P2. Outline. For the next 20 min and before our guest speaker, I would like to start with what sweetness modulator is, then talk about how to use them make high potency sweeteners (HPS) taste more like sugar by fixing 4 things: sweetness onset, peak, linger and mouthfeel.

P3. Three Taste Problems. Sweetness modulators are ingredients for the most part tasteless themselves but make sweeteners taste more like sugar. The first problem they can fix is time-intensity curve. This is a plot of sweetness intensity vs. time sweetener is in your mouth. Green is sugar and blue is all HPS including stevia and monk fruit. Sugar, being highly water soluble and migrates quickly in saliva from beverage to the sweetness receptor on the tongue, gives sweetness perception very quickly and it’s called fast onset. It’s sweetness intensity is linear to its concentration in beverage range so very sweet, and has a high peak. Being hydrophilic, sugar either get tasted by staying in the saliva or get swallowed and never tasted. It’s called no linger. HPS, being less water soluble, migrates slowly from beverage to receptor so slow onset. HPS intensity plateaus out at 8-10% sugar equivalence and it’s always not sweet enough by itself. It’s more hydrophobic and sticks to hydrophobic mouth proteins and perceived as linger. Various modulators we are going to get into will shorten the onset, increase the peak, and/or cut the linger.

P4. Concentration-Intensity Curves. The second problem sweetness modulators can fix are these concentration-intensity curves with stevia Reb A as example. Green is sweetness and blue in bitterness. Reb A maxes out at about 8% sugar and below 200-300ppm (depending on if it’s more bitter RA50% or the cleaner RA99%) beverages it is sweet. It becomes both sweet and bitter above 300ppm.

P5. This is because it activates not only the only sweetness receptor T1R2/T1R3 but also 2 out of the 25 bitterness receptors TAS2R4 and 14. Bitterness blocker reduces bitterness perception.

P6. The third and last problem unlike sugar is mouthfeel. The focus of this talk is beverages, so I am going to save the bulking agents to compensate for other missing functions for foods like weight, volume, browning in baking and anti-freezing in ice cream to the Q&A section. HPS, even at very low usage level where bitterness is not a problem, has these non-sugar-like traits like thin, astringent, and metallic. A lot of these are oral somatosensation or touch in neuroscience.

P7. Sweetness modulators are clean label ingredients under 6 different mechanisms for making HPS taste more like sugar in beverages. I am going to cover them by the 4 problems they fix and explain how they do it by their mechanisms.
P8. I will talk about how to fix the first 3 problems together as they can be fixed sometimes by one more universal modulator. Sweetness onset, peak and linger.

P9 and P10. Shorten onset. The best 3 are GSG, ErOH and Allulose. GSG, glucosyl steviol glycosides, starts from farm-based stevia extract but enzymatically modified with tapioca maltodextrin and mixed enzymes. As 1-20 glucose are added to native steviol glycosides, the new GSG becomes less sweet but also less bitter and much more water soluble. I recommend it as a FEMA FMP to shorten sweetness onset and increase peak as a natural onset below FEMA beverage limit of 175ppm. Not as a sweetener as some of the components in the final GSG mixture is not-found-in-nature.

P11. Flavorings with Modifying Properties or FMP are classified and regulated classically as sweeteners, but as natural flavor when used below FEMA beverage limit. All FMP must pass FEMA Test 1 (that is, not sweet or more precisely significantly less sweet than 1.5% sucrose the TH) and Test 2 (sweetness & flavor enhancement). Use of multiple FMPs in a food or beverage formulation is however not permitted. ErOH and Allulose being very water soluble adds a quick onset and higher peak to stevia’s and the 2 curves are additive in our brain and together they are closer to sugar.

P12 and P13. To make HPS sweeter (that is, with a higher peak), there are 4 kinds of mechanisms: GSG increases peak we already covered, congruent flavor (or sweet aroma), bitterness blockers and PAM. Sweetness is perceived in the brain when a sweetener binds to any location on the only sweetness receptor T1R2/T1R3. A smell is perceived in the brain when a aroma chemical (like a sweet aroma here) binds to at least one of the 400 smell receptors in our nose. There is interaction between taste and smell when we drink, which is the basis of sweetness modulators based on retronasal sweet smell.

P14. The best example is the molasses distillate or sugar distillate. 100ppm of these “sugary smell” adds about 1-2% sugar equivalence to beverages formulated with stevia or monk fruit. It’s labeled as natural flavor and one of the most cost effective sweetness modulators.

P15. Bitterness blockers reduce bitterness thus the perceived sweetness goes up via a thing in neuroscience called mixture suppression. Here are the 3 best ones for stevia extracts, with other blockers better suited for other bitter compounds to modulate like bitter amino acids, protein, caffeine or the trendy CBD. Don’t ask me anything about CBD, I have no expertise. Narigenin from grapefruit is a stevia bitter blocker. Na Gluconate by fermentation and mushroom mycelia extract are both bitter blockers proven to make stevia less bitter. They all have FEMA #s and labeled as natural flavor.

P16. PAM is not a girl but stands for Positive Allosteric Modulator. They bind to the sweetness receptor in locations next to the sweetener and increase binding efficacy thus sweetness enhancement. There are very few found-in-nature PAM with Oricil an exception. It makes
sweetener sweeter with itself tasteless. Phloretin in apple bark/root extract maybe another. Both are claimed or proven to enhance sweetness and labeled as natural flavor.

P17 and P18. The problematic sweet linger can be reduced by osmolytes and other ingredients. Sweet linger is believed to be due to non-specific binding of the hydrophobic HPS to the hydrophobic protein in the mouth interior. Osmolytes are low molecular weight compounds that can osmotically shock and shrink the protein by osmotic pressure increase. They then release the bound the bound HPS back into the saliva faster and prevent them from being tasted a little bit at a time and over time.

P19. 0.01% table salt is such a osmolyte. Erythritol is multi-functional as it shortens sweetness onset, increase peak and also cut linger. Malic and lactic acids are useful they need to be congruent with the flavor, apple and pear for malic and dairy in general for lactic acid. Three other ingredients, soluble corn fiber/a special essential oil extract and a special yeast extract are at least claimed and some proven to cut linger. They do not fit in the osmolyte definition and their mechanisms are unknown.

P20 and P21. Coming to the end and it’s about compensate for the missing sugar mouthfeel in beverages. It’s common and easier to explain that we use hydrocolloids to bind lots of water to increase viscosity like sugar does. This viscosity equates to “mouthfeel” in food science, but it really is somatosensation or “touch sensation” in neuroscience. Use as little as possible.

P22. Then there are compounds that deliver mouthfeel without binding water like gums and sugar. They may activate our touch receptors directly and here are 3 examples. Stevioside is a bitter sweetener in stevia but when used below FEMA limit of 35ppm is claimed at least as a mouthfeel agent. Glucosylated Stevia Extract (GSE) is different from the GSG that shortens onset and increase peak, it is claimed a mouthfeel agent possibly due to high unreacted maltodextrin hydrocolloid effect or activating directly touch receptor. Reb E is the newest stevia sweetener FMP claimed to deliver mouth feel when used below FEMA limit. All 3 are FMP and labeled as natural flavor.

P23. In summary, there are 3 take home messages. 1, sweetness modulators is a cottage industry that grew up with plant-based sweeteners, and the best clean label ones are based on taste & smell neuroscience and ingredient technologies. 2, There are at least 6 mechanisms notably FMP, PAM and Osmolytes. They are designed to fix 4 HPS problems, sweetness onset, peak, linger and mouthfeel. 3, don’t give up on plant-based sweeteners stevia and monk fruit. It’s increasingly possible to make them taste more like sugar by contemporary clean label sweetness modulators.