POLYOLS: A SWEET ALTERNATIVE TO SUGAR REDUCTION

OVERVIEW OF POLYOLS

WHAT ARE POLYOLS?

- Polyols are sugar-free, low-digestible carbohydrate sweeteners
- They are also known as sugar replacers, a more consumer-friendly name which better describes how and why polyols are used
- Polyols are referred to as “sugar alcohols” by the US Food and Drug Administration and are labeled as such on Nutrition Facts labels, though they are neither sugars, nor alcohols

USE OF POLYOLS IN THE US

- The polyols which are used in the US are:
  - Erythritol
  - Hydrogenated starch hydrolysates (HSH; polyglycitols, polyglucitols)
  - Isomalt
  - Lactitol
  - Maltitol
  - Maltitol syrups
  - Mannitol
  - Sorbitol
  - Xylitol

WHERE ARE POLYOLS USED?

- Polyols are used to prepare a wide range of food products, including:
  - Breath Mints
  - Chewing Gum
  - Candy and Confectionaries
  - Frozen Desserts
  - Ice Cream
  - Fruit Spreads
  - Baked Goods
  - Chocolate
- Polyols are also used in oral health and pharmaceutical products, including:
  - Mouthwash
  - Toothpaste
  - Cough Drops
  - Cough Syrup

COMPARISON TO SUGAR

- As compared to sugar, which provides 4.0 calories per gram, polyols provide the following calorie content:

Polyol	Calories Per Gram
Erythritol	0.0 calories
Mannitol	1.6 calories
Isomalt	2.0 calories
Lactitol	2.0 calories
Maltitol	2.1 calories
Xylitol	2.4 calories
Sorbitol	2.6 calories
Hydrogenated starch hydrolysates (HSH; polyglycitol, polyglucitol, maltitol syrups)	3.0 calories

ROLES OF POLYOLS IN FOODS

- Polyols are used as sugar replacers and can replace both the bulk and the sweetness of sugar in products
- They can also enhance the flavor of the products in which they are used
- Unlike low-calorie sweeteners, most polyols are caloric, but can also replace the bulk necessary in the product similar to sugar
- They can be used in the same volume as sugar, allowing them to add bulk to the product with about half the calories of sugar
- Polyols have a mild sweet taste and are less sweet than sugar

ADVANTAGES OF POLYOLS

- Polyols taste like sugar, yet provide fewer calories.
- There are many sugar-free and reduced-sugar foods which also have fewer calories thanks to polyols and high-intensity sweeteners. Polyols are synergistic with high-intensity sweeteners, making them beneficial for use in blends.
- Polyols do not cause sudden increases in blood glucose levels, generally with a very low blood glucose response.

POLYOLS AND ORAL HEALTH

- Polyols do not promote tooth decay.
- They are not readily converted to acids by bacteria in the mouth, so therefore do not contribute to tooth decay nor promotion of dental caries/cavities
- The US Food and Drug Administration (FDA) has approved a health claim that sugar-free foods sweetened with polyols “do not promote tooth decay.”
- The American Dental Association has issued an official statement which supports the FDA claim, noting that sugar-free products contribute to overall good oral health.

HOW DO POLYOLS FUNCTION IN THE BODY?

- Polyols are only partially absorbed by the body.
- The absorbed portions are either metabolized, generally by insulin-independent mechanisms, or excreted via the urinary tract.
- Unabsorbed polyols are partially fermented in the colon and excreted.

JECFA ADI OF "NOT SPECIFIED"

- The Joint Food and Agricultural Organization (FAO)/World Health Organization (WHO) Expert Committee on Food Additives (JECFA) (1987) has issued an Acceptable Daily Intake (ADI) for polyols of "not specified," stating:
  - "On the basis of available data (chemical, biochemical, toxicological, and other), the total daily intake of the substance, arising from its use at the levels necessary to achieve the desired effect and from its acceptable background in food, does not, in the opinion of the committee, represent a hazard to health."
- This ADI is the most favorable from JECFA, noting no safety concern for the use of polyols

GASTROINTESTINAL EFFECTS

- For the vast majority of consumers, consumption of products made with polyols is problem free
- In some people, however, excessive consumption may cause mild and temporary gas or laxative effects, similar to reactions to beans and other high-fiber foods
- Most people will adapt after several days of consuming polyol-containing products
- If someone believes they are sensitive to consumption of polyols, they should start with small amounts and gradually increase the consumption of these products in their diet

REVIEW OF GASTROINTESTINAL EFFECTS

- In 2009, a review of 68 clinical studies evaluated reported gastrointestinal effects of polyols and other low-digestible carbohydrates. Researchers Dr. Joanne Slavin and Hollie Grabitske analyzed the studies for associations between gastrointestinal effects and intake levels of low-digestible carbohydrates and concluded:

  "Although the prevalence of low-digestible carbohydrates in the food supply is increasing, it appears that normal intakes of foods with these added carbohydrates are below the levels that would cause significant gastrointestinal effects."

Grabitske HA, Slavin JL. Gastrointestinal effects of low-digestible carbohydrates. *Crit Rev Fd Sci Nutr*, 2009; 49: 327-90.

DIABETES AND WEIGHT CONTROL

- Sugar replacers, including polyols, can be useful for people with diabetes or those trying to control their weight
- Polyols have a low rate of digestion and absorption, and thus cause smaller increases in blood glucose and insulin levels as compared to sugar and other carbohydrates
- Further, since polyols have fewer calories than sugar, products made with them may make weight goals easier to achieve

CALCULATIONS FOR EXCHANGE LISTS

- In calculations for exchange lists for those with diabetes, if all the carbohydrates in a food are from polyols and the total carbohydrates are less than 10 grams, the food is considered a “free food”
- If all the carbohydrates in the food are from polyols and the grams of polyols is greater than 10 grams, subtract half the grams of polyols from the total carbohydrate grams
- If there are several sources of carbohydrates in the food, including polyols, subtract half the grams of polyols from the total carbohydrate grams and count the remaining grams of carbohydrates according to a diabetic exchange list.

POLYOLS ARE GENERALLY CALORIC

- "Sugar-free" foods may be sweetened with one or more polyols, low-calorie sweeteners or a combination of both.
- Consumers should note that the claim "sugar-free" does not necessarily mean that a product is calorie- or carbohydrate-free.
- Polyols are not calorie- or carbohydrate-free and foods containing them will vary in their calorie and carbohydrate content.

NUTRIENT FACTS LABEL

- When looking at a product's Nutrient Facts label, the polyol ("sugar alcohol") content may be listed under the Total Carbohydrates.
- The US Food and Drug Administration (FDA) allows for voluntary declaration of the amount of polyols in a product unless a claim is made about the sugar content of the product, in which the amount must be labeled.
- If only one polyol is used, it may be declared individually by name on the Nutrient Facts label. Otherwise, if more than one are used, it will state "Sugar Alcohols."

POLYOLS AND ADDED SUGARS

- With the finalization of their rule on revisions to the Nutrient Facts label in 2016, the US Food and Drug Administration (FDA) has mandated labeling of added sugars on products
- The declaration of added sugars will appear under the declaration of total sugars in the section on total carbohydrates
- It is important for consumers to understand that the total sugars content represents all the sugar in the product and the added sugars line only notes the sugars which have been added, so these two numbers should not be combined
- In their final rule, the FDA stated that polyols are not considered added sugars and are thus not subject to the new mandate, making them ideal in reformulation of products to have reduced levels of added sugars

2012 CONSUMER SURVEY

- In 2012, the Calorie Control Council, at the request of the US Food and Drug Administration (FDA), conducted a consumer survey regarding the use of the term “sugar alcohols” versus “polyols”
- Even though sugar alcohols contain no sugar or alcohols, the results of the survey found that 74% of respondents believed a product labeled as “sugar free” containing “sugar alcohols” would contain some sugar, with 64% believing it would contain alcohol

CARBOHYDRATE LABELING

- Some food manufacturers using polyols in their products use the terms “net carbs” or “impact carbs” on the food label. These terms mean that same thing and labels vary which terms are used. However, it should be noted the US Food and Drug Administration (FDA) does not have definitions for these terms.
- As used, the total grams of polyols and fiber are subtracted from the total grams of carbohydrates in the food, meaning manufacturers are assuming that polyols and fiber have no significant impact on blood glucose. While polyols have less impact on blood glucose as compared to sugars, the impact is not zero.

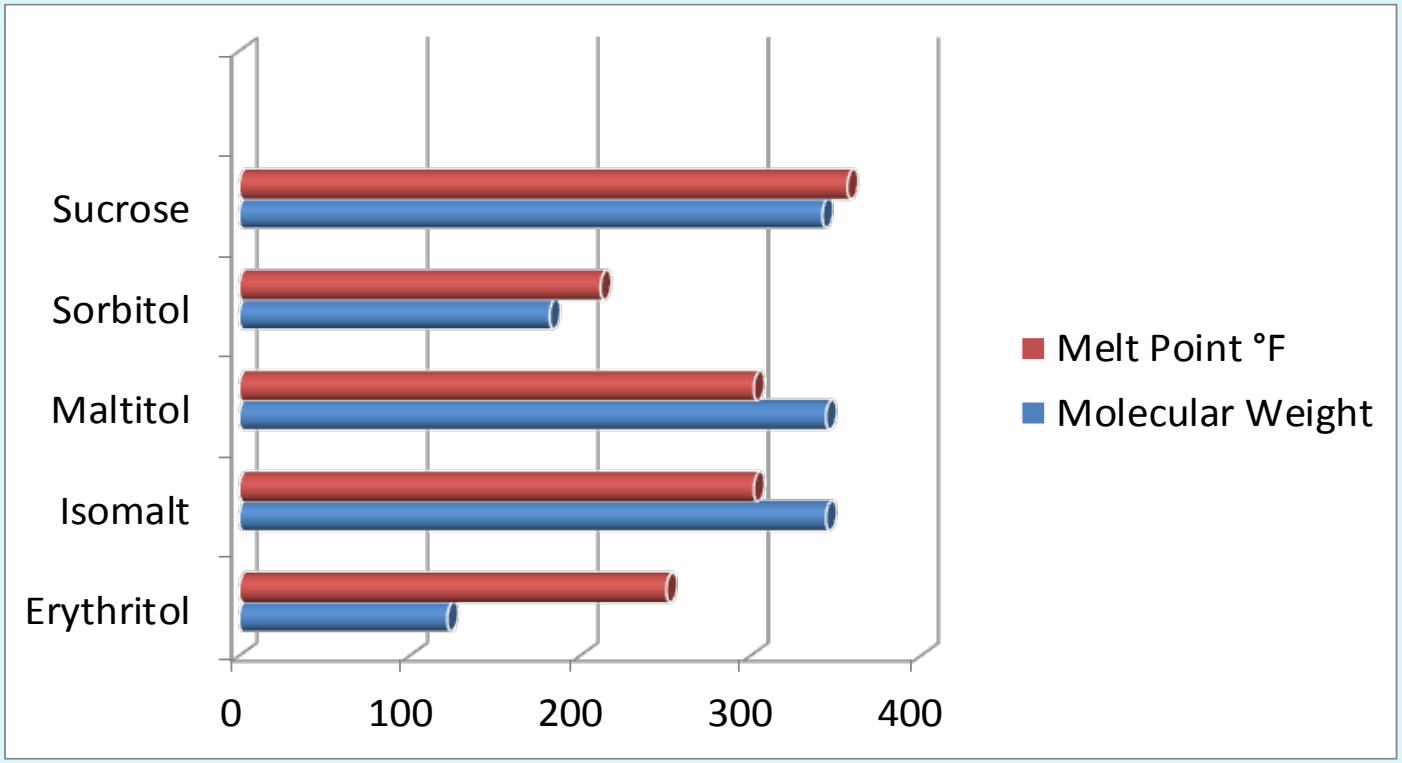
SUMMARY

- Due to the increased availability of polyols and innovations in food technology, consumers can enjoy many good-tasting products that are reduced in calories and sugar or that are sugar-free.
- Products made with polyols may assist in managing weight and blood glucose levels and in maintaining good oral health.
- Polyols are not considered sugars or added sugars, and with the new mandate for added sugar labeling, should be considered in reformulations to reduce levels of sugars and added sugars.

FUNCTIONALITY OF POLYOLS

MOLECULAR WEIGHT AND MELT POINT

- Molecular weight and melt point, while not the only functionalities to consider, are good to investigate when initially screening ingredients for applications
- Molecular weight compared to melt point for sucrose and polyols

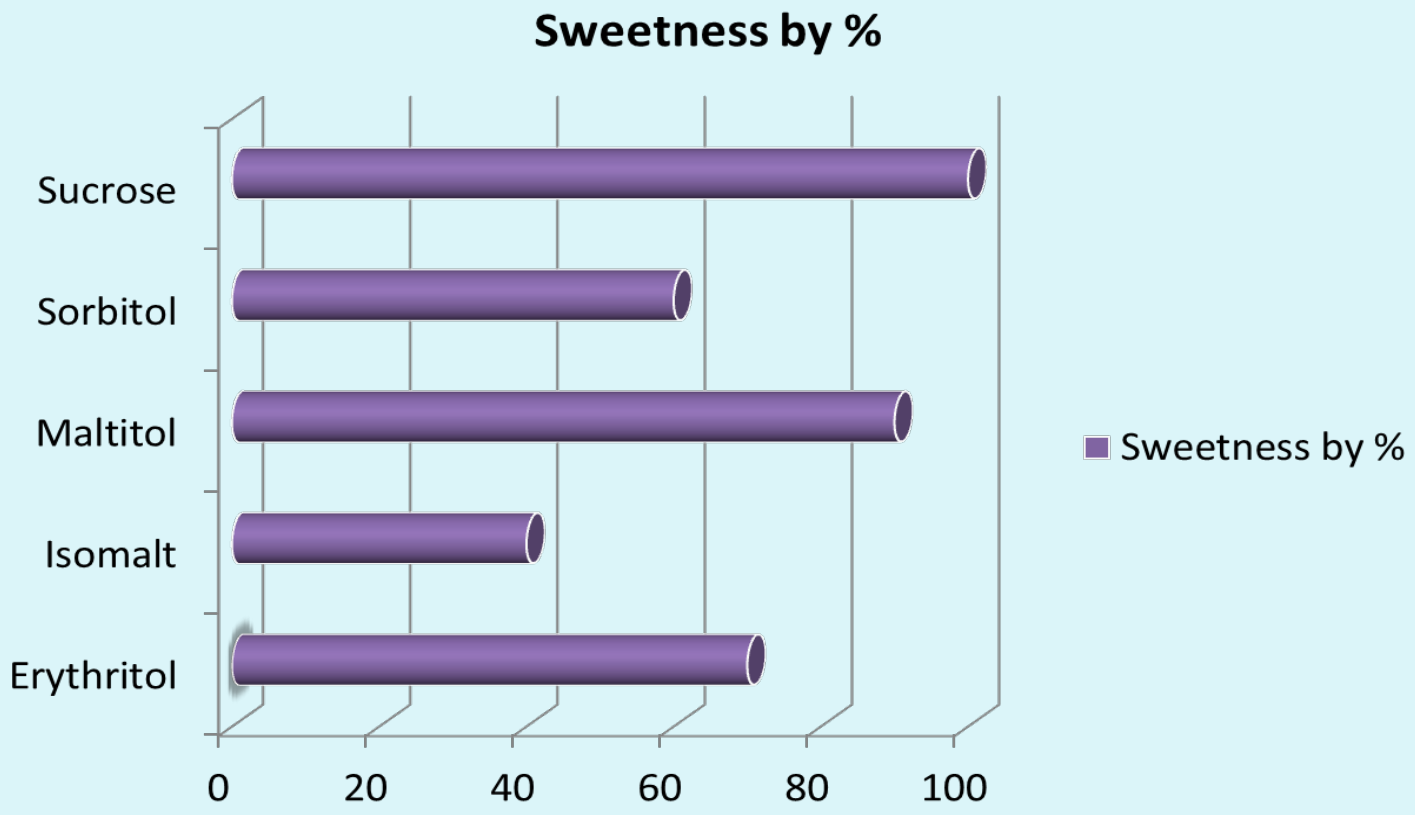


MOLECULAR WEIGHT AND MELT POINT

- As shown, sucrose has the highest melt point, with isomalt and maltitol being comparable
- Additionally, for bulking and structure, sucrose will behave similarly to isomalt and maltitol when considering molecular weight
- With a lower molecular weight, erythritol is not suitable for bulking and an additional agent may be needed
- While sorbitol has the lowest melt point of the polyols shown, it is very heat stable, making it ideal in certain applications

SWEETNESS OF POLYOLS

- Sweetness by percentage (sucrose is 100%)

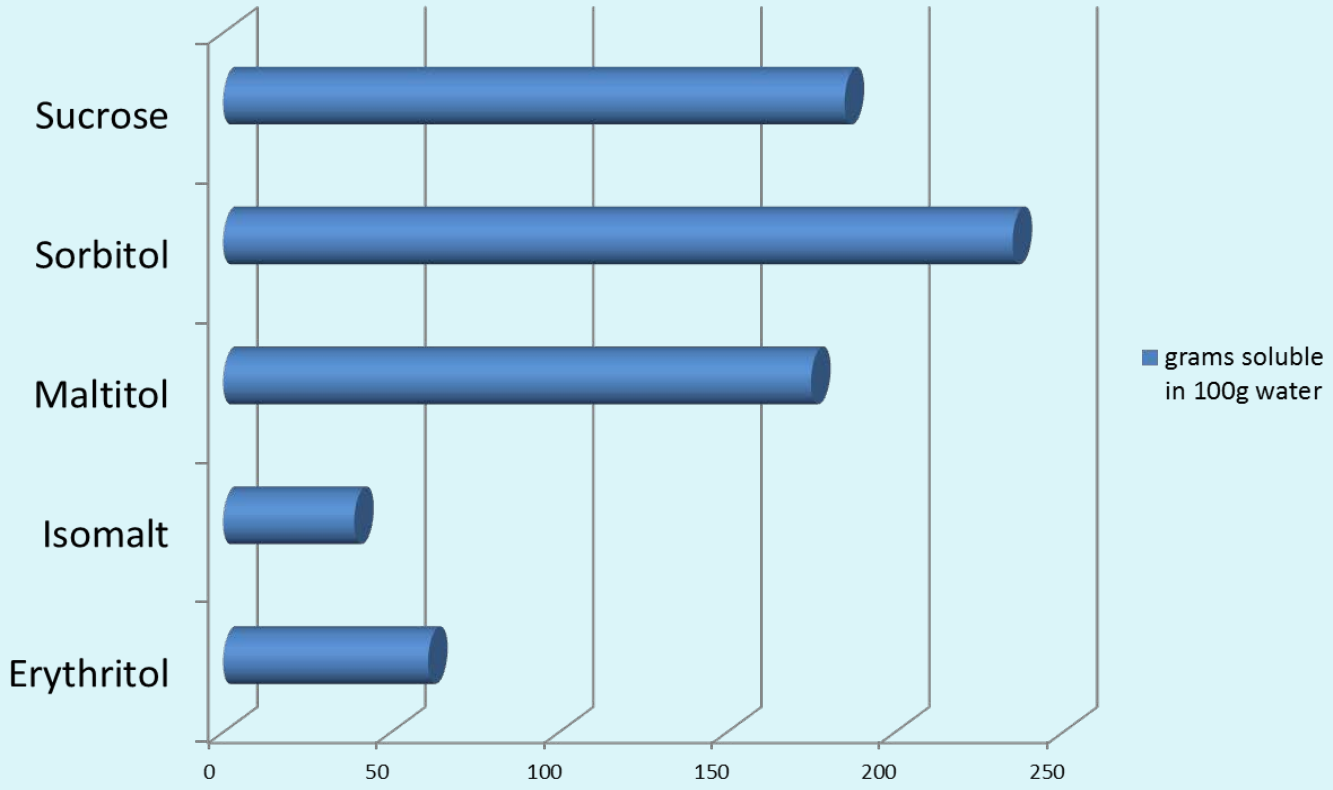


SWEETNESS OF POLYOLS

- Sweetness is top of mind when considering sugar replacement in a product and important to the quality of the product
- Polyols are generally less sweet than sucrose
- With those polyols which are much less sweet as compared to sucrose, formulators can consider blending with a high-intensity sweetener to help match a full-sugar product

SOLUBILITY OF POLYOLS

- Solubility at 25°C



SOLUBILITY OF POLYOLS

- Solubility of a polyol can lead to re-crystallization in a product, so it is important to tailor to the specific application and monitor throughout shelf-life of the product
  - Stability testing should be done to predict the impact over shelf-life of the product
- Lower solubility can lead to greater energy or cook time required for use in application, which should be considered, especially with large volume production

SUCROSE: HYGROSCOPICITY AND STABILITY

- Sucrose is highly water-soluble and very hygroscopic, allowing for humectancy and formation of crystalline structure once set in the system
  - This will also provide much of the bulking in baked goods and confectionaries
- Sucrose is sensitive to acid hydrolysis, leading to the development of glucose and fructose in a system
  - This could lead to pooling out in applications such as candies or weeping of syrups from products if there are too many acids
  - Reducing sugars will result in caramelization
  - Formulators would not see these reactions when using polyols

SORBITOL: HYGROSCOPICITY AND STABILITY

- Hygroscopicity is slightly higher than that of sucrose, which allows for more humectancy in baked goods, leading to products which will be more tender and moist
  - Might be good in an application such as a soft cookie, but not something which is meant to be crisp
- Lower melting point than sucrose and other polyols, but has a high temperature stability, so it would be beneficial in systems with high temperatures
- Sorbitol is also naturally present in fruits such as pears, apples and plums

MALTITOL: HYGROSCOPICITY AND STABILITY

- Maltitol is weakly hygroscopic as a solid
- Maltitol mimics sucrose fairly well (similar molecular weight, 90% as sweet), so is often used as a 1:1 replacement for sucrose
  - Often considered the industry “gold standard” for sugar replacement
- Since it has low hygroscopicity, maltitol can work well in fat systems such as chocolate
  - When in its crystalline formation, it stays in this formation more readily
- Works well in solution and can hold more moisture than sucrose, making for more tender baked goods over shelf-life

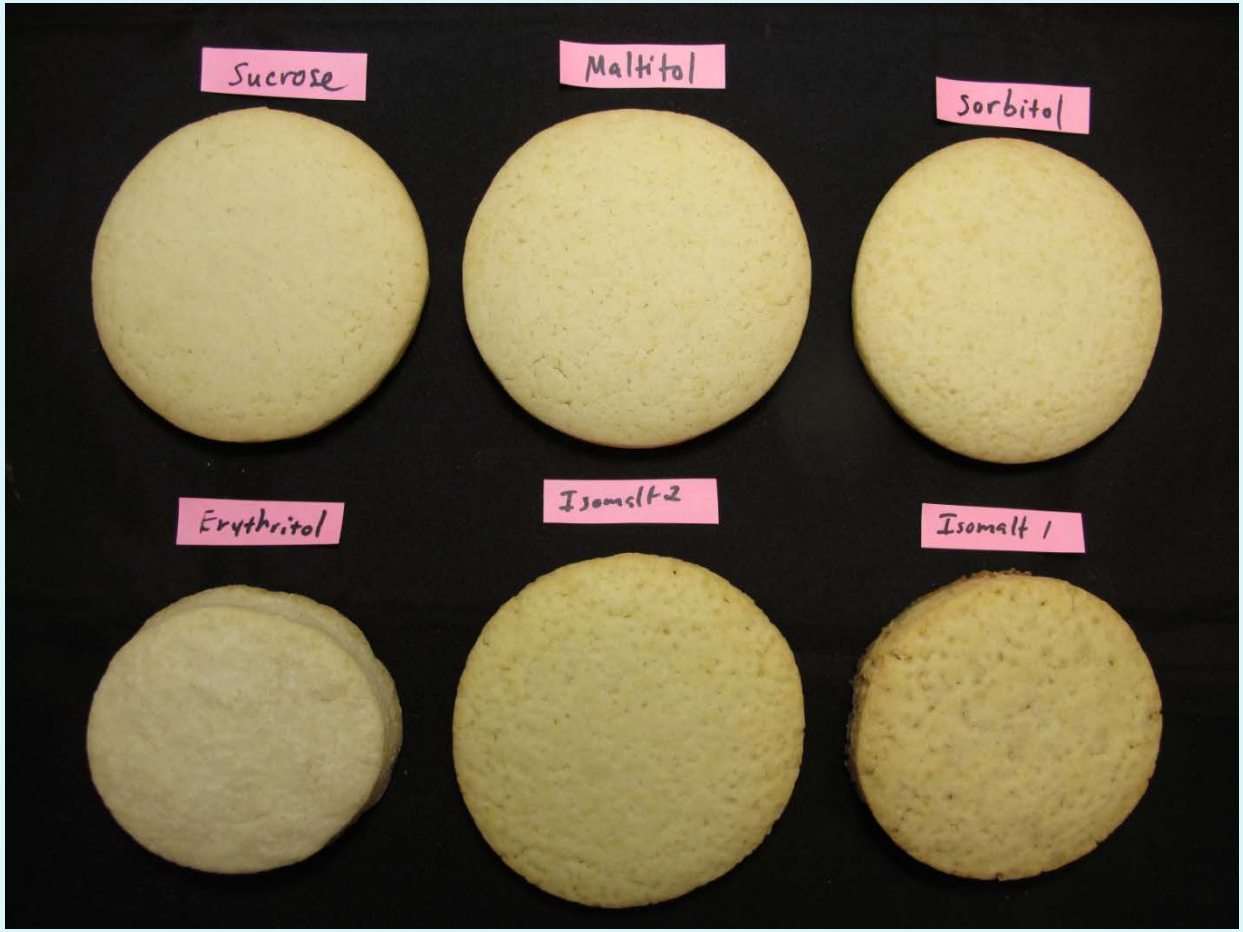
ISOMALT: HYGROSCOPICITY AND STABILITY

- Lower hygroscopicity compared to other polyols and sucrose, leading to stability over time in applications such as hard candies
- Since it has low water solubility and hygroscopicity, there can be re-graining over time
  - Can be desirable in applications where re-graining is desirable (e.g., fudge, foundat)
- Isomalt is heat and humidity tolerant
  - This can be advantageous for candies in which there is a concern about stickiness, though it can create a cloudy appearance

ERYTHRITOL: HYGROSCOPICITY AND STABILITY

- Erythritol has very low hygroscopicity, resulting in low water solubility and a strong tendency to re-crystallize
- It is strongly endothermic, requiring energy to break down
  - This property leads to a mouth cooling sensation
- Erythritol can be found naturally in fruits, mushrooms and other fermented products, making it ideal for “clean” applications
- However, erythritol is not ideal in baked goods due to its low hygroscopicity and low molecular weight
  - These properties keep starch gelatinization temperature low which will bind up water and not allow for it to be absorbed
    - This result prevents cookies from spreading and cakes from rising

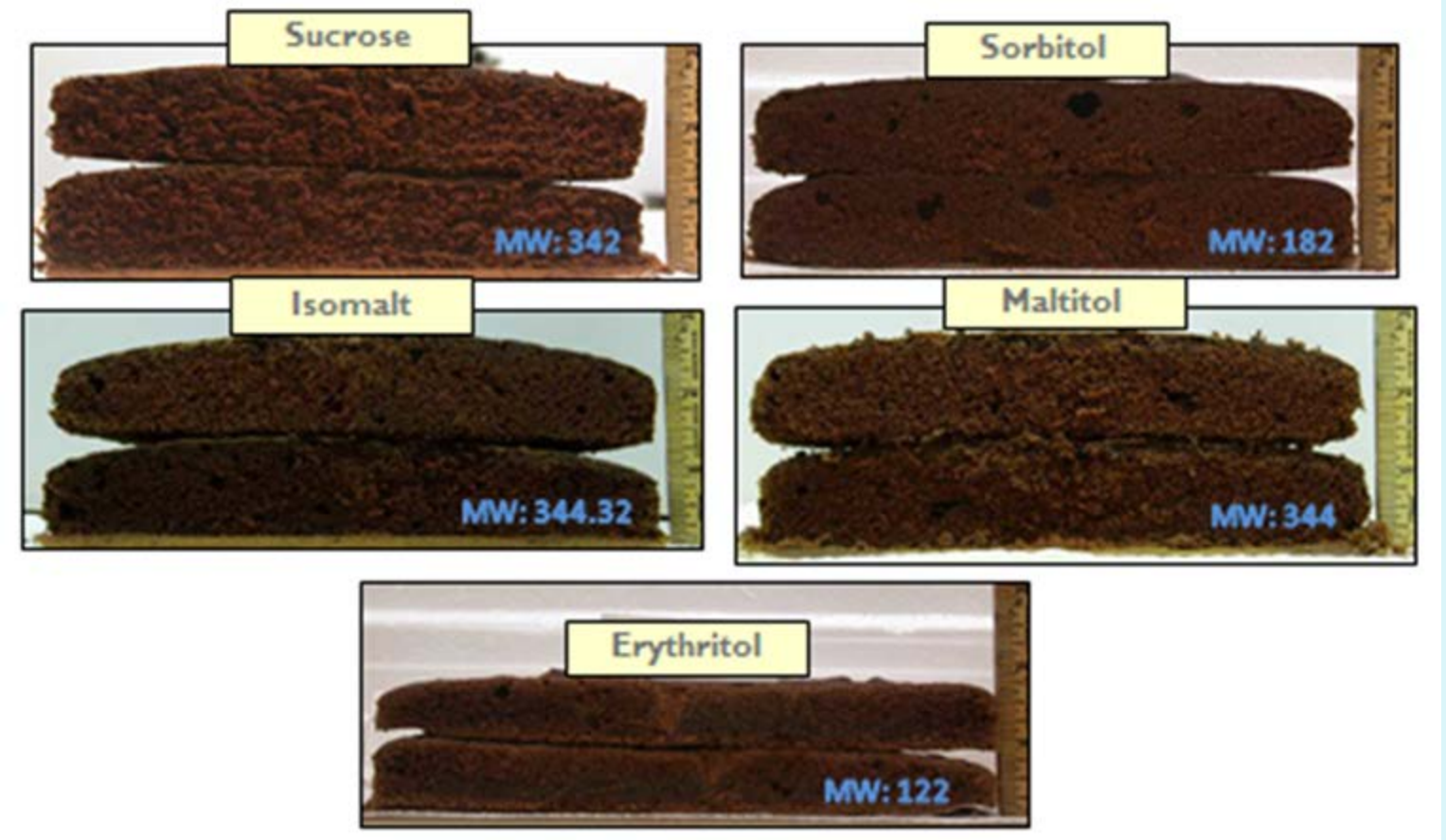
APPLICATIONS WITH POLYOLS: COOKIES



APPLICATIONS WITH POLYOLS: COOKIES

- Polyols were replaced in a 1:1 formula compared to the control with sucrose
- Compared to a control sucrose cookie, maltitol and the fine grain isomalt had similar spreads due to their comparable molecular weights
- The lower molecular weights of sorbitol and erythritol lead to less spread compared to sucrose

APPLICATIONS WITH POLYOLS: CAKES



APPLICATIONS WITH POLYOLS: CAKES

- Polyols were replaced in a 1:1 formula compared to the control with sucrose
- With similar molecular weights as sucrose, the cakes with isomalt and maltitol performed most similarly to the cake made with sucrose, with comparable rise and crumb structure
  - Over the shelf-life, with isomalt, there could be some crystallization and re-graining on the surface due to low solubility and hygroscopicity
- The cake made with sorbitol has a finer structure with some tunneling and a much more moist texture due to its high hygroscopicity
- With the low molecular weight, the cake made with erythritol displayed little rise and there is no leavening before the starch begins to gel, resulting in a flat, dense product

CONCLUSIONS

- Polyols are great replacements for sugars, including both sweet and savory applications
- With varying properties and functionalities, it is important to consider ideal conditions for the desired application, including solubility, molecular weight, sweetness and hygroscopicity