Use of Single or Multiple Attribute Time-Intensity and Conventional Panel Results to Compare Sucralose, Stevia, or Sucrose Sweetened Chocolate Meal Replacements Beverages

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Introduction

Chocolate meal replacement beverages are a convenient food form for delivery of functional benefits. Consumers seek not only reduced calories but also satiety from meal replacements. Meal replacements must not only satisfy strict nutritional requirements but must also be formulated to deliver an acceptable flavour experience for frequent/routine consumption by consumers. Sucralose, an artificial sweetener, and Stevia, a natural sweetener and sugar substitute, are both alternatives to sucrose for delivering sweetness without calories. Both alternatives, however, alter sweetness taste perception.

This research was used to provide detailed understanding of how artificial and natural sweetener profiles varied from a sucrose-sweetened chocolate meal replacement beverage as a control sample. The study was also designed to explore differences in the time-intensity attributes of chocolate, sweetness and bitterness of sucralose-sweetened samples made with and without the sweet enhancer versus the sucrose-sweetened control. Data were gathered using single-attribute TI, multi-attribute TI and conventional descriptive panel (maximum intensity ratings) following the cycling protocol of multiple sips and expectoration over a 3-minute consumption.

Research Objectives

The main objectives of this research were:

- Determine which test sample was most like the control (sucrose)
- Assess method consistency, advantages and disadvantages
- Measure panel performance in the 3 methods

Materials and Methods

Sample Preparation

Chocolate flavoured meal replacement beverages sweetened with various natural sweeteners were mixed with skim milk using an emersion blender.

Table 1. Samples

Sample	Sweetener
1	Sucrose
2	Sucralose
3	Sucralose with Sweet Enhancer
4	Stevia

Panel

Eleven trained panelists who had completed at least 120 hours of descriptive training using universal scale attribute standards participated in the study. Panelists were oriented and trained on the MATI/SATI/Conventional evaluation over a 2-week period.

Evaluation Protocol

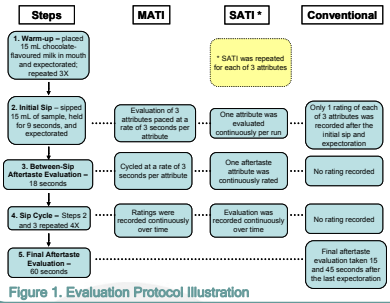

Figure 1. Evaluation Protocol Illustration

Materials and Methods (continued)

Evaluation Protocol (continued)

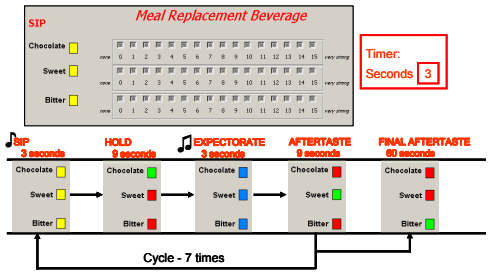

Figure 2. MATI Panel Ballot and Illustration of Sip Protocol

Statistical Analysis

- Product ratings and parameter values (Imax) of curves were compared based on similarity (equivalence) testing
- Methods were compared using analysis of variance (ANOVA)
- Curves were smoothed with a spline smoothing technique
- Adaptive high-dimensional analysis of variance (HANOVA) was used for comparisons of products and methods based on curves
- Intraclass correlation coefficient (ICC) and multivariate intraclass correlation (MICC) were used for measuring panel performance

Results and Discussion

Sample

- Sweetness varied most among the samples; chocolate and bitterness showed smaller differences.
- None of the samples matched the control on sweetness.
- Sucralose or Sucralose with Sweet Enhancer were the closest matches to control on sweetness.

Table 2. Means and Similarity Test P-Values with Sucrose Control

Sample Name	Conventional			SATI			MATI		
	Chocolate	Sweet	Bitter	Chocolate (Imax)	Sweet (Imax)	Bitter (Imax)	Chocolate (Imax)	Sweet (Imax)	Bitter (Imax)
1-Sucrose	4.7	5.8	0.8	5.6	6.6	2.6	5.2	5.9	1.7
2 - Sucralose	4.4	4.4	1.4	4.8	5.6	2.3	4.5	5.2	1.7
3 - Sucrolose w/Sweet Enhancer	4.1	4.7	1.3	5.0	5.6	2.2	4.2	4.9	1.7
4 - Stevia	4.5	3.7	2.0	5.6	5.0	3.0	4.6	4.2	2.1

Sample Name	Chocolate	Sweet	Bitter	Chocolate (Imax)	Sweet (Imax)	Bitter (Imax)	Chocolate (Imax)	Sweet (Imax)	Bitter (Imax)
1-Sucrose									
2 - Sucralose	0.0002*	0.3792	0.0007*	0.0023*	0.0970*	0.0007*	0.0356*	0.0023*	<0.001*
3 - Sucrolose w/Sweet Enhancer	0.0014*	0.0786*	0.0000*	0.0001*	0.0319*	0.0004*	0.0949*	0.0161*	<0.001*
4 - Stevia	0.0092*	0.8775	0.0653*	0.0000*	0.6301	0.0011*	0.0228*	0.7527	<0.001*

Note: *Significant at alpha=0.1 with similarity limit 1.5.

Panel Performance

- ICC is defined as a ratio of the variance of interest (e.g., variance of products for evaluation) over the total variance (e.g., the sum of the variance of products and the variance of responses of panelists).
  Hence, ICCs can measure both difference among products (or discriminability of a panel) and reliability of a panel.

$$ICC = \frac{\sigma_a^2}{\sigma_a^2 + \sigma^2}$$

- ICC values for sweetness are 0.35, 0.32 and 0.19 respectively for the 3 methods (conventional panel, SATI and MATI).
- No ICC significant differences were found across methods, though MATI ICC tends to be smaller.
- ICCs for chocolate and bitter are about zero for SATI and MATI.
  It suggests the differences among products are relatively small for these attributes.

Results and Discussion (continued)

Method

- While generally consistent, the three methods show significant differences, MATI and especially SATI Imax ratings are larger than conventional panel ratings. In part, this may be because the Imax from conventional panel data are based on the first sip, while for SATI or MATI are based on the maximum values of the 5 sips (Figure 3).
- Whole curves are significantly different across sweeteners (Figures 4-5).

Table 3. HANOVA for Testing SATI or MATI Curves vs. Sucrose Control

Sample Name	SATI Chocolate T_{AN}	SATI Chocolate SN	SATI Sweet T_{AN}	SATI Sweet SN	SATI Bitter T_{AN}	SATI Bitter SN	MATI Chocolate T_{AN}	MATI Chocolate SN	MATI Sweet T_{AN}	MATI Sweet SN	MATI Bitter T_{AN}	MATI Bitter SN
1 - Sucrose												
2 - Sucralose	0.06	N	1.41	N	-2.9	N	-1.7	N	-1.6	N	-1	N
3 - Sucralose w/Sweet Enhancer	-1	N	-0.2	N	-2.9	N	0.58	N	10.3	S	1.77	N
4 - Stevia	-3.3	N	7.93	S	-0.8	N	-2.1	N	6.82	S	-2.5	N

If T_{AN}>2.86, a significant difference is found at alpha= 0.1 based on Table 1 (n=T/2=110) in Fan and Lin (1998).

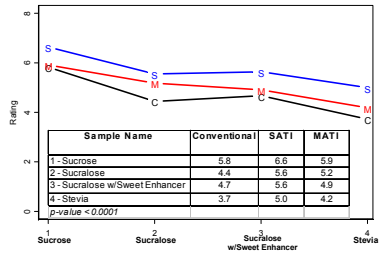

Figure 3. Method Comparison (Sweet)

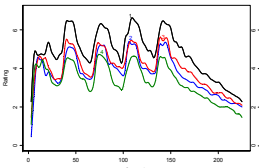

Figure 4. SATI Sweet Curves

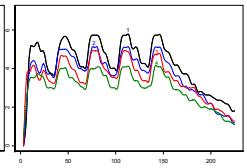

Figure 5. MATI Sweet Curves

Conclusions/Recommendations

The current research was used to provide detailed understanding of how artificial and natural sweetener profiles varied from a sucrose-sweetened control sample.

- SATI and MATI (curves) provide more information about sensory attributes than conventional panel (point) descriptive analysis.
- MATI is a time-saving method by measuring several attributes in a run compared to SATI or conventional methods.

Guidance was provided to deliver a sweetened, reduced-calorie chocolate meal replacement that most closely matched a sucrose sweetened meal replacement. MATI can be used cost-effectively for ingredient research formulation efforts.

References

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