**Consumption of Honey, Sucrose, and High Fructose Corn Syrup produces similar metabolic effect in Glucose Tolerant and Intolerant Individuals**

**Introduction**
How do three different disaccharides affect blood glucose, insulin, triglycerides, cholesterol, and inflammatory markers in healthy and pre-diabetic individuals?

**Methods**
- Randomized cross over design
 - Consumed normal diet minus added table sugar or other sweetened beverages
 - Consumed either 50 grams of honey, or sucrose, or high fructose corn syrup
 - Consumed treatment diet (normal diet + 50g of sugar) for 2 weeks, then just normal diet for 2 weeks (wash out), then switched to next sugar for 2 weeks, then normal diet only, then final consumption with normal diet + final sugar type.
 - Measures were taken at baseline (before intervention), and then again after the intervention ended (2 weeks later, for each).
- 55 participants, mainly women, 20 – 80 years old.
 - 28 healthy participants, 27 pre-diabetic participants
- Educated by a dietitian, and consumption was calculated based on self recording food intake.
- Measures were blood, anthropometric, and questionnaire.

**Results**

*Table 1*This shows the composition of each sugar used for the intervention.
- Honey: 36% Glucose, 41% Fructose, % Other
- Sucrose: 50% Glucose, 50% Fructose
- HFCS: 55% Glucose, 41% Fructose, % Other

*Table 2*
This shows the baseline (pre-study) differences and similarities between healthy (glucose tolerant) and pre-diabetic individuals (impaired glucose tolerance) individuals.
- Age was significantly higher in glucose intolerant.
- Weight was higher in in glucose intolerant.
- BMI was higher in glucose intolerant.
- Blood glucose levels were higher in glucose intolerant (a pre-requisite, obviously).
- Blood insulin levels were higher in glucose intolerant.
- Blood C-Reactive Protein & IL-6 (inflammatory markers) were higher in glucose intolerant.
- Cholesterol was higher in glucose intolerant.
- Sugar intake was not different between groups.

Take away: There are substantial, confounding differences between the two groups, making between group comparisons difficult, at best.
*Figure 1*
This shows the screening process for choosing participants and how they ended up at 55.

*Table 3*This shows a number of things, the differences between: Pre-study (baseline) vs Post-intervention (sugar) values [Phase], their glucose regulation status (Glucose Tolerant/GT vs Glucose Intolerant/IGT) [Status], Sweetener they were on (honey, sucrose, HFCS) [Sweetener], and their glucose tolerance compared against the sweetener.

- All sugars increased insulin (likely, because adding more sugar to the diet, so of course, more insulin is needed to shuttle that added blood glucose)
- Diastolic blood pressure decreases with HFCS in healthy group.
- Greater inflammation markers with intolerant group with HFCS and sucrose (most likely – tough to tease out).
- No increase in cholesterol with HFCS or honey in healthy, but do see rise in sucrose.
- Triglycerides increase with honey, but decrease with HFCS in healthy.

Take away: We are more interested in the “within-group” comparisons, because each person will act as their own comparison without confounding variables like weight differences throwing off the results between groups. Nothing shows HFCS is unhealthy for healthy individuals.

*Figure 2*
A & B
Here, they are showing glucose level control when injecting a set amount of glucose (Glucose tolerance test) into the body for healthy at baseline (A) vs after 2 weeks of sugar consumption (B).
- No difference, whatsoever, for any of the sugar types.

C & D
Here, same story as A & B, but in pre-diabetic/intolerant group.
- Again, no difference between baseline vs 2 weeks of sugar consumption.

Take away: Blood glucose regulation is unaffected by any of the three sugars.

Figure 3
A & B
Here, same as Figure 2, but looking at insulin levels as opposed to glucose levels.
- No significant difference between baseline vs 2 weeks sugar consumption

C & D
Same as A & B, looking at insulin, but in pre-diabetic/intolerant individuals.
- No significant difference between baseline vs 2 weeks sugar consumption

Take away: Blood insulin levels are unaffected by any of the three sugars.

**Conclusions**

1. There are too many between group differences at baseline (before the study even begins) to make any serious conclusions about the differences these sugars have on glucose intolerant individuals vs healthy individuals at the end of the study.

2. However, looking at within-group differences, HFCS and sucrose seem equivalent or better than honey in the measured markers
 - HFCS does not seem to lead to insulin resistance, elevated blood glucose, increased blood pressure, increased inflammation markers, cholesterol, or blood triglycerides in healthy or intolerant (except intolerant may have slightly elevated inflammatory marker CRP)
 - Sucrose shows increases in cholesterol in healthy, but not intolerant.

3. After 2 weeks of mild added consumption (baseline consumption + 50g) of various sugars, HFCS and sucrose are unlikely to provide serious negative impact health outcomes for healthy individuals. So, roughly 25 grams of added fructose is not detrimental to health – this could change at larger doses, in isolation (not paired with glucose like in all these sugars), or consumed for longer periods of time.