2020 Sweetener Systems Post-Conference Magazine

What's Inside on Sweeteners...

- Retooling for the New Sweetener Influencers
- Update on Added Sugar Labeling
- Culinary Strategies for Enhancing Sweetness
- Genetics, Short Sleep and Sweet Preferences
- Clean Label Sweetness Modulator Practicalities
- Breakthrough Sweetness Modulator Technology
- Sugar Replacement & Product Sensory Attributes
- Allulose to Tagatose, Properties & Performance
- Solving the Puzzle: Sugar Reduction Strategies

New Sweeteners Systems Website
https://sweeteners.globalfoodforums.com

Note: This digital magazine, initially posted at https://GlobalFoodForums.com, is now at **https://foodtrendsntech.com/global-food-forums-magazines/**

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2020 Sweetener Systems Post Conference Magazine

Covid-19 brought innumerable changes to how the food industry researches, develops, and brings new and reformulated products to the marketplace. Adjustments, advances and a few retreats also have been made by companies in food media and conferences. Covid-19 forced the cancellation of Global Food Forums' in-person 2020 Sweetener Systems Conference, leaving most speakers with nowhere to give their presentations.

Happily, our speakers agreed to record videos that were released to registered attendees months ago. Those recordings also provided the information for this publication and for articles posted on our new website: https://sweeteners.globalfoodforums.com.

In the coming months, we will be releasing some of these videos, pending speaker approval.

Our next in-person Sweetener Systems event will be held May 24-25, 2022, in conjunction with the 2022 Clean Label Conference. Please visit sweeteners.globalfoodforums.com for updates. We hope to see you then!

Warm regards,

Peter Havens & Claudia O'Donnell

Co-owners, Global Food Forums®, Inc.

The Sweetener Systems website joins Global Food Forums' two other satellite websites, one on Clean Labels and one on food proteins. Go to https://globalfoodforums.com to see them all. See https://bit.ly/34mHhpz for presentation PDFs from this and past Sweetener Systems Conferences. (https://sweeteners.globalfoodforums.com/category/sweetener-systems-rd-academy)

Table of Contents

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Consumers & Sweeteners: A Complicated Love Affair

A COMPREHENSIVE MARKET and consumer trends assessment entitled "Retooling for the New Sweetener Influencers" was provided by Elizabeth Sloan, Ph.D., of Sloan Trends, Inc. for the 2020 Sweetener Systems Conference.

Sloan began her talk with the comment, "There are great opportunities in the $83 billion global sweetener industry, despite the sugar bashing." The emerging market that has arisen with COVID-19 is demonstrating an accelerated interest in both indulgent and healthy items. At end of March 2020, sales of ice cream, cookies and low-calorie soft drinks had increased from 2019 by 29, 10 and 5%, respectively, she noted.[1]

In 2019 and 2017, half of consumers in a Technomic survey indicated that sweet flavors were very appealing.[2] "This includes the younger population—with 70% of Gen Y identifying 'sweet' as the third most craveable flavor," Sloan said.

Bakery had a banner year in 2019, with cakes a leading best seller, up 14% in sales.[3] "Yet, 33% of bakery shoppers check labels looking for 'nothing artificial;' 25% for the type of sweetener; and 27% check for a sugar claim.[4]

Data from NPD's 2018 "National Eating Trends" report showed that, for the first time in 10 years, sweet snacking is on the rise.[5] Consumers are eating more sweet snacks as the day progresses, with after dinner occasions gaining in popularity. "Interestingly, 40% of snack sales are represented by household with kids," stated Sloan. "This is an opportunity, as by 2026, 80% of Millennials will have kids."

In restaurants, sweet bites are the fifth fastest growing menu item for 2020, and 59% of consumers would order more desserts if made with healthier natural sweeteners. "This report shows that using 'real sugar' is more likely to encourage dessert purchases for 56% of consumers; low sugar/sugar-free options for 47%; and alternative sweeteners for 38% of consumers," said Sloan.[2]

According to Euromonitor's "2019 Health & Nutrition Survey," globally, 40% of consumers are limiting sugar intake, with 19, 10 and 9% following a low-sugar, low-calorie or a low/no carb diet, primarily to lose weight and secondly to feel better.[6]

Consumers that seek out "no artificial flavors or sweeteners" are similar across regions: Europe 33%, Asia-Pacific 31%, Latin America 31% and MEA 30%.[7] "Interestingly," stated Sloan, "taste and price top sweetener purchase drivers—not naturalness."[8]

In the U.S., 33% of consumers, mostly in the age brackets of 30-39 years and older, use low/no calorie sweeteners (LNCS). Key perceived benefits of using LNCS sweeteners include simply consuming less sugar, losing weight, consuming fewer total calories and to manage diabetes/control blood sugar.[9] Core organic and clean-eating consumers are twice as likely to avoid sugar, in comparison to 25% of general U.S. consumers. "But, only 21% of adults think natural sweeteners are healthier," Sloan averred.[10] Natural, whole-food sweeteners, such as honey, fruit juices, maple syrup, agave, monk fruit and stevia were viewed as the healthiest.[11]

A Technomic report shows that using "real sugar" is more likely to encourage dessert purchases for 56% of consumers; low-sugar /sugar-free options for 47%; and alternative sweeteners for 38% of consumers.

Areas favored by 42% of U.S. consumers for use of artificial sweeteners include meal replacements, nutrition products, weight and protein drinks, which represented a market of $5.3B in 2019.[12]

Sloan presented a number of key points in her summary. "It's not just about health for sweetener choice, as flavor/taste, novelty and price are strong influencers." She noted that "actions taken to limit sugar are personal and diverse. 'Real' is an important, untapped perspective."

Natural, organic and clean are highly desired options. Consumers are also seeking novel food-based sweeteners/extracts/superfoods. Sweeteners that deliver health benefits, such as prebiotics and antioxidants, are the "brass ring" going forward. Those that improve long-term health will succeed, with examples being low-glycemic/blood-sugar management and satiety via prebiotics/fiber. In times of stress, such as the reality of today, a sweet and indulgent treat is a welcome comfort.

"Retooling for the New Sweetener Influencers," Elizabeth Sloan, Ph.D., Sloan Trends

(1) IRI, Y/E March 29, 2020 (2) Technomic, Inc., Flavor Consumer Trend Report, 2019, 2017 (3) Progressive Grocer, 2019 Retail Bakery Review; 7/2019 (4) ABA, Power of Bakery, 2019 (5) NPD, 2018 National Eating Trends (6) Euromonitor, Health & Nutrition Survey, 2019 (7)


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Mintel, Sugar Reduction, 2020 (8) Mintel, Sugar Reduction: Balancing Health, Naturalness and Taste, 3/2020 (9) IFIC, Food and Health Survey, Gen X, 2019 (10) Packaged Facts, The Organic and Clean Label Food Shopper, 2019 (11) Hartman Group, Health and Wellness, 2019 (12) Mintel, Nutrition Drinks, US, Feb 2020

An Update on Added Sugar Labeling

THE FOOD & DRUG ADMINISTRATION (FDA) published the Small Entity Compliance Guide titled "Revision of the Nutrition and Supplement Facts Labels" in February. Its purpose is to help industry apply the finalized FDA rulings on what foods and ingredients meet their "Added Sugars" definition for the Nutrition Facts label, said Lauren Swann, MS, RD, LDN, CEO and President, Concept Nutrition, Inc., in her presentation, "Update on Added Sugar Labeling: News, Nuances and Needs," recorded for the 2020 Sweetener Systems Conference. It included summaries of the June 2019 provisions established specifically for honey, maple syrup, other single-ingredient sugars and syrups, and certain cranberry products.

FDA's April 2019 "Allulose Draft Guidance for Industry: The Declaration of Allulose and Calories from Allulose on Nutrition and Supplement Facts Labels" is insightful, relative to the more recent "Added Sugars" requirement and agency considerations for novel and unique entries in the sweeteners market, Swann noted. FDA is exercising enforcement discretion—pending possible future rulemaking to amend regulations regarding the definition of "Total Sugars". The agency considered data and information provided in citizen petitions and other submissions along with recognizing that, although chemical structure has traditionally determined "Total Sugars," food technology advances have led to introduction of novel sugars.

For example, allulose is not metabolized by the human body, so it does not contribute four calories per gram to the diet. FDA also considered an association with dental caries, effects on blood sugar, insulin and caloric contribution. It concluded allulose must be included in the amount of "Total Carbohydrate" declared on Nutrition and Supplement Facts labels.

"However, because the majority is excreted intact in the urine, and it is poorly fermented in the gut—its caloric contribution is very low, at no more than 0.4 calories per gram—FDA concludes that allulose should not be included in the Nutrition Facts 'Added Sugars' or its associated 'Percent Daily Value' declaration," explained Swann.

The FDA re-opened the comment period for a 2005 proposed rule for consideration regarding establishment, revision or elimination of a food standard of identity. [*Comments had to be submitted by July 20, 2020.*]

Over 280 current food standards of identity are requirements that define or distinguish significantly relevant food properties, including the content and production of sugars, sweeteners, syrups and related ingredients, such as fruit jams, jellies, preserves and juices.

With more new food development and updates in nutrition, FDA is revisiting standards of identity that also document acceptable labeled common or usual labeled name descriptions. This is to meet consumer expectations and avoid deceptive, misleading practices in the required disclosure of mandatory and optional ingredients, or the minimum and maximum compositional levels or manufacturing process that influence the finished food and labeled ingredient declarations.

Food standards modernization strives to protect consumers against adulteration, while maintaining the basic nature, essential characteristics and nutritional integrity of foods. It is also intended to promote industry innovation and technological advances from manufacturers for production of an improved food supply in the interest of the public.

Advances at GlobalFoodForums.com

Through this last decade, Global Food Forums has built a treasure trove of content on its website https://globalfoodforums.com. As the food, beverage and nutritional products industries cancelled countless in-person events in 2020, we took the opportunity to relaunch our website into four distinct domains. This new structure permits a sharper content and visitor focus on our core topics of food proteins, clean labels and sweetener systems.

Each of these websites has its own "R&D Academy" of PowerPoint presentations and a growing number of videos.

View a video of Lauren Swann's informative presentation at https://bit.ly/2Sz2uHq (the direct URL is https://sweeteners.globalfoodforums.com/sweetener-systems-rd-academy/added-sugar-labeling/).

Standards can ultimately create a clear, simple, easy way for compliance enforcement. Proposed regulations for new or revised food standards address the importance of consistency with common or usual name regulations for related commodities or products. For ingredients, incorporation of current scientific nomenclature, as with other food standards, is key.

[*NOTE: This passage was updated by Lauren Swann, June 2020.*]

"Added Sugar Labeling: News, Nuances and Needs," Lauren Swann, MS, RD, LDN, CEO, President, Concept Nutrition, Inc.

Culinary Sweetener Strategies

THERE ARE SO MANY WAYS chefs use sweeteners, but how do we perceive sweetness? Sweetness is one of the main taste components of flavor, balancing out with salty, sour, bitter and *umami*. Understanding sweetness perception is especially important to building balanced flavors, Allison Rittman, CRC, Owner, Culinary Culture, pointed out in her presentation "From Amazake To Acid Blockers: Culinary Strategies for Enhancing Sweetness," prepared for the 2020 Sweetener Systems Conference. Here are a few highlights from her presentation.

First, let's clarify a few definitions:

- **Aroma** - refers to an actual aromatic compound with a specific scent that can be identified by smelling.
- **Taste** – the tongue can sense taste and feel texture. Taste is developed through the taste buds on the tongue, and there are five basic tastes: sweet, sour, salty, bitter and umami.
- **Flavor** - Flavor is the brain's association between what it smells through the nose; tastes with the tongue; and feels in the mouth.

Since flavor is a combination of smell and taste, it can be useful to consider that the sense of smell is more sensitive than sense of taste. And, when consumers talk about "taste," they may well be referring to how a food smells, looks, its consistency, texture and other characteristics, such as temperature and even sound (e.g., the crunch of celery).

So, how do chefs use aroma to create a unique experience? One example is Chef Grant Achatz, from Alinea restaurant in Chicago. Chef Achatz showcases the importance of aroma to flavor. He presents a dish with English peas, placed on a pillow inflated with lavender-scented air. As the pillow deflates, it releases lavender air slowly—creating an interactive sensory experience that incorporates aroma into the taste experience.

Sound is another sensation that can impact flavor. Professor Charles Spence, from Oxford University, found in a set of experiments that higher frequency sounds can enhance sweetness in foods, and lower frequency sounds can bring out bitterness in foods. Chefs could use this to enhance the sweetness in dishes without changing a single ingredient, suggested Rittman.

There are many common sweeteners used by chefs beyond white granulated sugar, including brown sugar, jaggery or piloncillo. Honey, agave, dates, maple syrup, sorghum and molasses are just a few of the many other common options.

The chefs are also experimenting with more unique components: yacón, aronia berry, lucuma, sweet potato syrup and *amazake*.

What exactly is *amazake* (ah-mah-za-keh)? It is a probiotic rice concentrate made from steamed rice, *kōji* and water. Fermentation converts naturally occurring starches in the rice into sugars, and it has a neutral flavor profile. All these attributes make it a great alternative sweetener.

kōji (koh-jee) is an important part of *amazake*. *kōji* is a filamentous fungus (mold), *Aspergillus oryzae*. Some of the sugar bound by starch in grains cannot be fermented by yeast, so this specialized fungus is inoculated with the grains and releases enzymes that convert these starches into sugars. *kōji* has been traditionally used to turn soybeans into *miso*; rice into *sake*; and rice into vinegar, Rittman explained.

kōji is being used more in kitchens in non-traditional ways. Chefs like David Chang have made miso with pistachios. Chef Sean Brock from Husk created a dish called *scallopbushi-kōji*

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***Amazake* is a probiotic rice concentrate made from steamed rice, köji, and water. Fermentation converts starches in the rice into sugars.**

spores and rice flour-coated scallops, then cured them for two days to create scallops that smell like honeysuckle and have a perfectly cured, sweet note. Chef Cortney Burns, from Duna in San Francisco, is using mother spores from a Japanese *sake* producer to sweeten a rice-based ice cream, which also acts as a stabilizer. For chefs, *kōji* is not an ingredient; it's not a technique; it's a little bit of both.

Sweeteners play a role in not just adding sweetness to a dish; they can also enhance other flavors, as well as mask bitterness, astringency and acidity. By mixing and matching sweeteners, it is possible to achieve different layers of sweetness impact within a dish.

Chefs also look beyond just ingredients to balance basic flavors and enhance sweetness. There are a wide variety of cooking techniques that can create this affect. Roasting, caramelization, drying/dehydrating, reduction and fermentation are just a few cooking techniques to enhance sweetness.

Chefs have many tools in their kitchen to enhance sweetness, including engaging all of the senses; experimenting with unique ingredients; and using a variety of cooking techniques. "I hope my presentation gives a glimpse of what is possible in the kitchen and beyond," concluded Rittman.

"From Amazake To Acid Blockers: Culinary Strategies for Enhancing Sweetness," Allison Rittman, CRC, Owner, Culinary Culture

Genetics, Sweet Preference and Short Sleep: Important Players in Food Choice?

ROBIN TUCKER, PH.D., Department of Food Science and Human Nutrition, Michigan State University, provided an update on the science related to two under-studied contributors to food choice—genetics (sweet-liking phenotype) and sleep—in a video done for Global Food Forum's 2020 Sweetener Systems Conference.

In her presentation titled "Genetics, Sweet Preference and Short Sleep: Important Players in Food Choice," Tucker began by explaining that sweet liking phenotypes (SLP) are observable traits that are the result of genetic and environmental interactions. "There are three-to-four 'foundational' patterns of sweet-liking responses consistently observed," she explained. Sweet "Likers" increase their liking as sweetness grows, whereas "Dislikers" are the opposite. Increasing sweetness decreases their liking.

The third type, "U-shaped" SLP, decrease liking once a threshold is reached; the fourth type, "Neutrals," have no change in liking when presented with differing concentrations of sweetness. These SLP are associated with beverage intake. "Adult sweet Likers consumed more energy from all beverages; more sweetened juice and tea; and less water than those in other clusters," stated Tucker.

Tucker and associates published a systematic review of studies which found that, when participants' SLP were considered, the likelihood of identifying relationships between taste and dietary intake was increased (Tan, S-Y & Tucker, RM. 2019. *Nutrients*. https://bit.ly/3dKjPG3). Sensitivity (thresholds) and intensity studies demonstrated little association with sweet stimuli. Hedonic measurements were more likely to be associated with dietary intake, especially if sweet Likers were analyzed separately from sweet Dislikers.

Tucker's research has shown that SLP predicts preferred sweetness concentrations for both sucrose and sucralose, with Likers preferring significantly higher levels of sucralose (Szczygiel EJ, et al., 2019. *Nutrients*. https://bit.ly/2SNm7fp).

Further work has shown that, among children, there are two clusters of liking patterns—Likers and Dislikers. For both adults and children, BMI, percent body fat, age and sex did not differ between clusters.

Moving onto the topic of sleep, data suggests that after insufficient sleep, a consumer will increase their intake of high-fat, high-sugar foods. Using observational studies, Tucker has investigated whether measures of sleep duration and sleep quality affect chemosensory function and sweet taste preference.

Sweet liking phenotypes (SLP) among humans are observable traits resulting from genetic and environmental interactions. SLP include sweet "Likers" who increase their consumption when a product is sweeter; and "Dislikers," where increased sweetness has the opposite effect.

"In both men and women, no correlation between sleep variables and sweet taste sensitivity (that is function) was found," said Tucker. "However, differences in sleep duration may contribute to differences in sweet taste liking or preference."

Tucker explained the findings of a study in which the effects of sleep curtailment on sweet taste function and perception were studied (Szczygiel EJ, et al., 2019. *Nutrients*. https://bit.ly/2SNm7fp). Habitual (usual night of sleep) vs. a curtailed night of sleep (33% reduction in habitual sleep) were evaluated for their potential impact on sweet taste perception. After curtailment, a significant increase in preference for higher concentrations of both sucrose and sucralose was observed. The slope of sucrose sweet-liking increased to greater extent than the slope of sucralose-liking. Intensity perception of the sweeteners was not altered by curtailment. Tucker postulated: "There may be a need to control for sleep in food sensory studies."

Based on these findings, another study looked at the sweet taste perception of complex food matrices after sleep curtailment (Szczygiel EJ, et al., 2019. *Foods*. https://bit.ly/2SPOTMb). A solid, oat-based food and oat-based beverage sweetened with sucralose were used. Overall and flavor-liking slopes across measured concentrations were steeper after sleep curtailment, suggesting that sweeter versions of the oat products were liked more after less sleep. The texture of a solid oat crisp was liked less among sweet non-likers ($p < 0.001$), but this did not hold for the oat beverage. "These findings suggest various effects of sleep on hedonic response in complex food matrices," summarized Tucker.

A follow-up study examined the effects of sleep curtailment on appetite, food reward and food cravings (Yang, C-L, et al. 2019. *Nutrients*. https://bit.ly/2WJ8saj). Non-obese women who said they typically slept seven to nine hours per night were evaluated after a normal night's sleep (NN) and also after a curtailed night (CN)—where time in bed was reduced by 33%. The women reported increased hunger, tiredness, sleepiness and food cravings after CN. More chocolate was consumed after the CN. Larger portion sizes selected after the CN resulted in increased energy plated for lunch.

In summary, Tucker stated that patterns of SLP may be useful to characterize consumers, especially in food development. Strong epidemiological and experimental evidence suggests insufficient sleep increases the risk of weight gain and higher BMI. She concluded, "These changes in perception are likely part of the puzzle that explains relationships between insufficient sleep and alterations in food choice."

"Genetics, Sweet Preference and Short Sleep: Important Players in Food Choice," Robin Tucker, Ph.D., R.D., F.A.N.D., Department of Food Science and Human Nutrition, Michigan State University

Clean Label Sweetness Modulators

SWEETNESS MODULATORS are ingredients that make high-potency sweeteners (HPS) taste more like sugar by fixing some of the flavor-quality issues associated with these ingredients, explained Alex Woo, Ph.D., and CEO of W2O Food Innovation. Woo's presentation, "Recent Research on Clean Label Sweetness Modulators," had been scheduled for the 2020 Sweetener Systems Conference.

The first challenge with HPS is the time-intensity curve. Sugar is highly water-soluble and migrates quickly in saliva from a beverage to the sweetness receptors on the tongue—giving a fast onset of sweetness perception. Sucrose delivers a high sweetness peak and has no taste linger. In contrast, HPS are less water-soluble and migrate slowly from beverage to receptor, thus delivering a slow onset. HPS are also more hydrophobic and, thus, stick to hydrophobic mouth proteins, providing a lingering taste perception, Woo explained. Various sweetness modulators will shorten the onset; increase the peak; and reduce or eliminate the linger.

The second issue is the taste profile. Stevia Reb A has a maximum sweetness equivalence of about 8% sugar. Below 200-300ppm, it delivers a sweet taste profile; however, it becomes sweet and bitter above 300ppm.

The lingering sweetness of high-potency sweeteners may be reduced with several ingredients, such as erythritol, soluble corn fiber, malic acid (for apple and pear flavors) or lactic acid (dairy applications).


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The third challenge is mouthfeel. In beverage applications, HPS impart thin, astringent and metallic properties.

Sweetness modulators use six different mechanisms to make HPS taste more like sugar in beverages. Woo addressed four of these mechanisms.

The best modulators to shorten HPS sweetness onset are glucosyl steviol glycosides (GSG), erythritol and allulose, suggested Woo. The traditional GSG starts from farm-based stevia extract that is enzymatically modified.

GSG FEMA 4728 is an example of Flavorings with Modifying Properties (FMP), which are classified and regulated as sweeteners but can be labeled as "natural flavor" when used below the FEMA beverage limit of 175ppm. All FMP must be demonstrated to FEMA to be less sweet than 1.5% sucrose and contribute to sweetness and flavor enhancement. Examples also include erythritol and allulose.

A smell is perceived in the brain when an aroma chemical binds to at least one of the 400 smell receptors in the nose. Congruent flavors create an interaction between taste and smell when we drink. The best examples are molasses distillate or sugar distillate. Adding 100ppm of these "sugary smells" in beverages formulated with stevia or monk fruit increases sugar equivalence by 1-2%. Bitterness blockers reduce bitterness; thus, the perceived sweetness goes up. Woo offered that the best three to use in combination with stevia extracts are narigenin, sodium gluconate and mushroom mycelia extract.

PAM stands for Positive Allosteric Modulator. A PAM binds to the sweetness receptor in locations next to the sweetener and increase binding efficacy and, thus, sweetness enhancement. There are very few found in nature, but two exceptions are a patented FEMA GRAS compound and, maybe, phloretin.

Sweet linger is caused by the non-specific binding of the hydrophobic HPS to the hydrophobic protein in the mouth interior. It can be reduced by osmolytes and other ingredients. Osmolytes are low molecular-weight compounds that can shock and shrink the protein, releasing the bound HPS back into the saliva faster and preventing them from being tasted "a little at a time over longer time," said Woo. One example is 0.01% table salt.

Erythritol shortens sweetness onset, increases peak, and reduces linger. Malic acid is useful to reduce linger in apple and pear flavors, while lactic acid works well in dairy applications. Three other ingredients that reduce linger are soluble corn fiber, a special essential oil extract (stevia masker NA10022), and a specific high-peptide yeast extract.

Hydrocolloids bind water and increase viscosity. This viscosity equates to "mouthfeel" in food science and "touch" in neuroscience. Ingredients that may be useful in delivering mouthfeel include: stevioside (when used below 35ppm), glucosylated stevia extract and REBE (when used below FEMA limit), Woo said.

Sweetness modulators grew up with plant-based sweeteners, and the best clean label ones are based on taste and smell neuroscience and ingredient technologies. Most can be labeled as "natural flavor." It's increasingly possible to make stevia and monk fruit taste more like sugar by adding these contemporary clean label sweetness modulators.

"Recent Research on Clean Label Sweetness Modulators," Alex Woo, Ph.D., and CEO of W2O Food Innovation

Taste Improvement through New Sweet Taste Modulator

NO NON-CALORIC SUGAR SUBSTITUTE tastes exactly like sucrose. "Research into improving taste of sugar substitutes in beverages involves 10 metrics," explained Grant DuBois, Consultant, Sweetness Technologies, LLC. DuBois imparted this information in his presentation "Breakthrough Technology Dramatically Improves Sweetener Taste," which was prepared for the 2020 Sweetener Systems Conference. He then gave insights into a new sweet taste modulator.

Safety: The first metric is safety. The cost of developing a new sweetener could approach $100 million for going through the Food Additive Petition process or $20 million for the GRAS Self-Affirmation process.

Taste Quality, Maximal Response: Maximal response is the maximal sweetness intensity of a sugar substitute compared in sucrose

More Information from Grant DuBois' Presentation

A more detailed summary of key points from the presentation "Breakthrough Technology Dramatically Improves Sweetener Taste," is available at Global Food Forums' new Sweetener Systems website (https://sweeteners.globalfoodforums.com). The presentation, prepared by Grant DuBois, Consultant, Sweetness Technologies, LLC, contains additional information on the development and current state of positive allosteric modulators (PAM); REBA ingredients from the stevia plant; and it touches on the cost of sweetener systems with all-natural ingredients.
See https://sweeteners.globalfoodforums.com/sweetener-systems-articles/new-sweet-taste-modulator/ (shortened URL: https://bit.ly/33rh364)

Recent research investigated the impact of mineral-salt blends on non-caloric sweetener temporal profiles.

equivalent units. As examples, the maximal sweetness intensity of saccharin is equivalent to 9.1% sucrose, cyclamate 18.4% sucrose, aspartame 24.7% sucrose and rebaudioside A (Reb A) 9.7% sucrose in water at ambient temperature.

Taste Quality, Flavor Profile: The next metric is the flavor profile or relative levels of sweetness, bitterness, licorice taste, mouthfeel, etc. At a sucrose equivalency of 7%, saccharin has a lot of bitter taste and aspartame only a trace of bitterness. Reb A, at most commercial levels of purity (e.g., 97%), has some bitterness but significant, licorice-like off-taste. Ultra-high purity Reb A (e.g., 99.5%) has negligible licorice off-taste, but it is higher in cost.

Taste Quality, Temporal Profile: A major issue with non-caloric sweeteners is temporal profile, which is how quickly the sweetness rises and how long it lingers. At a maximal sweetness response equivalent to 7% sucrose, aspartame rises rapidly, but lingers significantly. Reb A comes on more slowly but lingers more than aspartame.

Taste Quality, Adaptation/Desensitization: Some sweeteners desensitize or cause adaptation of the sweetness sensory system. When tasting a beverage sweetened with HFCS 55, there is little or no change in response when iteratively tasting every 30 seconds. However, a beverage sweetened with aspartame was significantly reduced in sweetness with subsequent tastes, said DuBois.

Cost: In the beverage industry, the costs of ingredients are measured on a cost-per-unit case basis (cents/UC), where "UC" is a case of 24, 8oz bottles. The sweetener cost for a full-calorie HFCS sweetened beverage is approximately 54 cents/UC. In contrast today, the cost of the sweetener for a zero-calorie beverage sweetened with aspartame is approximately 3 cents/UC. Sweetening a diet cola beverage with Reb A today would cost some 34 cents/UC, but the taste would not be acceptable. For comparison, a blend of Reb A and erythritol would be acceptable in taste, but the cost would be around 90 cents/UC, said DuBois.

The last four metrics are "Solubility," "Stability" (to hydrolysis and light exposure), "Patentability" and "Consumer Acceptance."

In the late 1990s, consumers began to demand all-natural ingredients. After consideration of 50 structural classes of natural non-caloric sweeteners, The Coca-Cola Company determined that the stevia sweetener Reb A most closely met the 10 metrics. Reb A was GRAS self-affirmed in 2008 and received a "No objection" letter from the FDA in the same year. Subsequently, Reb D and Reb M were also GRAS self-affirmed.

There are various quality and taste issues with the lower purity Reb A, and most of these have been overcome with commercialized ultra-pure Reb A (99.5% minimum purity).

Formulation research studies led to the hypothesis that the cause for the delayed onset of sweetness of Reb A, as well as its lingering sweet aftertaste, were slowed diffusion through the mucous hydrogel film covering the lingual epithelium. Sucrose and other carbohydrate sweeteners rapidly diffuse through the mucous hydrogel. In contrast, non-caloric sweeteners like Reb A bind to hydrophobic sites in the mucous hydrogel. Thus, they are delayed in reaching the sweetener receptors and are delayed in diffusing away from sweetener receptors.

This delay in egress from the receptors is believed to result in iterative activation of the sweetener receptors—a phenomenon perceived as sweetness linger. The research in which DuBois was involved led to the finding that formulation of Reb A, as well as other noncaloric sweeteners, with a blend of K, Mg and Ca mineral salts, resulted in acceleration of sweetness onset as well as a marked diminution of sweetness linger. This research suggests that the Mg and Ca mineral salts bind to sites in the mucous hydrogel, so as to create pores which allow more rapid diffusion of non-caloric sweeteners to and from the sweetener receptors.

In addition to the dramatic effects of such mineral-salt blends on non-caloric sweetener temporal profiles. A very pleasant, sugar-like mouthfeel in these mineral-salt fortified formulations was observed. The mouthfeel effect is believed to follow from activation of the Calcium Sensing Receptor, which Japanese scientists have recently demonstrated to be expressed by a subset of taste bud cells and to be responsible for *kokumi* taste, which is translated as "mouthfulness," said DuBois.

Many K/Mg/Ca mineral-salt formulations have been found to be effective in both modulation of non-caloric sweetener temporal profiles, as well as introducing a very pleasant, sugar-like mouthfeel and KCl/MgSO4/Ca(Lactate)$_2$ compositions were found particularly effective. This work is now covered by a 2020 U.S. patent.

Mineral-salt taste modulators work for all non-caloric sweeteners, both synthetic and natural. These taste modulators improve non-caloric sweetener temporal profiles very significantly; deliver sugar-like mouthfeel; and they are clean label, cost effective and GRAS, concluded DuBois. In addition, these mineral-salt taste modulators increase the sugar-like mouthfeel of carbohydrate formulations and, in effect, make sugar taste better than sugar.

"Breakthrough Technology Dramatically Improves Sweetener Taste," Grant DuBois, Consultant, Sweetness Technologies, LLC, grant.dubois@gmail.com

Sugar Reduction Insights: Dairy Products to Protein Bars

SUGAR REDUCTION is universally attractive to consumers across a wide range of foods, including both indulgent and healthy products. However, sugar plays multiple roles in foods, contributing to flavor, texture and structure. This makes replacing sucrose particularly challenging, said MaryAnne Drake, Ph.D., William Neal Reynolds Professor, North Carolina State University, in her presentation, "Sugar Reduction in Food Products: Flavor Still Rules!" prepared for the 2020 Sweetener Systems Conference.

"Consumers have different opinions about the types of sweeteners they prefer and the level of sugar reduction they desire but, ultimately, what is most important is taste. Successful sugar reduction requires formulators to understand consumers, the application and the sweeteners," Drake continued. She offered formulation advice for reduced-sugar foods, including chocolate milk, yogurt and protein bars.

Chocolate Milk: Drake's laboratory has explored sugar reduction in chocolate milk. Parental perception is important, because parents hold the purchasing power. For parents, the ideal chocolate milk claims include: "all natural," "reduced sugar," "reduced fat" and "all-natural sweetener."

Despite parental perceptions, ultimately, chocolate milk also has to taste good. Several years ago, commercial chocolate milks typically contained 17g of added sugar. Currently, that amount is slightly lower. Not surprisingly, as sugar content decreases, so does product liking. Chocolate milk with 30% sucrose reduction still maintains acceptable liking scores of at least 7 out of 9, on a hedonic scale, Drake said.

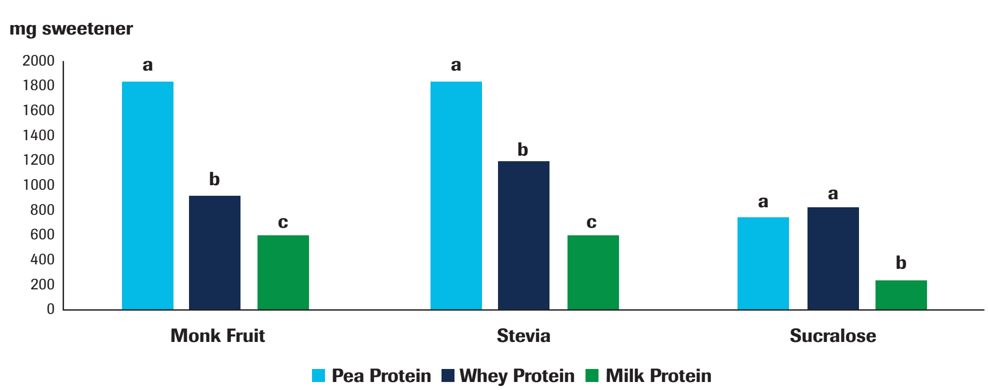
To achieve even greater sugar reduction, natural non-nutritive sweeteners were added to achieve an iso-sweet taste intensity equivalent to 12.5g of sucrose. This required 200mg/L of stevia or 350mg/L of monk fruit. Drake's group then compared combinations of non-nutritive sweetener and sucrose, at levels ranging from 12.5g of added sugar to 0g of added sugar.

A trained panel found that, as the concentration of non-nutritive sweeteners increased, bitterness and astringency increased, and viscosity decreased. A 25% substitution of monk fruit or stevia for sucrose did not change liking. Increases to 50% of non-nutritive sweeteners resulted in less liking, and 100% substitution resulted in significantly less liking. Reduction beyond 40% is possible with further formula modifications.

Yogurt: An online survey compared attitudes and knowledge of 1,300 consumers who regularly consume and purchase yogurt. Over half of consumers surveyed said that they read nutrition labels. When asked questions about a sample label, over 96% correctly identified the grams of saturated fat and protein, while only 84% correctly identified the grams of added sugar, Drake explained.

When consumers were asked which sweeteners they were familiar with, not all consumers could distinguish between sucrose and cane sugar. Monk fruit was not as familiar as stevia, and consumers were even less familiar with erythritol and allulose.

Impact of Protein Type on Iso-sweet Concentrations



NOTE: SWEETENERS ARE SHOWN AS MG PER 500GM PROTEIN BARS. BARS WERE FORMULATED AT 15GM PROTEIN/62GM SERVING.
ROWS WITHOUT A COMMON LETTER ARE DIFFERENT ($P<0.05$).
BARS WERE FORMULATED TO SWEET TASTE EQUIVALENCY TO A 10% W/V SUCROSE SOLUTION.
SOURCE: MARYANNE DRAKE, PH.D., NORTH CAROLINA STATE UNIVERSITY/2020 SWEETENER SYSTEMS CONFERENCE

In a model system, pea protein required higher sweetener levels than dairy proteins for the same perceived level of sweetness.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There were four distinct segments of yogurt consumers. The largest group (551) prefers "no artificial sweeteners," and the smallest group (213) prefers "unsweetened" yogurt. Universally, the most appealing sugar claim is "naturally sweetened."

When looking at individual sweeteners, honey was most appealing (21.8 on a scale of 100) across all consumers. The term cane sugar (15.7) was more appealing than sucrose (10.1).

Kano questions—an approach that prioritizes a product's features based on the degree to which they are likely to satisfy customers—were used to explore satisfaction with different label claims and help understand purchase drivers. A "high protein" claim is very attractive, but the product must also taste good. Interestingly, consumers were fairly indifferent to claims of "reduced sugar," "low fat," "high calcium," "fortified," "probiotics," "indulgent" and "natural ingredients."

Protein beverages and bars: When looking at protein beverages, Drake identified three distinct consumer segments: one focused on protein type and label claims; another focused on total protein amount; and a third focused on products that contain an all-natural sweetener. Great taste is a universal expectation.

In a study of over 1,000 consumers of protein powders, beverages and bars, respondents universally want naturally sweetened products, and stevia is the natural sweetener of choice. Out of 32 attributes evaluated for protein products, "all natural" was the top claim, and "naturally sweetened" ranked third. Protein amount had no impact on sweet taste values for any sweetener. However, more sweetener is required for a beverage with a thicker texture or for a bar.

Many companies currently are developing products with plant or vegan protein. Protein type was found to affect sweetener perception in a model bar application. Pea protein required more sweetener to get to the same iso-sweet level as whey or milk protein.

Sugar reduction is complex, because all consumers are not the same, and their desires change across product types, concluded Drake.

"Sugar Reduction in Food Products: Flavor Still Rules," Mary Anne Drake, Ph.D., William Neal Reynolds Professor, North Carolina State University

Allulose to Tagatose: Properties & Performance in Sugar Replacement

MANY OF OUR FAVORITE BAKERY TREATS contain about one third sugar, noted Melanie Goulson, MSc, General Manager & Principal Scientist, Merlin Development in her presentation, "New Kids on the Block: From Allulose to Tagatose, Properties & Performance in Sugar Replacement," prepared for the 2020 Sweetener Systems Conference. "There is no magical drop-in solution that can replace the taste and function of sugar, so food scientists must use all of the tools in their toolbox to optimize sugar reduction," she said.

At Merlin Development, sugar drop cookie formulas with tagatose, allulose or erythritol were adjusted to produce a greater spread, more similar to when 100% sucrose was used.

Bulking sweeteners include sucrose, glucose, fructose, sugar alcohols, and the newer, rare sugars—allulose and tagatose. When bulking sweeteners are used to replace sucrose, the usage level is often close to one-to-one.

Non-bulking sweeteners include sucralose, acesulfame potassium, stevia and monk fruit. These high-potency sweeteners are used at very low parts per million (ppm) levels and need to be combined with a bulking agent in bakery applications.

Sucrose provides sweetness, bulking, tenderizing, browning, caramelization, freezing-point depression and preservation. Replacing the functionality of sucrose is difficult enough, but food formulators must also consider regulatory issues, taste profile, nutritional targets, digestive tolerance, shelflife issues and product claims.

Rare sugars exist in nature in extremely low quantities. They are not fully digested and, therefore, provide a lower energy content.

Allulose is produced by enzymatic conversion of fructose. It is GRAS in the U.S., but it is not currently approved in Europe. While sucrose yields 4 calories/gram, allulose only provides 0.4 calories/gram. Allulose has recently been exempted from being labeled as a sugar; has a very low glycemic index; and is non-cariogenic, Goulson said.

Erythritol is a sugar alcohol which is also not labeled as a sugar; has a low glycemic index; and is non-cariogenic. Erythritol is fully absorbed and excreted in the urine, so little reaches the large intestine, where it might be fermented, explaining why it is the best tolerated of all the polyols.

Tagatose, another rare sugar, is a monosaccharide isomer of fructose. It is naturally occurring in dairy and some fruits. Commercially, it is produced by isomerization of galactose from lactose or by enzymatic conversion of galactose. Tagatose delivers 1.5 calories/gram. It is currently labeled as sugar but may eventually follow the precedent set by allulose regulations and become exempt from sugar/added sugar regulation in the U.S. Tagatose is about 20% absorbed and fully metabolized. Its digestive tolerance is comparable to allulose. It has a low glycemic index and is "tooth friendly."

A trained panel in Merlin Development's laboratory evaluated the sweetness intensity of these bulk sweeteners in water and found that tagatose is 90% as sweet as sucrose, while allulose and erythritol are both 70% as sweet as sucrose. Tagatose has a clean, sweet taste profile, similar to sucrose. However, allulose is significantly more bitter, at both 5% and 10% sucrose equivalent sweetness (SEV). At 10% SEV, allulose has significantly greater chemical and astringent taste.

Temporal dynamics of sweeteners include time for sweetness onset; time to meet maximum sweetness; and time for sweetness decay. The temporal properties of allulose and tagatose are similar to sucrose. Neither exhibited the delayed sweetness onset and linger that is often seen with high-potency sweeteners. Blending a rare sugar with a high-intensity sweetener can round out taste dynamics.

In baking applications, sugar contributes to spread, bulking, tenderness, aeration, shelflife and more. The food technologists at Merlin Development used drop sugar cookies to screen allulose, tagatose and erythritol for functionality, both at 100 and 50% sucrose replacement levels.

Tagatose and allulose are both monosaccharides and reducing sugars, and both contributed to browning more than the sucrose control. Although all three alternative sweeteners have a lower melt point than sucrose, none spread like the sucrose control. Goulson noted the 50% replacement formula was subsequently adjusted to increase the fat-to-flour ratio, and baking time was reduced. This modified recipe produced spread comparable to the sucrose control. In the modified formula, allulose produced more surface browning, but none of the alternate sweeteners provided the same level of surface cracking as the sucrose control.

Tagatose and allulose produced cookies that were softer, less crispy and "cakier" than the control. There was no significant difference in sweetness. Tagatose and allulose produced more caramel notes. Cookies baked with allulose were more bitter than those with erythritol or the control.

With formula adjustments, these new sugars show great potential for reducing total and added sugar in bakery applications, Goulson concluded.

"New Kids on the Block: From Allulose to Tagatose, Properties & Performance in Sugar Replacement," Melanie Goulson, MSc, General Manager & Principal Scientist, Merlin Development

Formulating to Reduce Sugar: Tools & Strategies

FORMULATING FOR SUGAR REDUCTION is similar to solving a jigsaw puzzle. Food products are built off components that interact with others, like puzzle pieces, to create an overall result. By understanding how the pieces interact, foods can be modified to fit specific goals and criteria.

Using this puzzle analogy, Catalin Moraru, Ph.D., Technical Manager Product Development at The National Food Lab, discussed in his presentation titled "Solving the Puzzle: Sugar Reduction Strategies," originally scheduled for the 2020 Clean Label Conference, an overall approach to sugar reduction and its implementation in a specific case study.

Potential Sugar Functionality in Food Applications

- Sweetness, flavor enhancement and palatability
- Color and flavor formation
  - o Browning
  - o Caramelization
- Texture
  - o Body/mouthfeel/viscosity
  - o Tenderizer
  - o Control crystallization
  - o Gelling
  - o Creaming
- Stability
  - o Water-activity reduction
  - o Prevention of browning discoloration
  - o Prevents staleness
  - o Foam stabilizer
- Fermentation Support

CHART SOURCE: CATALIN MORARU, PH.D., THE NATIONAL FOOD LAB, INC./PREPARED FOR THE 2020 SWEETENER SYSTEMS CONFERENCE

Reducing sugar content in foods can be accomplished using one or more of the following strategies:

• Substituting some or all sugar(s) with other sweeteners

• Reducing sugar without adding other sweeteners (an option that is gaining ground, as consumers may mistrust other sweeteners)

• Using technology to enhance the perception of sweetness and overall sensory profile

• Switch to savory

However, sugar has many different functions. Sugar provides sweetness and enhances flavor and palatability, while also contributing to color and flavor thorough browning and caramelization. Sugar contributes to texture and stability and, in some applications, provides fermentation support. The importance of each function depends on the application. In a baked product, for example, all of sugar's functions may be important; in a beverage, sugar's role may be limited to providing sweetness and sometimes contributing to its body.

Depending on the food product, nutritive or non-nutritive sweeteners may be options for sugar replacement. Nutritive sweeteners include simple mono- and disaccharides (fructose, dextrose, etc.); polyols (maltitol, sorbitol, etc.); natural extracts/combinations (honey, agave, etc.); or other compounds (maltodextrin, inulin, etc.). Calorie content, glycemic load and potential gastric distress are important considerations.

Non-nutritive sweeteners have no calories, because they are either non-digestible or so intensely sweet that the minute quantities contribute negligible calories in food products. Allulose and erythritol are non-digestible with a sweetness profile similar to sugar and, along with natural high-intensity extracts of stevia or monk fruit, are of high interest right now. Artificial high-intensity sweeteners, such as sucralose, acesufame-K, aspartame, saccharin and neotame, are still popular—although consumers exhibit increasing interest for natural sweeteners.

Stevia extracts are particularly interesting and challenging, due to the different performance of their active compounds. The bitterness of early stevia extracts was overcome with increased purification—but at increased cost. While the most popular active compound of stevia extracts is rebaudioside A (Reb A), new Reb D and Reb M active compounds are sweeter than the purest Reb A and less bitter. However, these compounds are present at low levels within stevia, so stevia extracts with high Reb D or Reb M levels are expensive. Blends of different rebaudiosides can help achieve a balance between price and taste, said Moraru.

Besides replacing sugar with other sweeteners, other strategies may support sugar reduction. Sweetness potentiators/modulators are not sweet by themselves, but they can improve the sweeteners performance by increasing sweetness perception. For instance, ethyl hexanoate from apples can make some foods taste as if more sugar were present. Reducing intrinsic sugars is another strategy: for example, removal of natural milk lactose by ultrafiltration. Natural sugar can also be modified to make it dissolve faster or increase its surface area, allowing an augmented perception of sugar in selected applications.

Moraru advised that sugar-reduction projects typically include several rounds of refinement and require a number of specific steps, which are also akin to solving a jigsaw puzzle:

• Define the application

• Define objective and scope

• Identify criteria and "guardrails" (sugar'[s] functionality, regulatory/labeling considerations, calorie targets, cost, consumer preference)

• Select tools that meet criteria

• Design solution, narrowing down on potential ingredients or combinations, and strategies of potential interest

• Test the sugar-replacement solution and ensure it meets requirements, or refine and reiterate as needed

A final case study in Moraru's presentation demonstrated using the puzzle analogy of how a sugar-reduction exercise was implemented for a flavoring add-on for plain yogurt. After several iterations, the final formula developed using erythritol, stevia (Reb D and Reb A), freeze-dried fruit pieces, flavors and a texturizer system met the targets for sweetness, calorie and sugar content, and sensory performance.

Because of its association with chronic conditions, sugar has moved past salt and fat as "public enemy #1" among food ingredients. Reducing sugar content in foods is similar to a jigsaw puzzle exercise; but, with the right tools, approach and analysis, the puzzle can be solved, Moraru concluded.

"Solving the Puzzle: Sugar Reduction Strategies," Catalin Moraru, Ph.D., Technical Manager, Product Development, The National Food Lab, Inc., catalinmoraru@eurofinsus.com

We would like to thank Global Food Forums' speakers, registered attendees, sponsors and exhibitors as we work through this difficult time of Covid-19. We are emerging as a better, stronger Global Food Forums with our enhanced websites and increasing number of videos, webinars and other online offerings. Be safe!

– Global Food Forums Staff

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Setting Up for Success

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