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Consumer acceptance of natural sweeteners in protein beverages

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ABSTRACT

Protein beverage consumption by Americans has increased in recent years. Coupled with this increased consumption is an interest in natural sweeteners. The objective of this study was to evaluate the sensory properties of naturally sweetened ready-to-mix (RTM) whey protein beverages using 3 temporal methods and to formulate a natural noncaloric sweetener blend that could be added to RTM protein beverages to provide sweetness while still appealing in flavor to consumers. Iso-sweet concentrations of sweeteners (sucralose, sucrose, fructose, stevia, monk fruit) in RTM vanilla whey protein beverages (25 g of protein/360 mL of water) were established using magnitude estimation scaling and 2-alternative forced-choice testing. Temporal sensory profiling was then conducted on each beverage by a trained panel using time intensity, temporal dominance of sensations, and temporal check-all-that-apply. These findings were used to formulate natural sweetener blends that closely matched the temporality of sucrose-sweetened RTM vanilla protein beverages for consumer testing. One sugar-free blend (25% stevia/75% monk fruit) and 1 reduced-sugar blend (25% stevia/25% monk fruit/50% fructose) were selected for consumer testing (n = 150 consumers) in addition to 3 control RTM beverages containing sucralose, stevia, or monk fruit. Two distinct consumer clusters were identified. The label-conscious segment of consumers preferred beverages sweetened with natural blends when primed. The flavor-driven segment of consumers conceptually preferred naturally sweetened beverages but preferred sucralose-sweetened beverages when primed. An all-natural label claim was most preferred across all consumers. Application of these findings to commercially produced RTM protein beverages aids in the development of naturally sweetened protein beverages with reduced calories and desirable sensory properties and highlights the importance of label claims to consumers overall but to a label-conscious segment of consumers in particular.

Key words: protein beverage, natural sweetener, consumer acceptance

INTRODUCTION

Protein beverages have increased in popularity among American consumers in recent years as more Americans aim to increase their dietary protein intakes (Gerdes, 2012; Jacobson, 2015). One of the most common protein sources for protein beverages is whey protein, in the form of either whey protein concentrate 80 or whey protein isolate (**WPI**). Both products are produced from membrane filtration of liquid whey (Foegeding and Luck, 2011). Whey proteins are a complete source of essential AA and are high in branched-chain AA that may aid in muscle recovery after exercise, making it an ideal protein source in protein beverages (Blomstrand and Saltin, 2001; Hazen, 2003; Childs et al., 2008).

Previous research has demonstrated the importance of naturally sweetened protein beverages with low carbohydrate content to consumers (Gerdes, 2012; Jacobson, 2015; Oltman et al., 2015). However, sweet taste is also a desirable attribute to many consumers, and direct sugar removal may negatively affect consumer liking. Previous literature demonstrated a threshold for direct sugar removal of 25 to 40% in various dairy products without negatively affecting consumer acceptance (Cadena et al., 2012; Chollet et al., 2013; Hoppert et al., 2013; Li et al., 2015; Oliveira et al., 2015). Beyond this threshold, nonnutritive alternative sweeteners can be used to replace sugar and maintain sweet taste.

Natural nonnutritive sweeteners are derived from plants and comprise natural compounds, typically sweet glycosides (Kim and Kinghorn, 2002). *Siraitia grosvenorii* (monk fruit) is a fruit native to southern China that contains sweet glycosides mogroside IV, mogroside V, and mogroside VI (Kinghorn and Compadre, 2001; Pawar et al., 2013). Stevia, another natural sweetener, is composed of sweet glycosides stevioside and rebaudioside A (Kinghorn et al., 2001). To best formulate

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sucrose replacement with alternative sweeteners, the sweetness equivalence (iso-sweetness), or the amount of alternative sweetener that produces the same sweetness intensity, must first be determined. Magnitude estimation scaling (**MES**) followed by descriptive analysis and 2-alternative forced-choice (**2-AFC**) testing is one set of methods to confirm sweet taste equivalency (Cardello et al., 1999; Lawless and Heymann, 2010; Li et al., 2015).

Although alternative sweeteners are useful for reducing sugar, carbohydrate, and calorie content, they may have a different sweetness temporality compared with sucrose at iso-sweetness and may may contain undesirable off flavors such as bitter or metallic tastes (Kim and Kinghorn, 2002; Souza et al., 2013; Morais et al., 2014; Zorn et al., 2014). As such, sensory documentation of the temporality of sweet taste as well as the presence and temporality of other flavors or tastes associated with nonnutritive sweeteners is important when replacing sugar. Previous studies have evaluated sweeteners in food and beverage products using temporal sensory methodologies (Palazzo et al., 2011; Souza et al., 2013; Morais et al., 2014; Zorn et al., 2014; Azevedo et al., 2015). These methods have also been used for other food products such as hot beverages, flavored gels, red wine, and dairy products (Le Reverend et al., 2008; Labbe et al., 2009; Meillon et al., 2009; Pineau et al., 2009; Castura et al., 2015).

The majority of previous studies have focused on artificial nonnutritive sweeteners, whereas relatively little work has been done to investigate and characterize the temporality of natural nonnutritive sweeteners. In addition, there has yet to be a study that investigates how the addition of alternative sweeteners to whey protein beverages affects their sensory properties. The objective of this study was to profile the sensory properties of ready-to-mix (**RTM**) whey protein beverages sweetened with the natural sweeteners stevia, monk fruit, and crystalline fructose and blends of these sweeteners using 3 temporal methods: time intensity (**TI**), temporal dominance of sensations (**TDS**), and temporal check-all-that-apply (**TCATA**). Through temporal sensory evaluation of these beverages, the ultimate goal was to formulate a natural sweetener blend that could be added to RTM protein beverages to provide sweetness without added sugar, calories, or carbohydrates and that was still desirable to consumers.

MATERIALS AND METHODS

Experimental Overview

Ready-to-mix vanilla whey protein beverages were formulated with iso-sweet concentrations of 5 sweeteners (sucralose, sucrose, fructose, stevia, and monk fruit). Iso-sweetness was confirmed in each beverage with MES and 2-AFC testing. Sweetened beverages were profiled using descriptive analysis and temporal sensory profiling methods (TI, TDS, and TCATA) with trained panels. These results were used to formulate natural sweetener blends that closely matched the temporality of sucrose-sweetened RTM vanilla protein beverages. Of the 7 natural sweetener blends, 1 sugar-free blend and 1 reduced-sugar blend were selected for consumer testing against 3 control RTM beverages sweetened with sucralose, stevia, or monk fruit. Consumers (n = 150) evaluated beverages with and without priming statements in a 2-d crossover design test.

Sample Preparation

Protein beverages were prepared according to a common industry formulation to contain either 15 or 25 g of protein per 360 mL of water (Table 1). Two commercial sources of WPI (Cheddar, microfiltration, Northwest commercial supplier; Cheddar, anion exchange, Midwest supplier) were used to make RTM protein beverages. Both WPI met the legal definition of WPI (at least 90% protein). Beverages were formulated with WPI, deionized (**DI**) water, sweetener, and vanilla flavoring (natural vanilla 1032, natural cream 0151, natural French vanilla 1068; Flavor Artistry, Corona, CA). Both WPI sources were obtained directly from the plant as spray-dried powders within 30 d of production and stored at −80°C throughout the duration of the study. Sucrose (Imperial Sugar Co., Sugar Land, TX), crystalline fructose (Krystar 300; Tate & Lyle, Decatur, IL), sucralose (Hard Eight Nutrition, Henderson, NV), monk fruit extract (Purefruit Select monk fruit extract; Tate & Lyle), and stevia leaf extract (Tasteva stevia sweetener; Tate & Lyle) were added as sweeteners to the RTM vanilla protein beverage base. All sensory testing was approved as exempt by the North Carolina State University Institutional Review Board for human subjects.

Power Function Curves of Natural Nonnutritive Sweeteners in Water, Protein Base, and Vanilla-Flavored Protein Beverages

Power function curves were generated for stevia, monk fruit, fructose, and sucralose in DI water, WPI solution (15 or 25 g of protein/360 mL of DI water), and vanilla-flavored WPI beverages (15 or 25 g of protein/360 mL of DI water) by trained panelists (n = 8; 5 women, 3 men, ages 22–30 yr). Each panelist had a minimum of 40 h of previous descriptive analysis