
</tr>
<tr>
<td>DB</td>
<td>-157</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td><strong>Fruit &amp; vegetables (kcal)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>+26</td>
<td>*</td>
<td>ns</td>
</tr>
<tr>
<td>DB</td>
<td>-16</td>
<td>ns</td>
<td></td>
</tr>
</tbody>
</table>

*Piernas et al. 2013 Ajcn*
Peters et al. 2014

The effects of water and non-nutritive sweetened beverages on weight loss during a 12-week weight loss treatment program

AIM: To test efficacy of non-nutritive sweetened beverages (NNS) vs. water for weight loss

METHOD
• N=303. All consumers of NNS
• 12-week behavioral weight loss program

RESULTS
• No food choice data
• Hunger declined in NNS beverage group but increased in the water group
• (Weight loss results suggest that NNS consumption did not increase energy intake from other foods compared to water, consistent with other studies)

Dietary quality changes in response to a sugar-sweetened beverage–reduction intervention: results from the Talking Health randomized controlled clinical trial

Valisa E Hedrick,* Brenda M Davy, Wen You, Kathleen J Porter, Paul A Estabrooks, and Jamie M Zoellner  AJCN March 2017

- Talking Health study
- 6-m, community-based RCT
- SSB reduction or physical activity
- educational classes + calls
- All consumers of >200kcal SSB (incl. juice drinks, sweet tea and coffee
- mean BMI=33, 80% female
- Sipsmart (n149) aim to limit SSB to 250ml
- Movemore (143) aim to increase PA to 150min/wk

Results (change from baseline, between groups)

- Sipsmart gp reduced SSB & sweet coffee
- Had greater increase in HEI score: 42.3 to 45 (P<0.01)
- Had greater Increase in vegetables and whole grains
- Lower empty calories score

<table>
<thead>
<tr>
<th></th>
<th>SIPSMART</th>
<th>PA</th>
<th>P group*time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added sugar</td>
<td>-5.2%</td>
<td>-1%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EI kcal</td>
<td>-285</td>
<td>-44</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Regular Soft drinks</td>
<td>-165</td>
<td>0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>LCB</td>
<td>+57</td>
<td>-30</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Sweet tea and coffee</td>
<td>-183</td>
<td>-66</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>
Wise et al. 2016
Reduced dietary intake of simple sugars alters perceived sweet taste intensity but not perceived pleasantness

- Hypotheses: eating less sugar will
  - cause foods and drinks with a given amount of sugar to taste sweeter
  - cause people to prefer lower levels of sugar in foods and drinks

- Methods
  - 5-month study (baseline 1m → 3m diet → free choice 1m)
  - 40% reduction in sugar (told to replace with fat/protein/starch) vs. controls on usual diet
  - Monthly rating of sweetness in vanilla puddings and raspberry soft drink
  - Monthly 7d food record and PA
  - By month 3, the low-sugar subjects rated both low and high concentrations in puddings as ~40% sweeter than did the control group
  - A weaker effect on rated sweetness was obtained for beverages.
  - Rated pleasantness was not affected for either of the stimuli.

Overall, lowering whole diet intake of simple sugars would appear to increase the perceived sweetness of sweet foods, and to a lesser degree, sweet beverages. However this does not appear to change the hedonistic aspects.

3. What is the effect of reducing or maintaining sweetness on food choice and consumption? (RCTs)

- **Maintaining** sweetness (via LCS) helps compliance and does not induce compensatory eating of sweet foods (Piernas/CHOICE 2013; Bellisle, 2015)

- **Reducing sweetness via sugar** (sweet beverage intake) increased diet quality (Hedrick et al. 2017)

- **Reducing sweetness by sugar replacement** (isocaloric) may not reduce preference for sweetness even if it increases sensitivity (Wise et al., 2016)

- However, more long-term studies are needed of changes in dietary patterns after manipulating sweetness levels.

  - SWITCH trial is underway (2016-2018) (Jason Halford, Univ of Liverpool) (Effects of Non-nutritive sweetened beverages on appetite during active weight loss) 100 weeks
Ongoing trial: SWITCH

EffectS of Non-nutritive sWeetened Beverages on appetITe During aCtive weigHt Loss (SWITCH)

Jason Halford 2016-2018 University of Liverpool

• 432 participants, parallel randomized design
• NNS beverages or water (control) (660ml/d)
• 12 week period of weight-loss
• 40 weeks weight-maintenance (supervised) +52weeks
• Body weight and composition
• Appetitive behaviours
• Energy intake and food choices (3d diet diary x4)
SWITCH methodology

U. Masic et al. / Contemporary Clinical Trials 53 (2017) 80-88

Participant Screening
BMI and associated questions for inclusion

Randomization
(N = 432)

Subset 1 – Probe Day Participant Recruitment
(N = 116) 15 sessions in total

Subset 2 – DXA Scan Participant Recruitment
(N = 50) 4 sessions in total

NNS Beverage Group
(N = 216)
Consume at least 2 NNS beverages/day (660ml)
108 = naive to NNS
108 = regular NNS consumers

Water Beverage Group
(N = 216)
Consume at least 2 water beverages/day (660ml)
108 = naive to NNS
108 = regular NNS consumers

Baseline Assessments
Including questionnaires and blood draws

Exercise Armbands
Mid- and end-WLP periods

12 Week Weight Loss Programme (WLP)
Weekly sessions in groups with a dietician trained researcher

Post WLP Assessments
Including questionnaires and blood draws

Exercise Armbands
Last week of WMP periods

40 Week Weight Maintenance Phase (WMP)
Monthly sessions in groups with a dietician trained researcher

Subset 1 – Probe Day Sessions
3 sessions

Subset 2 – DXA Scan Session
Part of Baseline Assessment Session

Subset 1 – Probe Day Sessions
3 sessions at the start of WLP
3 sessions at the end of WLP

Subset 2 – DXA Scan Session
Part of Post WLP Assessment Session

Subset 1 – Probe Day Sessions
3 sessions at the end of WMP
Conclusions

Sweetness could affect diet quality 2 ways:

1. If sweet diets were necessarily nutrient-poor (compositional effect)
   - Sugar-Sweet diets may have lower nutrient density depending on types of food selected.
   - LCS in diets may improve diet quality by replacing sugars

2. If appetite/preference for sweetness drove consumption towards less nutritious foods (behavioural effect)
   - Not proven – rather maintaining sweetness with LCS may increase compliance with a healthy diet (in motivated adults liking sweetness)
   - But - sweetness has hedonic appeal, and might make low nutrient quality foods more appealing?
Research needs

• Further studies are needed into long-term effects of unsweetened vs. LCS-sweetened diets, and on low sugar vs. usual diets on food choices in real life.

• Do effects of diet quality vary according to
  • Level of sweetness reduction?
  • Vehicle for sweetness?
  • Age and sex of subjects? BMI? Emotional eating?
Research needs:

- Effects on longer-term changes (3m) in food preference and selection with low sugar diets (sweet vs. unsweetened).
- Measure consumption behaviours in detail (food choice, amount, frequency & context).
- Does reducing/maintaining sweetness (low sugar diet +/- LCS) change sensitivity and preference for sweet and/or other tastes (fatty, salt, sour, bitter)?
- How do the hedonics relate to actual consumption?

Considerations

- Control composition but ad lib amount? Or advice-based free choice?
- 3 conditions: Low sugar LCS/low sugar unsweetened/ usual diet.
- Studies in men, women, adults, children, & by BMI and dietary habit (LCS use).
- Ideally, cross-over studies
- In which foods/drinks?
- Additional mechanistic studies
Effects of reducing sugar and/or sweetness (2 x 2-way study)

- Design - RCT 6m+
- Gp 1. Crossover A & B (sweetness)
- Gp 2. Crossover B & C (sugar)
- Random start order
- 3m each diet

- Adults, teens & children?

A. 5% FS (45% starch)
B. 5% FS +NNS + 45% starch
C. 15% FS 35% starch

- Match for fibre, energy
- Ad-lib

Outcomes (at base, week 1, 3m, 6m, week 28)
- EI, macronutrients
- Food consumption
- Sensitivity
- Preferences
- Biomarkers
- Weight
Thank you for your attention

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