J. Dairy Sci. 97:3262–3272
http://dx.doi.org/10.3168/jds.2013-7365

Use of just-about-right scales and penalty analysis to determine appropriate concentrations of stevia sweeteners for vanilla yogurt

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ABSTRACT

With the mainstream emergence of natural sweeteners such as stevia, which is available in different commercial formulations, suitability for yogurt needs to be validated. The present study aimed to determine the appropriate concentration level of 3 processed stevia sweeteners/supplements in commercial plain low-fat yogurt flavored with natural vanilla. Three different levels of sucrose, aspartame, an erythritol and 95% rebaudiana A stevia sweetener, a 95% pure mix of maltodextrin and steviol glycosides, and a cold water stevia extract were used in the study. The just-about-right level for each sweetener and consumer acceptability of each naturally flavored low-fat vanilla yogurt were evaluated. Results from penalty analysis demonstrated that only 0.7% of stevia containing maltodextrin and 95% steviol glycoside was necessary, whereas higher levels (between 4.0 to 5.5%) were more appropriate for stevia containing erythritol and 95% rebaudiana A or cold water extract of stevia, respectively. The concentrations of stevia sweeteners used influenced the perceived sweetness and sourness. In general, consumers disliked the yogurt sweetened with stevia or aspartame, and neither disliked nor liked the yogurt sweetened with sucrose, which was largely driven by perceived sourness of the base yogurt. The findings underline the importance of careful selection of stevia type and concentration as well as optimizing yogurt cultures and fermentation conditions before product launch.
Key words: yogurt, stevia, just-about-right scale, penalty analysis

INTRODUCTION

Probiotic dairy foods are among the predominant foods that offer health-promoting (functional) properties to the human intestinal tract (Shah, 2000; Granato et al., 2010). Among the many foods that are used as carriers to deliver probiotics, dairy foods still prove to be the most promising mode (Skovsende, 2003); cheese and yogurt appear particularly promising (Lollo et al., 2012, 2013). Among probiotic dairy foods, yogurt is recognized as a nutrient-dense, healthy food and has gained particular popularity due to its availability as a natural flavored product containing a variety of fruits (Chandan, 2006). Besides the overall health appeal of yogurt itself, the presence of a significant amount of antioxidants (flavonoids and anthocyanin) in fruits such as strawberries, blueberries, and blackberries enhance the healthy image of yogurt (Tamime and Robinson, 1999; Chandan and O'Rell, 2006). To promote consumption of functional dairy foods by consumers with dietary restrictions, variants of "lite," low-fat, and nonfat probiotic dairy products, including yogurt, have been introduced commercially. These variants often include use of nonnutritive artificial sweeteners to improve palatability, consumer acceptability, and reduce total calories. As modern consumers seek natural foods with minimal additives, and concerns exist about additive safety, the food industry aims to create clean labels (Shim et al., 2011; Wu et al., 2012). With the awareness of plant-based high-intensity sweeteners such as stevia, processors can make "lite" products without artificial nonnutritive sweeteners.

Rebaudiana (**Reb**) A, isolated from *Stevia rebaudiana*, is relatively new to the US market as a natural sweetener. Often called sweet leaf, stevia originated in Paraguay from a genus comprising about 150 species of herbs and shrubs from the family Asteraceae. For about 1,500 yr, tribes in South America have used the leaves or extracts of stevia for its sweetening and medicinal properties. Stevia typically consists of 9 glycosides: stevioside; steviolbioside; rebaudioside A, B, C, D, E, and F; and dulcoside A (Kennelly, 2002; Starratt et al., 2002; Gardana et al., 2010). These glycosides have sweetness intensity of about 300 times that of sucrose and exhibit a high melting point and low solubility in water (Cramer and Ikan, 1987). With such stable properties, inclusion of stevia in the diet proves advantageous for diabetics and people suffering

Received August 13, 2013.
Accepted January 25, 2014.
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from obesity, heart disease, and dental caries (Kinghorn and Soejarto, 1985; Geuns, 2003). Stevia leaves have a slow onset, but long duration of sweet taste, whereas extracts often have a bitter, licorice-like aftertaste at high concentrations (Megeji et al., 2005).

Currently, stevia is available commercially in the isolated, ultrapure, crystalline form as a sweetener and in the crude form (whole or powdered leaf or as liquid extract) as a dietary supplement. Whereas the food-grade stevia sweetener is devoid of its inherent antioxidant property (i.e., antioxidant free), the dietary supplement possesses the inherent antioxidant property (i.e., it is antioxidant rich). Polyphenols present in stevia extracts inhibit hydroxyl radical, nitric oxide, superoxide anion, and hydrogen peroxide scavengers. The emerging role of antioxidants in inhibiting free radicals associated with diseases such as diabetes, cardiovascular disease, cancer, and aging (Keaney and Frei, 1994; Rice Evans, 1996; Arts and Hollman, 2005; Vita, 2005) has gained stevia attention (Ghanta et al., 2007; Shukla et al., 2009). Hence, the polyphenols in stevia might be beneficial as potential antioxidants.

Although raw stevia leaves and extracts are permitted for use as dietary supplements (McCaleb, 2006), they do not qualify for use as general sweeteners in foods due to concerns about the presence of secondary components that have pharmacological properties such as antiinflammatory, antitumor, antidiarrheal, diuretic, and immunomodulatory functions (Kinghorn, 2002). Many processes are used to purify steviol glycosides from stevia leaves. To further suppress or modulate the sweetness intensity of stevia, a variety of bulk sweeteners or fillers are added to purified stevia. Some of the fillers commonly used include sucrose, maltodextrin, lactose, inulin, and sugar alcohols (polyols) such as maltitol and erythritol. With an increasing demand for alternative sweeteners in the food industry (Haley et al., 2005), it might be beneficial to preserve the inherent antioxidant properties of stevia for use in functional food applications such as probiotic yogurt, but additional research must be conducted to evaluate suitability.

As both consumer acceptability and viability of probiotic bacteria define yogurt shelf life, the effect of natural sweeteners such as stevia on the sensory attributes and probiotic microorganisms must be investigated. Sensory attributes of yogurt with stevia sweeteners have been described using trained panelists (Guggisberg et al., 2011; Reis et al., 2011; Lisak et al., 2012), but no studies have reported consumer acceptability of yogurt with stevia. Additionally, penalty analysis has had limited application in food science publications (Endrizzi et al., 2013) and has not been reported for the sensory evaluation of yogurt. Penalty analysis, or mean drop analysis, is an emerging method in the food industry to provide direction in product development and optimization. Penalty analysis combines just-about-right (**JAR**) and overall liking tests to relate a decrease in consumer acceptance to attributes not at the JAR level (Lawless and Heymann, 2010). Just-about-right tests are used to measure the intensity of a specific sensory attribute (i.e., too-high, just-about-right, or too-low sweetness). Generally, a 5- or 7-point JAR scale is used to determine intensity of attributes that can affect the acceptance of the overall product. Acceptance tests are used to identify the liking of a product and individual product attributes. Rating scales for acceptance tests may be 5-, 7-, or 9-point hedonic scales, ranging from dislike extremely to like extremely (Lawless and Heymann , 2010). In the development of new products, as well as reformulating products, JAR tests are commonly used to connect consumer acceptance tests with the intensity of specific attributes to help improve consumer acceptability (Gacula et al., 2007; Villegas et al., 2010). Penalty analysis penalizes products in terms of penalty or deviation from JAR. Hence, this study was designed to investigate consumer acceptance of commercial yogurt, flavored with natural vanilla and sweetened with a variety of stevia extracts using JAR and penalty analysis.

MATERIALS AND METHODS

A commercial sample of plain low-fat yogurt (Anderson Erickson Dairy, Des Moines, IA) was used to prepare the yogurt, which was flavored with pure natural vanilla extract in 35% alcohol (donated by Tone's Spices, Ankeny, IA). Although strawberry yogurt is more popular than vanilla yogurt, vanilla was selected because of its simplicity (2 ingredients). Production of strawberry yogurt would have required use of fruit pieces and building a pectin/starch based matrix gel to achieve ideal texture in final product. Ideal selection of strawberry flavoring, strawberries, sweetening, and coloring would have been more difficult and the objective was to focus on the sweeteners rather than flavoring per se. Sucrose (C&H cane sugar; C&H Sugar Co. Inc., Crockett, CA), aspartame (Equal; Merisant, Chicago, IL), erythritol and 95% rebaudiana A (**Ery-Reb**; Truvia; Cargill, Minnetonka, MN), and a 95% pure mix of maltodextrin and steviol glycosides (**Mdx-Glyc**; NOW Foods, Bloomingdale, IL) were purchased from US vendors. A polyphenol-rich cold-water (**CW**) extract of stevia leaves was prepared (Kutowy et al., 1999) from sundried leaves of *S. rebaudiana*, donated by GLG Life Tech Corp. (Vancouver, Canada; origin: Qingdao, China).