Tygon® E-65-F
"Taste and Odor Free" Claim Study
For Applications with Milk and Cola Syrup

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Background

Saint-Gobain (SG) is a leading producer of performance plastics and fluid systems who have a tubing product (Tygon® E-65-F) intended for use in a range of applications including syrups such as cola and dairy products such as milk. Saint-Gobain's marketing group wanted to claim the tubing as "Taste and Odor Free" for these applications to its customers. Consequently, SG contacted the Tufts University Sensory and Science Center (TUSSC) and requested the use of its trained and experienced descriptive sensory panel to apply standard sensory and material testing methods to develop sufficient data to support this claim.

The Sensory Practice at TUSSC is led by Roy Desrochers. (Appendix A) Mr. Desrochers has been a sensory practitioner for over 35 years and has trained and certified thousands of sensory panelists around the world in the use of descriptive sensory analysis. In addition, he has extensive experience in applying standard tests to measure and understand how materials in contact with food and beverage products affect sensory quality. Mr. Desrochers trained a descriptive sensory panel within TUSSC to conduct sensory tests such as these and served as the panel leader on all the descriptive sensory panels conducted in this study.

This report summarizes the approach, results, and conclusions of the sensory testing conducted by the TUSSC Sensory Practice on the tubing product of interest.

1. Approach

1.1 Objective

The overall objective of this study was to use the TUSSC trained descriptive sensory analysis panel to evaluate the sensory performance of Saint-Gobain's Tygon® E-65-F tubing in contact with Coca-Cola® Syrup and whole fat milk. Specifically:

- Qualitatively and quantitatively describe any effects to the aroma or flavor of Coca-Cola® and aroma and flavor of whole fat milk with direct contact to the Tygon® E-65-F tubing.
- Interpret the results using our extensive consumer testing experience and related knowledge to determine if the average user would consider the tubing when used to transfer whole fat milk or Coca-Cola® Syrup to be "taste and odor free"

1.2 Experimental Design

SG submitted three production dates (lots) of their Tygon® E-65-F tubing to TUSSC for sensory testing. The TUSSC descriptive sensory panel followed a robust design to evaluate the tubing. This design included:

- 3 different production dates of the Tygon® E-65-F tubing (lots)
- 2 test media (Coca-Cola® Syrup and whole fat milk)
- 3 sensory panel replications of each condition (randomized and presented blind)
- 1 fill and hold temperature (38°F)

1.3 Sample Preparation and Sensory Evaluation

1.3.1 Direct Contact Test

The direct contact test utilized in this study is a modification of ASTM E1870-11, Standard Test Method for Odor and Taste Transfer from Polymeric Packaging Film, to assess flexible tubing. The modifications include:

- The material surface area to medium volume ratio used is the greater of the intended use ratio or 1 cm^2/1ml (15$in.^2$/3oz)
- The contact time is set at the maximum allowed, 24 hours, to represent worst case direct contact time
- The number of assessors required is 3, consistent with the number of trained descriptive panelists required to conduct Flavor Profile (Appendix B) and Profile Attribute Analysis. (PAA-Appendix C)

- The sensory methodology used to evaluate the samples is modified flavor profile using the PAA seven-point intensity scale; 1=none, 2=very slight, 3=slight, 4=slight to moderate, 5=moderate, 6=moderate to strong, and 7=strong (Appendix D)
- The data is generated and collected using a discussion period and then recording consensus results

The Saint-Gobain Tygon® E-65-F tubing that we received and used for the sensory testing had the following dimensions and labeling:

- 0.250 Inner Diameter
- O.448 Outer Diameter
- 100 Ft Length
- Sample ID: 0531
- Lot number (either 1, 2, or 3)
- Date: 12/18/2017

These dimensions were the intended use dimensions and resulted in an inner tubing surface area to medium volume ratio of approximately 6 cm^2/ml, which is greater than the minimum ratio of 1cm^2/ml. Since the intended use ratio is greater than the minimum recommended in the standard, testing the tubing as received was a conservative and valid test.

We cut six 5 ft. (60 in, or 152.4 cm) sections of each lot of tubing. In three sections of each lot, we cold filled them with whole fat milk and pinched the ends with clamps. Different than a total immersion test, this preparation results in the medium (milk) in contact with the inside wall of the tubing samples only, as is the case in actual use. Once the ends were clamped, each section of filled tubing was wrapped in aluminum foil to prevent any vapor phase transfer (tainting) from other samples. The samples were then placed in refrigeration at 38°F for 24 hours.

In the other three sections of each lot of tubing, we cold filled them with Coca-Cola® syrup and pinched the ends with clamps. As with the milk samples, this preparation results in the medium (cola syrup) in contact with the inside wall of the tubing samples only, as is the case in actual use. Once the ends were clamped, each section of filled tubing was wrapped in aluminum foil to prevent any vapor phase transfer (tainting) from other samples. The samples were then placed in refrigeration at 38°F for 24 hours.

After 24 hours at 38°F, the tubing samples with milk were unwrapped and poured off into new 3-ounce white solo plastic cups that had been screened and confirmed to be odor free. These cups are preferred to glass since glass often contributes chalky and musty characteristics to samples during evaluation. The samples were then submitted blind and in random order to the TUSSC descriptive sensory analysis panel.

Also after 24 hours at 38°F, the tubing samples with Coca-Cola® Syrup were unwrapped and poured off into new 3-ounce white solo plastic cups that had been screened and confirmed to be

odor free. Each cup was then brought to the final recommended dilution of 5 parts water to 1-part syrup using cold, taste and odor free, carbonated water. The samples were then submitted blind and in random order to the TUSSC descriptive sensory analysis panel.

Controls for both milk and Coca-Cola® Syrup were prepared by placing 50 ml of cold media in separate clean glass bottles, covering them with aluminum foil, and tightly securing the bottle cap over the aluminum foil. The controls were also put into refrigeration at 38°F for 24 hours and prepared for submission to the TUSSC descriptive sensory analysis panel consistent with the way the tubing samples were prepared for both milk (direct analysis) and Coca-Cola® Syrup (diluted 5:1 using cold, taste and odor free, carbonated water).

1.3.2 Sensory Methodology

At least three members of the TUSSC descriptive sensory analysis panel, including Roy Desrochers, evaluated the samples cold and one at a time using Modified Flavor Profile. Modified Flavor Profile, which is based on the Flavor Profile Method of Sensory Analysis (ASTM Manual Series: MNL 13), includes two key measures of Total Intensity of Aroma (TIA) and Total Intensity of Flavor (TIF). In addition to rating the overall intensity of aroma and flavor, the panel also records the top sensory characteristics using terms based on reference standards, and any level of perceived taint notes. If taint notes are perceived, they are assigned their own intensity using the standard PAA seven-point intensity scale.

2. Results

2.1 Coca-Cola® Syrup

The results of the TUSSC descriptive sensory analysis panel evaluations of the tubing in contact with Coca-Cola®Syrup are presented in the table below and expressed as a panel composite of the sensory panel blind replications done in triplicate:

Sample	TIA	Description	TIF	Description
Control	5	Cola complex, vanilla, syrupy sweet	6	Sweet, Cola complex, sour, No taint off-notes
Lot 1	5	Cola complex, cinnamon, citrus, similar to control	5	Very slight suppression, no taint off-notes
Lot 2	5	Cola complex, cinnamon, citrus, similar to control	5	Very slight suppression, no taint off-notes
Lot 3	5	Cola complex, cinnamon, citrus, similar to control	5	Very slight suppression, no taint off-notes

Overall, there was a very slight suppression of the cola flavor and no detection of taint notes.

2.2 Milk

The results of the TUSSC descriptive sensory analysis panel evaluations of the tubing in contact with whole fat milk are presented in the table below and expressed as a panel composite of the sensory panel blind replications done in triplicate:

Sample	TIA	Description	TIF	Description
Control	3	Fresh milk, fatty, No taint off-notes	4	Fresh milk, fatty, No taint off-notes
Lot 1	3	Very slight plastic/rubbery	4	Plastic/rubbery/burnt ballast=2, very slight suppressed milk
Lot 2	3	Very slight suppression	4	Plastic/rubbery/burnt ballast=2, very slight suppressed milk
Lot 3	3	Very slight plastic/rubbery	5	Plastic/rubbery/burnt ballast=2, very slight suppressed milk

Overall, there was a very slight suppression of the milk flavor and detection of a very slight level of a taint note described as plastic/rubbery.

3. Conclusions

3.1 Conclusion for Coca-Cola® Syrup

Based on the descriptive sensory results of no detection of taint off-notes and only a very slight suppression of cola flavor, which we would not expect a typical consumer to notice, we, as an independent and objective third party, can support a claim for this tubing to be referred to as "taste and odor free" for applications with cold cola syrup and equivalent products.

3.2 Conclusion for milk/dairy applications

The TUSSC descriptive sensory analysis panel detected a very slight intensity of a taint off-note in the milk and described it as plastic and rubbery. There are two things to consider:

A. In our experience with consumers, a very slight intensity of a sensory characteristic, including off-notes, is rarely noticed and never drives emotion or affects overall liking. In addition, we have not seen this level of off-note affect overall consumption.

B. This test was very conservative as we used the maximum contact time and intended use surface area to volume ratio.

The very slight suppression of the milk intensity that was detected by the TUSSC panel was too low to even reduce the TIA and TIF values and we would not expect a typical consumer to notice this.

Based on our experience with consumers and their reactions to sensory effects, and the above interpretation of the results, we, as an independent and objective third party, feel comfortable supporting a claim for this tubing to be referred to as "taste and odor free" for applications with milk and similar dairy products.

Appendix A – Roy Desrochers, Sensory Practice Leader

Mr. Desrochers is the Director of Business Development and Sensory Practice Leader at the Tufts University Sensory and Science Center (TUSSC). His major interest is in the application of sensory analysis to develop winning products and strategies in consumer goods organizations. In addition to his business development and senior management experience, he is a practitioner and has conducted extensive consumer testing and sensory training programs around the world.

Mr. Desrochers has over thirty-five years of professional experience using sensory technology to help clients develop and maintain winning products in the marketplace, as well as solve complex problems. His experience covers a wide range of industries including Food and Beverage, Packaging, Chemical, Home Care Products, Personal Care Products, Automotive, Space (NASA), and Environmental. Some select examples include:

Mr. Desrochers has trained thousands of descriptive panelists around the world for companies, producing products such as soda, nutritional beverages, beer and wine, water (both private and public), food and beverage, packaging materials, pharmaceutical, distilled spirits, automotive, and government agencies.

For major U.S. producers of packaging materials including resins, paper, can coatings, and aluminum, Mr. Desrochers has conducted numerous flavor-training programs at their facilities. These programs concentrate on the basics of sensory analysis and flavor interactions between packaging materials and food products.

For multiple global producers of nutritional beverages, Mr. Desrochers designed and implemented global sensory programs to assist in new product development, approval of ingredients based on sensory quality, integration of new manufacturing processes, packaging material approval, and off-flavor complaint investigation and resolution.

For a major leading manufacturer of orange juice products in the United States, Mr. Desrochers worked with a team of professionals on a program that used professional sensory technology, chemical analysis, and innovative consumer testing to help develop a market leading product in the USA. Mr.

Desrochers coordinated an innovative consumer testing program in the Dominican Republic to better understand consumer needs for beer flavor. The result was the development of a new brand of beer that acquired over 70% market share in less than three years.

For a major international brewer, Mr. Desrochers conducted innovative consumer research focused on beer flavor in South America. The research helped to define the flavor profile of a new entry into mainstream beer that was preferred over the current market leader in blind consumer tests.

Mr. Desrochers managed a large complex case for a beverage manufacturer in Mexico to better understand consumer needs. This work resulted in the development of a liquid flavor strategy and a sensory platform that led to a new product and a significant increase in market share.

For a large international wine producer based in the U.S., Mr. Desrochers managed a multi-phased program to benchmark the beverage category, identify opportunities for new product introductions, and support development and product launch.

For a major producer of air fresheners, Mr. Desrochers managed efforts to assess efficacy and assist in the development of a range of successful new products.

For a major U.S. coffee producer, Mr. Desrochers managed efforts to benchmark coffee flavor quality and consistency. This work led to approval criteria that were used to select vendors on a monthly basis.

Mr. Desrochers managed efforts for a leading fast food chain in the U.S. to develop a leading coffee product. This work included flavor/factor interaction work including coffee type and blending, grind size, brew contact time, water temperature, and hold time.

Mr. Desrochers is a member of a specialized team of odor professionals working for both foreign governments and private industry in the area of environmental odor. This work has been conducted in North America, Europe, and Asia, and has resulted in new legislation guidelines.

For a multi-client project that included brewing, aluminum can, and can coating companies, Mr. Desrochers coordinated sensory panels to evaluate flavor interactions between packaging materials and beer. This work included sampling and tasting at aluminum production facilities, sampling and tasting at can production plants and sensory evaluation of can coatings.

Mr. Desrochers has contributed to numerous projects looking at off-flavors due to packaging. These have included cans, cardboard stock, plastic bottles, and aluminum lids. His sensory analysis experience on these cases includes both flavor and odor analysis.

Mr. Desrochers coordinated an innovative consumer testing program in Israel to better understand consumer needs for coffee products, resulting in a market leading product.

Mr. Desrochers coordinated a Sensory-Directed Chemical Analysis program to investigate an off-flavor in a medical supply product that traditional analysis had failed to detect. This work included professional odor analysis, sensory screening, and the use of chemical/sensory tools such as Split-Stream Gas Chromatography.

Mr. Desrochers is a recognized beer flavor expert for the Master Brewer's Association of the America's (MBAA). He has delivered numerous presentations over the last 33 years including annual presentations on beer flavor quality to the Master Brewer's Association of the America's (MBAA) Short Course in Brewing Science and Packaging Course held at the University of Wisconsin. In addition, he has presented at Nova-Pack, Consumer-Pack, the American Water Works Association (AWWA), Johnson and Wales University, and the National Beverage Packaging Association (NBPA). He has also conducted special workshops on flavor, most recently at the MBAA National Conventions in Austin, Texas and Milwaukee, WI. In addition, he has provided expert support to the legal industry and government agencies such as the BATF.

Mr. Desrochers received his B.S. in both Chemistry and Geology in 1983 from Tufts University. Prior to joining the Tufts University Sensory and Science Center, he was the Sensory Practice Leader

at GEI Consultants, Inc., and prior to that he founded DesSense, Inc., a global sensory company. He began his career at Arthur D. Little, Inc. where he spent 18 years in the food group including manager of the Sensory Technology Unit. Mr. Desrochers is an active member of the Master Brewers Association of the Americas (MBAA), and the American Society for Testing Materials – Committee E18/Sensory Methods (ASTM) and the American Water Works Association – Taste and Odor Committee (AWWA).

Appendix B

Flavor Profile Method

The Flavor Profile Method of evaluation was developed by Messrs. Sjöström and Cairncross of Arthur D. Little in 1948. It is a standard approach to the measurement and analysis of aroma and flavor. The flavor profile is empirically based, i.e., developed and learned through experience. It employs perceptual judgments of both the elements and structure of aroma and flavor impressions. These judgments are made by carefully selected and extensively trained panelists who work as a team to reach a composite judgment. While statistics may be employed to analyze profile data, confidence in profile results, reproducibility, is generally based upon the skill of the individuals' carefully monitoring each other's performance, and employing objective reference materials to eliminate discrepancies.

Perception has been defined as the integration into a complex whole of single stimuli or sensations, as well as the isolation of single elements within the complex whole. The Flavor Profile Method introduced a similar concept to flavor evaluation by an overall impression or perception created by the aroma and flavor, termed *amplitude*, as well as characterization of the individual elements which contribute to that impression. The amplitude characteristic measures the integration of balance and fullness in aroma and flavor. This perception has been found to be used both by consumers and experts to distinguish among samples.

Aroma, which is defined as the sensation perceived by the nose when the product is sniffed, is comprised of volatile components (such as the sweet fragrance of vanilla) and feeling sensations (such as the coolness of menthol).

Flavor is perceived when the sample is taken into the mouth and swallowed. It is a combination of aromatics (volatile components which reach the olfactory area), basic tastes (sweet, sour, salty and bitter), and feeling factors (sensations in the mouth and throat, such as pepper bite).

The flavor profile panel defines these character notes in terms of reference materials and assign numerical intensities reflecting the strength of the note in the product. The order of appearance of these aroma and flavor notes is recorded, as is the aftertaste, one minute after swallowing.

The Flavor Profile Method is based on the use of a panel of four or five persons who have normal ability to smell and taste, are trained in techniques of smelling and tasting, have had considerable experience as panel members, and undergo a training period for orientation to the product to be analyzed. One of the panel members is also selected to act as the panel leader.

The flavor profile panel acts as an analytical instrument in that the panel members write down objective, descriptive terms for the different components they perceive in the product's aroma and

flavor. Control is maintained over extraneous variables, and the panel works in a well-lighted, clean, quiet, odor-free, temperature-controlled room equipped with a round table and chairs. The panel sessions are held at a scheduled time, and no interruptions are permitted during any session. The samples to be profiled are as uniform as possible, and each panel member receives an aliquot for his or her own independent analysis. Each member follows a standardized procedure adopted for the most useful and complete analysis of each product. The number of panel sessions necessary for completing a flavor profile vary according to the complexity of the product. It is customary, however, to allocate the first session to orientation and general descriptions of the overall impressions and characteristics of the product under study. Subsequent sessions are used to reach agreement on the aroma and flavor components called character notes, their intensities or strength, and their order of appearance.

To eliminate confusion as to the meaning of the various descriptive terms used by the panel members, extensive use is made of reference materials. These references may be chemicals or natural materials if they adequately represent the term described by the panel members. All the panel members examine the reference materials and if it and the component it represents is agreed upon, the term and the reference material is accepted.

A product's aroma is analyzed first and then the flavor, with each panel member taking a minimum, but uniform, number of sniffs or tastes for a complete analysis. The specifics of the smelling and tasting techniques are worked out during an orientation period. A description of aftertaste, the sensations which are still present in the mouth one minute after swallowing, is also included in the flavor profile.

The characteristics of a product that each panel member looks for when doing a flavor profile are (1) a rating of the degree of blend and the amount of fullness present in the aroma and flavor as a whole; (2) an identification of the individual components of aroma and flavor (3) the strength, or intensity, at which these components appear (4) the order in which they appear; and (5) a description of the aftertaste one minute after swallowing. In addition, when texture is important to the product's description, this is also noted during the panel session.

The impression of blend and fullness is termed *amplitude*. When rated by a person trained in the method, amplitude measures the degree of integration of the perceptual experience, the complexity and structure of the aroma or flavor. Usually the greater the degree of this blended complex supporting the character notes, the higher the amplitude.

The ratings for amplitude are on a scale from ½ representing a very low amplitude, to a high of 3, where 1 is low and 2 moderate. This scale is used for all classes of products, and, therefore, does not describe its qualitative attributes. Amplitude is not a measure of aroma or flavor strength, but rather reflects fullness (ampleness) and the degree of blend.

The scale used to denote the intensity or strength of the aroma and flavor character notes in the product is the following:

0	=	not present
) (	=	threshold or just recognizable by 50% of the panel
1	=	slight
2	=	moderate
3	=	strong

with intermediate value of ½, 1½ and 2½ used by experienced panel members. This is a constant scale; that is, when sweetness is designated at a slight-to-moderate strength (1½) in both chocolate and orange juice, for example, the sweetness level detected can be related to a reference material of a slight-to-moderate level of sweetness exemplified by a certain concentration of sugar (sucrose).

After each panel member has finished his independent study of the product's aroma and aftertaste, the individual recites his findings, and an open discussion period is led by the panel leader. The findings are compiled by the panel leader and composites into a preliminary flavor profile. The prototype is used in subsequent panel sessions, and the examinations continue until a composite flavor profile is agreed upon. All products are studied singularly until a final session when a comparison with a companion product may yield more information and determine if the profile descriptions discriminate between samples.

The Flavor Profile Method characterizes the perceptual attributes of a product which to a large measure identify it and set it apart from equivalent products. Usually flavor profile analyses are conducted on a product under normal conditions of use, with the preparation and presentation of the samples standardized and controlled.

Appendix C

Profile Attribute Analysis

Method Development

Profile Attribute Analysis (PAA) is an objective method of sensory analysis that uses an expert panel to numerically describe the complete sensory experience through profile attributes. These attributes are a limited set of characteristics which, when properly selected and defined, provide a complete description of the sensory characteristics of a sample with little descriptive information lost. Additional detail is provided by panel comments which are stored in association with the attribute data. By limiting the number of profile attributes the panelist measures, it is possible to evaluate four or more samples per session compared to one sample per Flavor Profile session. PAA data can be efficiently stored in automated data handling systems and is amenable to statistical analysis and data summarization.

PAA is based on the Flavor Profile Method (developed at Arthur D. Little, Inc. and reported in 1949) in concept and implementation. It makes use of the expertise of trained panelists to identify and appropriately define the critical set of attributes for a specific project. A group of three or four trained panelists, drawn from a pool of six to eight familiar with the specific study, produces sufficiently uniform results that two or three replications can provide significant discrimination among samples.

The Flavor Profile Method introduced the concept of integrative perceptual measures of flavor in the amplitude characteristic. This measure includes aspects of balance and fullness which are perceptions used by both consumers and experts to distinguish among samples. PAA uses both terms as independent measures.

Flavor profiling requires the description of character notes in three chemical sensory pathways -- smell, taste, and (chemical) mouthfeel. These are extended in PAA to include visual and tactile measures. Both the visual and tactile sensations provide ways of differentiating among samples and may influence judgments of smell, taste, and mouthfeel either by altering or modifying one's perception.

PAA is a cost-effective and efficient method of sensory analysis. It is used to objectively describe the perceptual differences among samples in terms of average panel scores for a set of defined attributes. The method draws on over 40 years of experience in descriptive flavor analysis using small, trained panels to measure both integrative and analytic perceptions.

Description of Profile Attribute Analysis Method

The sensory or perceptual characteristics of a food or beverage are multi-variant. That means there are a variety of ways in which people distinguish among samples. These perceptions may be grouped into two sets -- integrative and analytic.

Integrative perceptions can be measured as the overall aroma and flavor impression of a food or beverage. Integrative perceptual attributes are an essential part of the product description. Not only do the attributes of balance and fullness distinguish among samples, but they closely correlate with consumers' descriptions of products. Additional integrative measures such as total intensity of flavor, complexity, impact and aftertaste may be necessary to differentiate among samples and, with concurrent laboratory work, record progress in optimizing formulations.

Analytic sensations in sensory measurement are the three chemical senses: smell, taste, and mouthfeel (e.g., astringency). Each of these three chemical senses can be distinguished in terms of strength, quality, and time. Visual and tactile sensations also provide data which differentiate among samples and, like the chemical senses, can have more than one perceptual dimension.

The flavor of a product (in its broadest meaning) is multi-dimensional and is composed of both integrative and analytic perceptions. The attributes often included in PAA studies can be characterized as follows:

Attributes Describing Integrative Perceptions	Attributes Describing Analytic Perceptions
Balance	Color
Fullness	Textural
Aftertaste	Aromatics
	Basic Tastes
	Mouthfeel

Other appropriate attributes will be included or substituted depending on the problem under study.

Based on data analysis and interpretation, there appears to be some merit in having a similar number of integrative and analytic attributes. However, it is essential to the success of any study that at least one attribute provides a measure of difference between any two samples that are not perceived to be alike.

To provide a manageable set of measures, PAA takes measures for each sensory modality in terms of a seven-point scale (1 to 7). These measures express perceptual differences from a reference and are relative to a standard. Thus, they cannot of themselves uniquely identify all possible variations.

The definition and uniform understanding of each attribute is key to the successful application of the method. It is here that Flavor Profile Method experience is essential. When coupled with the objective description (as opposed to a value judgment) and controlled sample presentation, the attribute scores provide a numerical characterization of the sensations associated with any food or beverage. More detailed qualitative description can be included from panel comments which are stored in association with specific attribute scores.

Identification of Profile Attributes for a Study

To identify the specific attributes necessary to conduct a PAA study and to develop their definitions, the trained panel will initially hold orientation sessions. The panel is presented with a wide variety of products that span the range of sensory differences to be included in the actual study. The panelists characterize the sensory properties of these products using descriptive analysis. From this characterization, the profile attributes necessary to completely describe the range of products are selected.

Once the profile attributes are selected, the attribute scales are defined. The panelists are made familiar with the definitions and anchor points with the use of reference standards. All attributes are defined along an integer scale of 1 to 7, with each unit representing a difference the panelists can detect with confidence on repeated analyses.

Data Analysis

Since PAA relies on numerical measures to describe differences among samples, it is essential to design experiments which often include an independent variable such as storage stability, method of serving or formulation. Such independent variables can be useful in assuring that the panel is operating effectively. Sufficient replication is included to come to statistically valid conclusions. The panel average is treated as the single result, to represent the population and the fact that people differ in their perceptions of foods and beverages.

The panel average attribute scores can be analyzed in more than one way. The average scores can be treated as ranks and the ranks can be analyzed using nonparametric statistics. Typically, we summarize the data using principal components analysis or variable cluster analysis taking the first principal component of each cluster as the summary statistic. Multivariate analysis of variance is then performed on the summary statistics and each of the average attribute scores. This analysis provides an overall

F test for significance both for the main effects in the test design and their interactions.

If there are two or three summary statistics, they can be usefully displayed as flavor maps. Such maps with appropriately labeled axes are helpful in visualizing the differences among samples, or brands, particularly over time.

Appendix D

Modified Flavor Profile

Total Intensity of Aroma (TIA) and Total Intensity of Flavor (TIF)

Total Intensity of Aroma (TIA) and Total Intensity of Flavor (TIF) are overall sensory measurements made by properly trained descriptive sensory panelists of the aroma and flavor of a product based on the Flavor Profile Method of Sensory Analysis (ASTM MNL 13-EB/May 1992). These overall measures are used primarily to assess the intensity and characteristics that define aroma and flavor.

TIA and TIF are typically measured using the standard seven-point Flavor Profile intensity scale to rate the overall intensity of an aroma or flavor:

- 0 = none
- ½ = very slight
- 1 = slight
- 1 ½= slight to moderate
- 2 = moderate
- 2 ½= moderate to strong
- 3 = strong

TIA and TIF can also be measured using the same seven-point intensity scale but the Profile Attribute Analysis (PAA) values as follows:

- 1 = none
- 2 = very slight
- 3 = slight
- 4 = slight to moderate
- 5 = moderate
- 6 = moderate to strong
- 7 = strong

In addition to the overall intensity, descriptive words based on reference standards are included, usually in order of strength. TIA and TIF can be modified further to include intensities for individual characteristics of an aroma or flavor.

An example for a TIA result would be:

TIA	Aroma characteristics
5	Piney, fruity, citrus, cocoa, pungent

Modified Flavor Profile is most often used when conducting tests on materials intended for food and beverage contact and when conducting odor surveys.