ASTM

MANUAL ON

DESCRIPTIVE ANALYSIS TESTING

FOR SENSORY EVALUATION

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Manual on Descriptive Analysis Testing for Sensory Evaluation

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Foreword

The Manual on Descriptive Analysis Testing for Sensory Evaluation was sponsored by Committee E-18 on Sensory Evaluation. Descriptive analysis is a sensory method by which the attributes of a food or product are identified and quantified, using human subjects who have been specifically trained for this purpose. The analysis can include all parameters of the product, or it can be limited to certain aspects, for example, aroma, taste, texture, and aftertaste. Many descriptive analysis methods and method variations are currently employed by sensory professionals. This forthcoming book will only be concerned with four, which have been published and are widely used: flavor profile, quantitative descriptive analysis (QDA), Spectrum, and texture profile. An overview of each method will be presented, with examples and differences among the methods and how they are used.

Committee E-18 believes this manual will be unique in that these four descriptive analysis methods have never before been put together in one book. We hope it is a useful reference for sensory professionals, laboratories, and management.

Contents

Introduction

Descriptive analysis is the sensory method by which the attributes of a food or product are identified and quantified using human subjects who have been specifically trained for this purpose. The analysis can include all parameters of the product, or it can be limited to certain aspects, for example, aroma, taste, texture, and aftertaste. While the principles of descriptive analysis are applied by many sensory professionals, overviews of four currently published methods will be presented. Many variations of these methods are in current use. This publication will be concerned only with the following: flavor profile, quantitative descriptive analysis (QDA), spectrum, and texture profile (Table 1). The following information is intended as a description of each method, not as a manual to be used for training of this type of panel.

Descriptive analysis is appropriate for use when detailed information is required on individual characteristics of the product or material or both. Some examples of application of descriptive analysis are as follows:

- Documenting product sensory characteristics
- Identifying and quantifying sensory characteristics for research guidance, product maintenance, and matching
- Correlating instrumental and chemical measurements with sensory responses
- Monitoring product quality
- Interpreting consumer responses

In many cases this sensitive method of descriptive analysis provides information that cannot be obtained by other analytical means. For example, analysis of salt content or pH does not indicate how salty or how sour a product may taste. Nor is it usually possible to monitor subtle changes in shelf life or package stability using analytical instruments. The only effective way to monitor complex changes in oxidation, rancidity, or flavor intensity, as well as the introduction of new attributes that so often occur with storage, is by using descriptive analysis methods.

Establishing a trained panel to perform descriptive analysis is not a casual matter. This method requires that the panel be carefully trained and maintained under the supervision of a sensory professional who has training and experience in the analytical method being applied. Because of the expense (in actual dollars and personnel time) of training and maintaining a panel, as well as the possible need for capital investment of a special facility, company management must provide a long-term commitment. Without such support it is almost impossible to successfully develop and maintain the panel. However, the benefits of having this important analytical method usually outweigh the disadvantages. For this reason, many companies have found the method of descriptive analysis to be an essential part of their sensory evaluation program.

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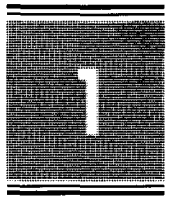
TABLE 1—*Differences among four descriptive analysis methods.*

Method	Panel Leader	Number of Panelists	Facilities	Screening	Time Required Training/Test
Flavor profile	Selected from the trained panel. Results are included in final consensus flavor profile if leader also acts as panelist.	min of 4	Quite, well-lit, odor-free panel room; round table suggested to facilitate discussion.	Basic taste, odors, ranking, and integrative discrimination skills plus a personal interview to determine interest and availability.	For training, ~6 months with daily practice. For product, 1 to 3 sessions. For testing, ~15 min/sample
QDA[a]	Sensory professional functions as panel administrator and discussion coordinator, but is not a subject.	10–12; however, some tests may use as few as 8 or as many as 15	Language development/ training done in conference-style room with appropriate lighting and environmental controls. Data collection in sensory test booths.	Product/product category users/ likers; discrimination testing with products, progressively more difficult (20 to 30 trials maximum).	Total: 2 weeks, 8 to 10 h, 3 to 5 min/ product
Spectrum method	Sensory professional trained in descriptive analysis and as a panelist. Or, a skilled panelist trained as a panel leader.	12 to 15	Booths for evaluation. Room with round table for discussion. Quiet, controlled atmosphere and apropriate lighting.	Prescreening, acuity screening, and interview to screen for availability, interest, good health, acuity in sensory dimension, scaling, and positive attitude.	One modality (for example, flavor) 3 to 4 months total (60 to 80 h). Testing 5 to 15 min/ product.
Texture profile	Sensory professional trained as a texture profilist with necessary skills to schedule and conduct panels.	6 to 10	Quiet room with appropriate lighting. Round table for discussion and evaluation.	Tests to discriminate textural attributes and an interview.	4 to 6 months (90 to 100 h). Testing 5 to 15 min/ product.

[a] QDA is quantitative descriptive analysis.

Training	Product Tested	Scales/Score Cards	Data Handling
Basic instructions on taste and odor, terminology development, product evaluations with reference standards, and interpretation and use of data.	Food, beverages, pharmaceuticals, cosmetics and household products, tobacco, packing materials, pet foods, environmental odors and any product that can be smelled or tasted.	Each panelist independently evaluates using a blank sheet: amplitude rating, character notes, intensities (7 point scale ranging from threshold to strong), order of appearance, aftertaste, texture, and appearance.	Final consensus profile in tabular form, principle component analysis, ANOVA.
Subjects develop terminology, explanations/ definitions, evaluation procedure. References provided as needed.	Foods and beverages including fermented and distilled, tobacco, paper products, nonwoven/woven fabrics, health, and beauty aids	Graphic rating scales, attributes listed in order of occurrence, repeated trials design (min of 3 reps)	Scale marks converted to numerical values and analyzed: means, standard deviations, one-way analysis of variance for each subject/attribute; treatment-by-subject repeated measures, mixed model ANOVA, Duncan and SNK multiple range tests, pairwise correlations, rank order, Kendall coefficient of concordance, PCA, and other multivariate analyses.
Basic principles of sensory evaluation, physiology, and descriptive analysis. Development of terminology, use of references, selection of evaluation techniques, product evaluation, and discussion of results.	All consumer products (for example, foods, personal, and health care, household, woven/nonwoven fabrics).	150 point scale. Score card lists detailed attributes (anchored to references). Detailed evaluation procedures attached to score card.	Individual scores collected. Graphic representation and statistical analysis on data. Variety of ANOVA and other statistical analysis (uni- and multivariate) depending on design and test characteristics.
Training on texture definitions, evaluation procedures, and standard reference scales. Evaluation of specific products and discussion of results.	Food and beverages	Intensity from 0,)(, →3. Written evaluation procedures. Glossary of attribute definitions.	Panel discussion to reach consensus on each attribute.



The Flavor Profile

by Patricia Keane[1]

Principle

The flavor profile method is based on the concept that flavor consists of identifiable taste, odor, and chemical feeling factors plus an underlying complex of sensory impressions not separately identifiable. The method consists of formal procedures for describing and assessing the aroma and flavor of a product in a reproducible manner. The separate characteristics contributing to the overall sensory impression of the product are identified, and their intensity assessed in order to build a description of the aroma, flavor, and aftertaste of the product.

This descriptive sensory analysis usually includes:

1. Overall impression (amplitude).
2. Identification of perceptible aroma and flavor character notes.
3. Intensity of each character note.
4. Order in which these character notes are perceived (order of appearance).
5. Aftertaste.

Panelists

Selection of Panelists

Panelists are selected according to their abilities to discriminate odor and flavor differences and communicate their perceptions. Their abilities to identify the basic tastes, rank intensities, and identify common odorants are determined through the following series of tests.

Identification Test—Independence of judgment is such a sufficiently important attribute for a flavor profile panelist to possess that it requires a separate test. Candidates are asked to taste a solution and then answer a related question. Solutions consist of sucrose and sodium chloride at low concentrations and plain water. Both correct and false suggestions are given to the candidates to test their independence of perceptual judgment.

Basic Taste Test—Prospective panelists are not tested for threshold acuity, but rather for their ability to differentiate among the basic tastes at above threshold levels. Solutions representing sweet (sucrose), sour (citric acid), salty (sodium chloride), and bitter (caffeine) tastes are used. None of the solutions are intense enough to influence the taste of succeeding samples so all may be tasted at a single session. The samples are presented along with one blank and one duplicate. The duplicate sample and blank sample are included to test consistency of response and discourage guessing.

Ranking Test—The candidates are asked to rank a series of four solutions for intensity of sweet basic taste. The solutions are a complex mixture of caffeine, phosphoric acid, and cola flavoring with supraliminal levels of sweetness. This test simulates actual flavor panel performance where panelists have to isolate and quantify elements from a complex whole.

Arrangement Test—An important part of the flavor profile method is the concept of amplitude, the initial overall impression of the balance and fullness of a product. The arrangement test seeks to measure a candidate's ability to perform this integrative measurement.

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Five versions of orange breakfast drink are presented. Some are diluted and may have sucrose or a flavor modifier added. The candidates are asked to rank the solutions in some meaningful flavor order and describe the basis for such ordering.

Odor Recognition Series—The odor recognition series is given to determine a candidate's aptitude for identifying and describing 20 different odorants, most of which have been encountered by the candidate. Some commonly used odorants are: vanillin, benzaldehyde, anise, amyl acetate, methyl salicylate, and so forth. Odorants should be perceptible but not overwhelming.

The odor recognition test is presented in two parts, each using 10 different odorants. In the first part of the test the candidates are instructed to identify the odorant or associate it with some product. The second part of the test is multiple choice, and the candidates choose the word that best identifies the odorant. Time limits are imposed to minimize fatigue.

Analysis and Interpretation of Screening Tests—Administration and evaluation of the screening tests should be performed by someone thoroughly experienced in the flavor profile method. A suggested system follows:

Identification Test

Candidates are not expected to answer all questions correctly but points are awarded for each correct answer. Susceptibility to false suggestion however serves to disqualify an individual from consideration.

Basic Taste Test

Candidates should be able to identify the four basic tastes. Points are awarded for each correct answer.

Ranking Test

The maximum number of points is awarded for ranking the solutions in the correct order. Fewer points are awarded if the two lower or intermediate solutions are reversed. Other combinations receive proportionately fewer points.

Arrangement Test

Candidates who correctly rank the solutions using blend or fullness as their criterion receive the maximum score. Other acceptable criteria might be: sweetness, sourness, orange identity, and so forth. Points are awarded based on correctness of response for whatever criterion is chosen.

Odor Recognition Test

In the odor recognition test maximum points are awarded for correctly identifying the odorant. Fewer points are awarded for product associations or characterizations.

Other Criteria—During the screening tests the candidates are also rated on other qualities. These include how they apply themselves in taking the tests, response to directions, level of confidence, and interest in and attitude toward the tests. Since the tests are given to a group of six candidates at a time, group interaction can also be observed.

Personal Interview—After the candidates have taken the screening tests, they are interviewed about their work, academic or personal experiences in sensory or associated areas. The

interviewer uses the candidate's screening test experience to initiate discussion. Candidates are evaluated and rated on the following attributes:

1. Interest in flavor and odor evaluation.
2. Ability to function cooperatively in a group.
3. Ability to effectively communicate opinions.
4. Confidence to report what one perceives.
5. Personal experiences that may contribute to flavor and odor analysis.
6. Availability for panel work.

The interviewer also discusses factors, such as allergies to or moral constraints about any food or beverage products, and addresses any health concerns that the candidate may have.

Summary—Test scores and data from the interviews are the usual criteria for panelist selection. The interviewer must rely on judgment, common sense, and experience to identify candidate potential. Lack of interest or availability, or both, for panel work serves to disqualify individuals from further consideration.

Training of Panelists

The selected candidates receive training to improve their abilities to describe aroma and flavor attributes using the flavor profile method. Training increases reliability. The duration of training will vary depending on the purpose of the panel. If the panel is expected to be capable of describing any food or beverage product, a training period of approximately six months is required. This includes approximately 60 h of training and 100 h of practice per person. Training for a single type of product can be accomplished in a shorter time.

The structured training consists of the following:

- A basic course of instruction that includes lectures and demonstrations on the nature of taste and smell, basic requirements for panel work, techniques and procedures for reproducible odor and taste work, and the development of terminology through the use of sensory exercises and reference standards. This usually requires three full days.
- Evaluation of products of increasing difficulty that have been selected for their particular teaching values. Approximately 1 h per day is spent on the evaluation of these products, and each panelist takes a turn at being panel leader.
- An advanced course that covers additional aspects of sensory evaluation, flavor situations of a more complex nature, and the interpretation and utilization of panel data. This usually requires three full days.
- Additional practice using products similar to those the panel will work with after training. During these sessions, the panel also practices application and interpretation of results.

Panel Leader

The panel must eventually have a panel leader who is responsible for conducting panel discussions, recording and compiling data, and interpreting and reporting results. The panel leader participates fully in the product evaluation and may also have responsibility for scheduling panels and preparing samples. The leader is usually chosen near the end of the training period on the basis of demonstrated ability, availability, and other considerations such as job responsibilities, and so forth.

Panel Operation

General Considerations for Panel Operation

For effective descriptive analysis, the panelists should be provided with seating in a quiet, well-lighted, odor-free area removed from external distractions. All utensils must be clean and odor-free.

Samples should be presented to the panel under identical conditions and should be evaluated by all panel members in an identical manner at the same time. A product's aroma is analyzed first, then the flavor, and finally the aftertaste.

Procedure

Four or more panelists work as a group to arrive at a consensus description of the sensory properties of the product. The panel members first independently evaluate the sample using standardized flavor profile techniques and record their findings on a blank sheet. An essential element of the procedure is the panel leader who is also one of the panelists. This person has each panelist present his/her findings, records them, and leads the panel's discussion in order to reach consensus on each component of the description. Reference materials are used to help the group reach agreement on terminology and intensity. The final composite profile typically takes three to five sessions. The panel leader interprets and reports the results. The abilities of panelists to function cooperatively within the group and communicate opinions effectively are important factors in the successful conduct of the consensus procedure.

Product Orientation

Product orientation takes place before the formal panel and involves one or more informal sessions depending on the experience of the group. At this time the panel leader outlines the objectives of the project and introduces the samples to be evaluated along with other products of the same or similar type. This helps to establish a framework for comparison. During this period, the panelists draw up a list of character notes for the samples, decide on reference materials (pure compounds or products that demonstrate particular odor or flavor notes), and develop the vocabulary necessary to describe these character notes. The panel also establishes at this time the best method for presenting and examining the samples.

Components of the Flavor Profile

The following are the components of the flavor profile:

1. Overall impression of aroma and flavor, called amplitude.
2. Identification of perceptible aroma and flavor notes.
3. Intensity of each character note.
4. Order in which these character notes are perceived, called order of appearance.
5. Aftertaste.

Additionally, when texture and color are important to the product's description, they are also noted during the panel session.

Amplitude—Amplitude is defined as the initial overall impression of the aroma and flavor of a product. It is an integrative measurement of the balance (blend) and body (fullness) in each case. Amplitude is measured on a seven-point scale composed of four major ratings with three intermediate (½ units) ratings between them:

0 = no blending or fullness.
1 = low degree of blend and fullness.
2 = moderate degree of blend and fullness.
3 = high degree of blend and fullness.

Character Notes—The perceptible aroma and flavor components are called character notes and are defined in descriptive or associative terms. These terms are objective rather than subjective (for example, a flavor note may be characterized as "vanilla" but not "good") and can be referenced. Character notes may include aromatics, basic tastes, and chemical sensations or feeling factors.

Occasionally, some panelists will describe a character note that others do not perceive. In the case where less than half of the panelists perceive a note, it is referred to as an "other" and listed as such at the bottom of the profile.

Intensity Scale—The degree to which each character note is perceived is called "intensity." The scale is constant over all product categories:

0 = not present.
1 = slight.
2 = moderate.
3 = strong.

This scale is further refined into ½ units to show narrower ranges.

Threshold, signified by the symbol,) (, is a statistic rather than a single point. It is used to represent a range of concentration which is barely detectable or detectable only half of the time.

Order of Appearance—The tabular profile lists the character notes in the order in which they are perceived. This is made possible through the use of standardized techniques for smelling and tasting since order of appearance is influenced by location of taste buds on the tongue, volatility of aromatics, and texture of the product. Also differences in the time of appearance of character notes are more apparent in unblended flavors.

Aftertaste—Aftertaste is a definite and important part of the flavor of a product. Aftertaste sensations can include basic tastes, aromatics, or feeling factors, or all of these. These sensations are noted at a predetermined time after completion of tasting, usually 1 min. Generally intensity ratings are not given, but for specific studies where aftertaste is important, intensity ratings add further definition.

Data Collection

Initially, the panelists work alone with a blank sheet recording amplitude, and character notes with their intensities and order of appearance, as well as aftertaste. When all of the panelists have completed their profile, the individual panelists recite their results, and the panel leader records them and compiles them. The oral review of findings gives panel members immediate feedback as to their ability to describe what they have perceived and indicates where practice may be necessary. It enables them to clarify terms and select suitable references. Most importantly, it permits panelists to draw on and learn from the experiences of others. At the conclusion of the first panel session a preliminary profile is generated. This profile is continually refined during subsequent sessions until all panelists agree a final composite judgment has been reached. This then becomes the final flavor profile. Three to five sessions are generally needed to produce a final composite. An example of a format for writing a flavor profile is shown in Fig. 1. Figure 2 illustrates a comparison of the flavor profiles of two similar product types.

AROMA

Amplitude Rating

Character note (in order of appearance) Intensity

Etc.

Others:

Flavor

Amplitude Rating

Character note (in order of appearance) Intensity

Etc.

Others:

Aftertaste (Time of measurement if not one minute)

Character notes (intensities optional)

Footnotes

Color, Appearance, Texture (optional)

Signature of Panel Leader

Date

FIG. 1—*Format for a flavor profile.*

Data Analysis

The flavor profile method was not designed as a numerical system for statistical analysis of data. Most applications are based on interpretation of the composite profile terms and intensities. The method provides a detailed blueprint of a product or products. The strength of the method rests on the ability of a group of highly trained individuals to work as a team to reach consensus.

The method can however provide multivariate data, which can be summarized to provide a statistically treatable comparison of several like products.

The process involves making a transformation to an expanded scale by assigning numbers to an aroma note index and flavor note index, summarizing the indexes, and using principal

component analysis and analysis of variance to treat the data. A case study where this was done for fluid milk products is discussed in detail by Dr. Irwin Miller (1978). Other studies employing statistics have also been reported.

Test Report

The flavor profile report should include complete identification of the sample(s) studied, and the objectives and duration of the study.

The body of the report should include the techniques used to examine the products, such as preparation methods and serving temperatures, so that the evaluation can be repeated accurately in the future. The report should also identify the reference standards used to reach agree-

MODERN REAL MAYONNAISE		YANKEE MAYONNAISE	
AROMA	AROMA		
Amplitude 2		Amplitude 1 1/2	
Oily, vegetable	1 1/2	Sour, vinegar	2
Eggy, cooked	1	Oily, oxidized	1 1/2
Sour, vinegar	1 1/2	Pungent	1
Spice complex(onion, garlic,mustard)	1/2	Garlic	1
Briny	1	Briny	1
Other: Black Pepper, Citrus		Other: Eggy	
FLAVOR		FLAVOR	
Amplitude 2		Amplitude 1	
Sweet	1/2	Sweet	1 1/2
Oily, vegetable	1 1/2	Sour	2 1/2
Sour	2	Vinegar	2
Salty	2	Oily,oxidized plus mouthfeel	1
Salivating	1 1/2	Salty	1
Vinegar	1 1/2	Spice bite and burn	1
Eggs, hard-cooked	1	Garlic	1 1/2
Spice complex(onion, garlic,mustard)	1	Astringent	1 1/2
Black Pepper	1/2		
Oily mouthfeel	1 1/2		
Other: Bite and burn		Other: Eggy	
AFTERTASTE		AFTERTASTE	
Salty		Sour	
Oily plus mouthfeel		Spice burn	
COLOR		COLOR	
Slight eggy yellow		Pale creamy white	
TEXTURE		TEXTURE	
Smooth, gelatinous		Lumpy, slightly grainy	

FIG. 2—*Examples of flavor profiles of mayonaise.*

MEMO TO: Project Manager - Canned Soups

FROM: Flavor Profile Panel Leader

SUBJECT: Flavor Profile Report of Tomato Soups

INTRODUCTION:

Samples of canned condensed Alpha Tomato Soup and Beta Tomato Soup were profiled during five panel sessions. The objective was to characterize the two market leaders in order to provide sensory data for management to select a flavor target for a new store brand soup line. For the study, a sufficient number of identically coded samples of each brand were purchased locally. Expiration dates for the two brands were similar. Samples were evaluated for aroma, flavor and aftertaste. Differences in appearance and texture were also noted. Tabular profiles are attached.

SUMMARY OF CONCLUSIONS:

- In aroma and flavor both tomato soup brands exhibited early tomato identity with the Alpha brand having a more intense fresh tomato identity and the Beta brand described as burnt or scorched tomato.

- The development of the tomato identity in Alpha's product was supported by other vegetable and spice notes to produce a moderately full and blended soup. Beta brand was more disjointed in the flavor with the tomato aromatic suppressed by the starchy character of the soup.

- In Alpha brand the salivating mouthfeel with a slight MSG character contributed to a quick washout of flavor and a shorter aftertaste. In Beta the pepper burn lingered into the aftertaste along with a drying mouthfeel.

- Both soups had very slight off-characteristics; metallic in Alpha soup and bitter and musty in the Beta product.

- The appearance and texture of the two soups were different. Alpha soup was dark red in color with dispersed oil and slightly pulpy. The Beta brand was thick and particulate with a burnt red-orange color. The Beta brand was also difficult to heat as it had a tendency to burn.

FLAVOR PROFILES OF CONDENSED TOMATO SOUPS RECONSTITUTED WITH SPRING WATER

ALPHA CODE:23567APR92		**BETA** CODE:54K8JUN92	
AROMA (160°F - 150°F)			
Amplitude	2	Amplitude	1 1/2
Tomato,cooked fresh	2	Tomato puree,scorched	1 1/2
Cooked vegetables	1 1/2	Starchy,cooked pasta	1 1/2
Sour,citrus-like	1	Briny	1
Briny	1	Sour,fatty acid,cheesy	1/2
Spice Complex, Black pepper	1	Cooked vegetables	1/2
Other: Starchy, Non-fat dry milk		Other: Spice complex,musty	
FLAVOR (150°F - 140°F)			
Amplitude	2	Amplitude	1
Tomato,cooked fresh, slight green	2	Starchy,cooked pasta	2
Sweet	1/2	Tomato, stewed, burnt paste	1
Cooked vegetables	1 1/2	Starchy mouthfeel	1
Sour	1 1/2	Sweet	1/2
Salty	1 1/2	Salty	1 1/2
Spice Complex, Black pepper	1	Cheesy, fatty acid sour	1/2
Salivating	1	Sour	1 1/2
Metallic	1/2	Bitter	1/2
Pepper bite	1/2	Pepper bite and burn	1/2
MSG	1	Musty	1/2
Other: Starchy, oily plus mouthfeel		Other: Spice complex, oily plus mouthfeel	
AFTERTASTE			
Tomato,sour		Sour,pepper burn,drying, starchy,tomato	
COLOR			
Dark red,oily sheen some pulp and skin pieces		Burnt red-orange	
TEXTURE			
Thin, smooth, slight pulpy		Thick,particulate, slight tacky	

EXPERIMENTAL DATA:

After several brands of tomato soup (including the test samples) were screened by the panel in an orientation session, the following reference standards were selected for use:

Basic taste intensity standards
Tomato puree and paste
Canned whole tomatoes
Cooked fresh tomatoes
Fresh chopped ripe and green tomatoes
Black Pepper
Garlic
Onion
Cooked and raw carrots
Fresh whole milk
Non-fat dry milk powder
Pasta with cooking water
0.5% and 1.0% solutions of MSG

The condensed tomato soup was reconstituted using equal amounts of bottled spring water and soup. The soups were heated in similar saucepans following the directions on the cans. Approximately 4 ounces of soup was presented to each panelist in a pre-heated 8 ounce ceramic bowl. Each panelist monitored the temperature of his/her sample and evaluated aroma between 160°F and 150°F while stirring. Flavor was evaluated when the temperature reached 150°F but not below 140°F. The soup was slurped from a stainless steel spoon and was limited to three tastes. Aftertaste was recorded one minute after swallowing the final taste.

RESULTS AND DISCUSSION:

Aroma

The aroma of the Alpha Tomato Soup was more blended and full than the Beta brand and was therefore given a higher amplitude. Alpha had a stronger and fresher tomato identity supported by a slight to moderate intensity of a cooked vegetable complex. The tomato character of Beta soup was followed in appearance by a starchy note similar to that found in the water after cooking pasta. Alpha soup was more briny than the Beta soup and had a citrus-like sour aromatic. The sour aromatic in Beta brand had a dairy or cheesy character. In addition, some panel members felt the Beta Tomato Soup had a burnt or scorched tomato character.

Flavor

The amplitude of the Alpha Tomato Soup was also higher (more balanced and full) than Beta in the flavor. Alpha Tomato Soup had stronger and earlier tomato, vegetable and spice characteristics. The early appearance of a moderate starchy note suppressing the tomato aromatic of the Beta brand contributed to the unblended character of this soup. Sweet, sour and salt intensities were similar in the two products although the order of appearance differed slightly. In mouthfeel the Alpha product was salivating with a slight MSG character whereas the Beta product was starchy and produced more mouth irritation.

Aftertaste

Tomato and sour notes were present in the aftertaste of both soups. In addition, in the Beta brand, pepper burn and a starchy aromatic lingered.

Appearance and Texture

Alpha Tomato Soup was described as dark red with a slight oily sheen and with visible small pieces of tomato pulp. The texture was that of a thin and smooth gravy.

Beta Tomato Soup was described as burnt red-orange and was thicker in viscosity, more particulate and slightly tacky.

FIG. 3—*Example of a flavor profile report.*

ment on descriptive terminology and intensities. The tabular presentation of the profile data (Fig. 1) need not always be submitted with the report. When it is, it is accompanied by written discussion to aid interpretation of the information. The report should contain a summary of the amplitude ratings and major character notes with their intensities. It should also mention the presence of any off-notes and discuss order of appearance and aftertaste. Observations of visual and textural qualities are also important. An example of a complete flavor profile report is given in Fig. 3.

Bibliography

ASTM Committee E-18, *Guidelines for the Selection and Training of Sensory Panel Members, STP 758,* American Society for Testing and Materials, Philadelphia, 1981.

Bartels, J. H. M., Buringame, G. A., and Suffet, I. H., "Flavor Profile Analysis: Taste and Odor Control of the Future," *Journal of the American Water Works Association,* March 1986, p. 50.

Cairncross, S. E. and Sjostrom, L. B., "Flavor Profiles—A New Approach to Flavor Problems, *Food Technology* Vol. 4, 1950, pp. 308–311.

Caul, J. F. "The Profile Method of Flavor Analysis," *Advances in Food Research* Vol. 7, No. 1, 1957.

Caul, J. F., Cairncross, S. E., and Sjostrom, L. B. "The Flavor Profile in Review," *Flavor Research and Food Acceptance,* Arthur D. Little, Inc. Reinhold Publishing Company, New York, 1958, p. 65.

Elsberg, C. A. et al., "The Sense of Smell. I. A New and Simple Method of Quantitative Olfactometry," *Bulletin of the Neurological Institute,* New York, Vol. 4, No. 1, 1935, p. 1.

Elsberg, C. A. et al., "The Sense of Smell. VII. The Odorous Substances to be used for Tests of the Olfactory Sense," *Bulletin of the Neurological Institute,* New York, Vol. 4, No. 2, 1935, p. 286.

Jellinek, G., "Flavour Testing with the Profile Method," *Recent Advances in Food Science,* Vol II, J. Hawthorne and J. M. Leitch, Eds., Butterworths, London, 1962, pp. 287–292.

Jellinek, G., "Basis of the Flavour Profile and Dilution Flavor Profile Tests," *Sensory Evaluation of Food—Theory and Practice,* Ellis Horwood Ltd., Chichester, England, 1985, p. 288.

Krasner, S. W., McGuire, M. J., and Ferguson, V. B., "Taste and Odors: the Flavor Profile Method," *Journal of the American Water Works Association,* March 1985, p. 34.

Miller, I., "Statistical Treatment of Flavor Data," *Flavor: It's Chemical, Behavioral, and Commercial Aspects, Proceedings of the Arthur D. Little, Inc., Flavor Symposium, 1977.* C. Apt, Ed., Westview Press, Boulder, CO, 1978.

Neilson, A. J., Ferguson, V. B., and Kendall, D. A., "Profile Methods: Flavor Profile and Profile Attribute Analysis," *Applied Sensory Analysis of Foods,* Vol. I, H. Moskowitz, Ed., CRC Press, Inc., Boca Raton, FL, 1988, Chapter 2.

Sjostrom, L. B., Cairncross, S. E., and Caul, J. F., "Methodology of the Flavor Profile," *Food Technology,* Vol. 11 No. 9, Supplement: pp. 20–24.

Syarief, H., Hamaan, E. D., Giesbrecht, F. C., Young, C. T., and Munroe, R. J., "Interdependency and Underlying Dimensions of Sensory Flavor Characteristics of Selected Foods," *Journal of Food Science,* Vol. 50, 1985, p. 631.

2

Quantitative Descriptive Analysis (QDA)

by Herbert Stone

Principle

The method of quantitative descriptive analysis (QDA) is based on the principle of a panelist's ability to verbalize perceptions of a product in a reliable manner. The method embodies a formal screening and training procedure, development and use of a sensory language, and the scoring of products on repeated trials to obtain a complete, quantitative description.

Quantitative descriptive analysis includes the following:

- a complete listing of sensory attributes (based on perceptions)
- order of occurrence for the attributes
- relative intensity measure for each attribute on several trials
- statistical analyses of the responses

Panel Leader

The panel leader is a sensory professional, responsible for the entire screening process, organizing and implementing the screening tests and selecting subjects for training. The panel leader does not participate as a panelist in any screening or training (or in testing) but coordinates the screening and training processes. This could include assistance to panelists requiring clarification for a specific product attribute or sensation, obtaining appropriate references, and determining when training is completed.

Panelists

Selection of Panelists

Panelists must be screened and qualified to participate and must maintain their skills (which are monitored at the conclusion of each test). The screening and qualifying procedure has three basic steps including (1) product usage and familiarity, (2) discrimination ability, and (3) task comprehension.

In addition to identifying individuals who can significantly discriminate differences, the selection process eliminates individuals who experience difficulty following instructions or are inconsistent in their ability to discriminate differences. It is reasonable to expect that about 60% of the individuals who volunteer will qualify. For QDA about 25 individuals is a sufficient number to start with an expected yield of about 12 to 15 qualified discriminators.

Product Usage

Candidates should indicate their interest in testing and complete a product attitude survey form [*1*]. They should be a homogeneous group of users and likers of the product (or product

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category) to be tested, but not the technologists or marketing specialists working with the particular product. Individuals with knowledge as to the variables being tested are biased and should be excluded. Also, individuals with extreme attitudes about the specific product category should be excluded. Experience has shown these people are relatively insensitive to product differences.

Discrimination Ability

Candidates should participate in about 15 to 20 (and usually not more than 30) discrimination trials over a period of three to five days depending on the products, availability, and number of trials. A series or product variables are prepared representing easy, moderate, and difficult sensory skill (from large to small differences). When preparing the product pairs, the experimenter should seek a level ranging from about 90% correct to about 50% correct. While the actual degree of difficulty will not be known until after completion of the trials, subsequent ability tests can draw from previous results as a guide.

Panelists participate in a series of trials beginning with the easy pairings and finishing with those considered difficult. Each pair is evaluated twice in the same test session, and the cumulative percent correct responses forms the basis for qualification. The number of trials in a session will depend on the panelist availability and on the products themselves. If the products have strong aromas or flavors, it will require more time to recover between trials, and this will extend the total amount of time required for screening. Usually not more than three 90-min sessions are required. Panelists should demonstrate minimum level of discrimination ability of about 65% correct matches. However, the panel leader can set the qualifying criterion higher to select only the most sensitive individuals. Setting an appropriate level for inclusion of an individual is done by the panel leader and is dependent on prior experience with the product category and availability of panelists.

For the product variables, select those considered by the technologist to occur with that product and able to be formulated with minimal difficulty. These same products can be used for future screening tests. The paired-comparison and duo-trio test methods are recommended for the discrimination screening. Other methods can be used for screening, such as ranking; however, results from the discrimination test are the single most important criterion.

Test Performance

On completion of discrimination tests, the panel leader selects ten to twelve individuals who exhibit greatest sensitivity and consistency in their performance and have the best potential for participation in descriptive tests. Participation is based on availability, promptness, and ability to communicate and work in a group. These are based on the panel leader's observations; however, no interviews are required. That is, in the panel leader's opinion the selected panelists will likely work well together, are communicative, and no one is expected to dominate the group discussions. In most instances having more than twelve panelists is not necessary; no significant improvement in product differentiation is obtained. Having fewer than ten panelists increases the potential of each one having a greater impact on the database. These are guidelines, and actual performance will determine whether an individual continues to participate in future tests.

Summary

Screening serves several purposes. It identifies candidates who cannot learn a sensory task within a reasonable time period or cannot follow test instructions. It familiarizes candidates with the products and their sensory properties. It provides the panel leader with experience in

product preparation and handling and any potential for sensory interaction. Finally, it enables the panel leader to make an overall assessment of the candidate's interest in the project.

Training of Panelists

In QDA, the next stage of training is the language development process leading directly to product testing. A primary objective of the training is to develop a scorecard which is used to score the products. Panelists, as a group, meet with the panel leader and develop a common language that describes their perceptions of the products. The panel leader facilitates the discussion, ensures that materials needed by panelists are available, keeps notes, but does not participate in the actual development of the attributes needed to fully describe the products. The panel leader may suggest attributes when the panel is experiencing difficulty describing a particular sensation; however, the panel, as a group, must come to agreement as to inclusion of each attribute. The agreement will not necessarily be unanimous. Each session lasts about 60 min to as long as 90 min, depending on panelist availability. There can be as many as eight to as few as four of these sessions, especially if panelists are inexperienced or the products are complex. During these sessions, panelists also develop the order of occurrence for the attributes, that is, what is perceived first, second, and so forth. This is achieved by the panel coming to an agreement with assistance from the panel leader, if required.

Other tasks accomplished in the sessions include an explanation for each word used, standardized procedure for product evaluation, including product amount, and use of the scale to record intensity judgments. The products used in language training are selected by the panel leader from those that will be tested. Other products, raw materials, and individual ingredients also may be used to assist panelists in identifying or characterizing a particular sensation. Panelists also practice scoring products in the latter sessions to familiarize themselves with scale use and to build confidence in their individual and collective judgments.

The panel leader keeps a complete record of each session (products evaluated, emphasis of session, and so forth), which is used when training new panelists. These newer individuals must satisfy the same criteria as the original group. For language training, new panelists follow the same procedure (as the original group) and are added to the panel once the panel leader is satisfied that they are ready, that is, they understand the attributes and can score products consistently. The usual procedure is to provide new panelists with the current set of attributes and explanations with the option of making changes, again based on a consensus decision.

Experienced panelists will not require as much training time as the naive, inexperienced individual. This is true if the product is similar (for example, the same product but a different flavor) or if an entirely new category is being studied. If a panelist has not participated for more than three or four weeks, at least one orientation session will be necessary. For the same product category, this is usually not more than a 30-min session, but if the product category is new, then several sessions could be necessary to add or delete attributes. In some instances the group sessions may be preceded by some discrimination trials. The discrimination trials always use the products that will be evaluated in the descriptive test. Of particular importance is the need to first determine if an individual is insensitive to differences, and second to familiarize the panelists with the sensory characteristics of the new product category. Organizing and implementing these tasks are the responsibilities of the panel leader.

General Conditions for Testing

Product evaluation is done in standard sensory test booths, with proper lighting and environmental control such that panelists are free from external distractions. Each panelist is provided with the list of attributes along with an explanation (or definition) for each attribute, a scorecard, product, napkins, a covered container for expectoration, water, and unsalted crack-

ers for rinsing. Insofar as is possible, panelists should participate the same time each test day. The interval between products is controlled, and panelists are encouraged to rinse. After an evaluation, the scorecard is examined for completeness before proceeding to the next. A typical test consists of four products and a scorecard which could have as many as 30 to 40 attributes. In training considerably more attributes would have been developed; however, the training will have enabled the subjects to eliminate redundancies. The number of attributes can be fewer or more depending on product complexity; however, the reader is cautioned to not decide in advance on the exact number. A single trial (evaluation of all four products) would require 15 min.

Experimental Design

A balanced block design is used such that each product is evaluated equally often by each panelist [*1*]. A monadic, sequential serving order is used, and all products are three-digit coded, each with a unique code different from all others in the test. A test could involve as few as 2 to as many as 30 products, but still served in a balanced design. In the latter situation all products would not be served in a single session but would be separated into blocks of sufficient size to minimize sensory fatigue but enable data collection to be completed in a reasonable time period.

Scorecard

A scorecard consists of name, date, appropriate designation for product code and serving order, and a list of the attributes that were developed in the language development sessions. The scorecard lists the attributes in order of occurrence and as agreed to by the panel, starting with the first perception and ending with the last. An example of a portion of a scorecard is shown in Fig. 1.

The scorecard covers appearance, aroma, and flavor attributes only. Mouthfeel and aftertaste would also be included in a full QDA. The scales are anchored with directional terms ½ in. (12.7 mm) from each end.

Scale

To record the intensity for each attribute, panelists make a vertical mark on a 6-in. (152-mm) horizontal line at that point that represents the intensity. The line has two word anchors, placed ½ in. (12.7 mm) from each end, and panelists are reminded that they can mark beyond the anchors; for example, marking to the left end of the line would mean that none of that attribute was detected while marking to the right end would mean the strongest intensity for that attribute. Alternatively one can use a 15-cm scale with the vertical anchors at 2.5 cm from each end. An example of the line scale as used with selected attributes is shown in Fig. 1.

Data Collection

After subjects have completed all evaluations, the panel leader collects the scorecards and prepares a data file for analysis. The mark on each scale is converted to a numerical value by measuring the distance from the far left end of the scale to the mark. For computational purposes the decimal point is moved one place to yield whole numbers from 0 to 60 (or 150 for the metric version). This is best done with a bit-pad (or digitizer), which automatically computes the numerical value and files it according to each subject, product, and replication. Some companies have a direct data entry system, in which case, a digitizer is not required.

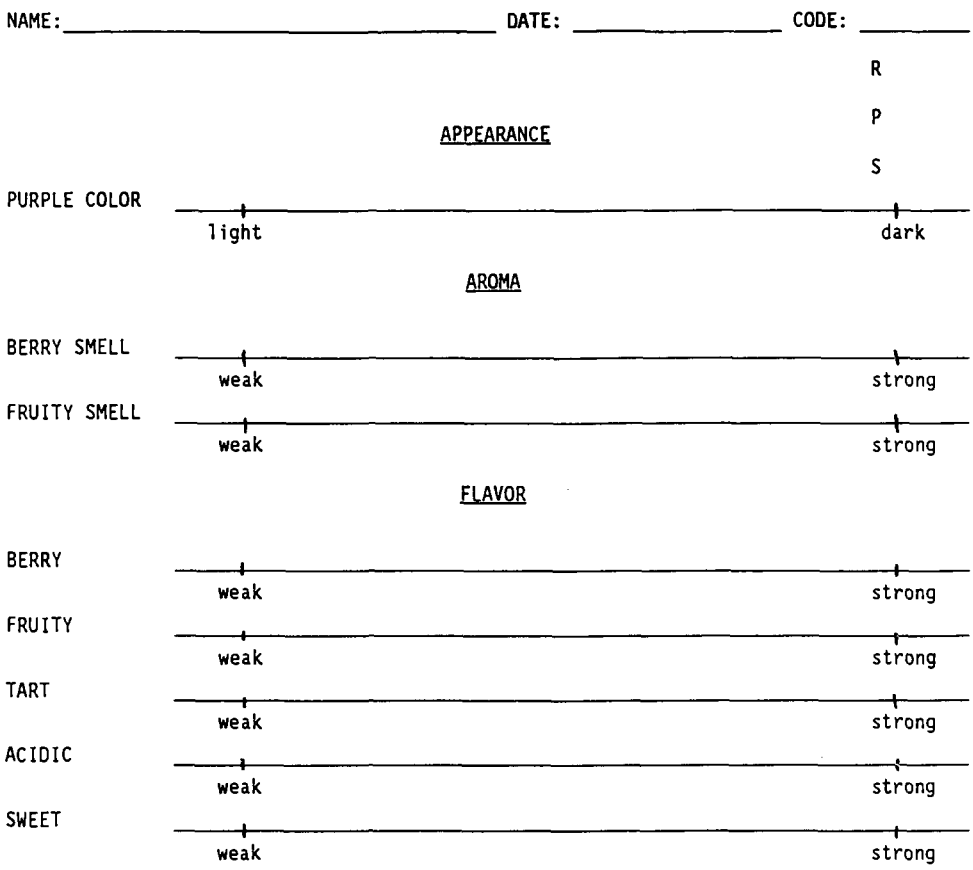

FIG. 1—*Scorecard and line scale for fruit-based juice product.*

Data Analysis

There are several considerations in the analysis of the responses with an initial assessment of the quality of the data on a subject-by-subject basis and on a scale-by-scale basis [*1–3*].

These assessments, along with related analyses, provide the basis for delineation of product differences. There is considerable reliance on the analysis of variance to partition the sources of variability and to determine product effects. Unless otherwise stated, the most frequently used analysis is a treatment-by-subject, with replication, mixed model analysis of variance. If the products constitute a design set of variables, for example, two treatments and each formulated at two flavor levels, then the appropriate design would be used (in this instance it would be a treatment-by-treatment-by-subject design). Regardless of these issues, analysis of responses begins with a one-way analysis of variance for each subject, which determines how well differences between products were perceived by that panelist and yields a numerical measure of performance for each panelist. This analysis also provides an indication of how helpful each attribute was in differentiating products.

The second and third analyses include a two-way analysis of variance to determine whether there are product differences, and the extent of interaction by the panel and the contribution of each panelist to that interaction. Additional analyses yield mean and standard deviation

TABLE 1—*Fruit based juice product.*

Purple Color		Berry Smell		Berry	
Berry 2	34.13	Berry 2	29.92	Berry 2	34.00
Berry 1	33.08	Berry 3	24.17	Berry 1	28.79
Berry 3	27.00	Berry 1	23.83	Berry 3	14.38
Fruity Smell		**Fruity**		**Tart**	
Berry 2	19.21	Berry 1	26.13	Berry 2	24.46
Berry 1	18.29	Berry 2	21.83	Berry 3	23.83
Berry 3	11.50	Berry 3	13.25	Berry 1	14.83
Acidic		**Sweet**			
Berry 3	29.96	Berry 1	30.50		
Berry 2	22.29	Berry 2	29.00		
Berry 1	20.04	Berry 3	23.29		

NOTES: Means within solid brackets are not significantly different at the 0.05 level of probability, unless otherwise specified. Means within dashed brackets represent interpreted trends based on ranks and individual respondent data. Mean values for the products are on an attribute basis for aroma and flavor. Product differences derived from multiple range tests. See text for further discussion.

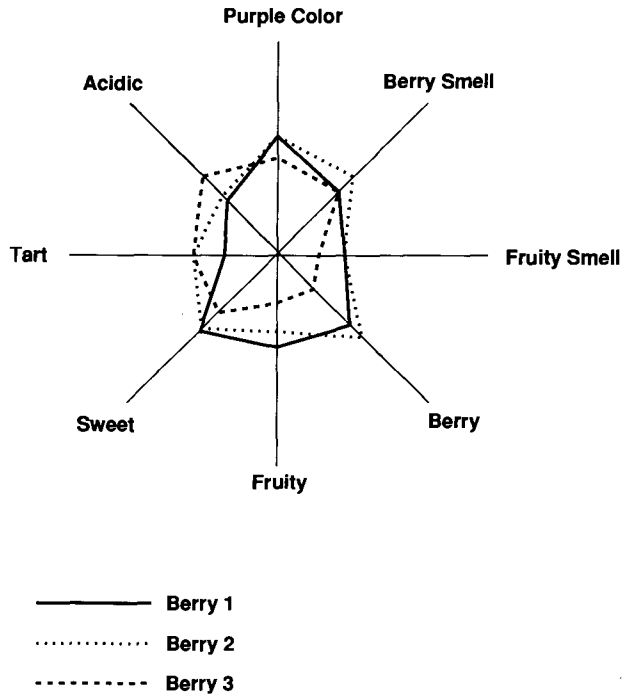

FIG. 2—*Aroma and flavor characteristics for fruit-based products. Graphical representation of the results shown in Table 1. Measuring from the center point along the line is the mean intensity value for that attribute.*

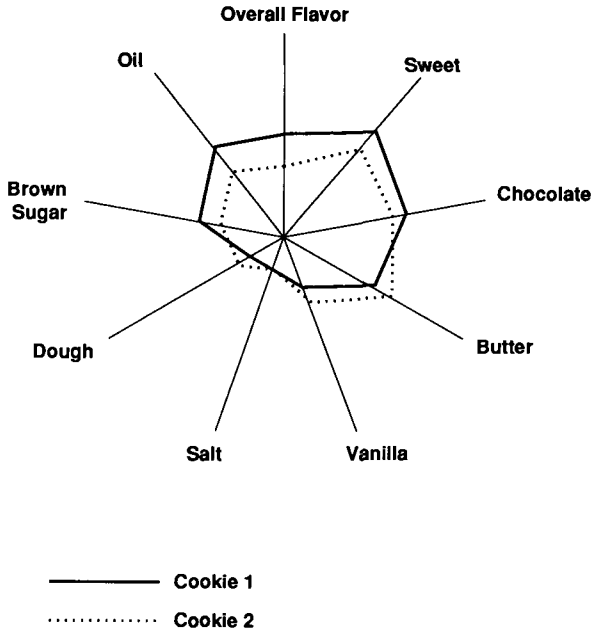

FIG. 3—*Flavor attributes for cookie product. Each spoke is one attribute, and relative intensity is represented by that point at which the product line crosses, with the lower intensity toward the center point and the maximum intensity furthest from the center.*

values for the products (on an attribute basis), pair-wise correlations, mean and individual ranks, and Kendall coefficient of concordance (a type of correlation for ranked data).

These analyses enable the panel leader to assess the overall quality of the data and identify the specific attributes for which product differences were obtained, leading to the determination of specific product differences on an attribute by attribute basis. In addition, the analyses identify panelists and scales that require more attention before the next test; that is, where the variability was much greater than that encountered with other subjects or with other attributes.

Test Reports

A report should include a brief explanation for the purpose of the test, conclusions and recommendations, results, the scorecard, explanations for attributes, test protocol, and related documentation. Results can be summarized in tabular form (Table 1) or depicted graphically as shown in Figs. 2 and 3. Each company will have its own report format. The extent to which test procedures and results are described should be determined before preparing the final report.

References

[*1*] Stone, H. and Sidel, J. L., *Sensory Evaluation Practices,* 2nd ed. Academic Press, Inc., Orlando, FL, 1992, pp. 206–240.

[*2*] Powers, J. J., "Current Practices and Applications of Description Methods," *Sensory Analysis of Foods,* J. R. Piggot, Ed., Elsevier, London, 1988, pp. 187–266.

[*3*] Stone, H., Sidel, J., Oliver, S., Woolsey, A., and Singleton, R. C., "Sensory Evaluation by Quantitative Descriptive Analysis," *Food Technology,* Vol. 28, No. 11, 1974, pp. 24, 26, 29, 32, 34.

3

The Spectrum Descriptive Analysis Method

by Alejandra M. Muñoz[1] and Gail Vance Civille[1]

Principle

The Spectrum Descriptive Analysis Method consists of a complete, detailed, and accurate descriptive characterization of a product's sensory attributes. This characterization provides information on the perceived sensory attributes (characters or notes) and the levels or intensities of each. The perceived intensities are recorded in relation to absolute or universal scales, which allow the comparison of relative intensities among attributes within a product and among products tested.

A Spectrum panel is trained on principles of appearance, aroma/fragrance, flavor, and texture for the evaluation of these modalities. Alternatively, the method can emphasize any one of these sensory modalities alone to fit the various needs. The Spectrum method can be used to evaluate an array of product categories including foods, beverages, personal care, home care, paper, and other products. This descriptive method gives emphasis to both the qualitative and quantitative aspects of descriptive measurements, that is, a Spectrum panel describes accurately and in detail the various characteristics/parameters of appearance, flavor, and texture. A scale with enough discrimination and anchor points is used in the evaluation of products. The Spectrum Descriptive Analysis Method provides the following:

1. A description of the major product sensory categories.
2. A detailed separation and description of each sensory attribute within each major sensory category.
3. The perceived intensity of each sensory attribute.
4. Statistical evaluation of the descriptive data.

Selection of Panelists

Panelists are selected based on several criteria: acuity, rating ability, interest, availability, positive attitude, health, and capacity of abstract reasoning. This information is obtained during two selection stages: the prescreening and screening processes. For the final selection of 15 panelists, approximately 40 to 50 people (employees) or 60 to 80 people (from the local community) are recruited to participate in the prescreening. This is a sufficiently large pool to obtain qualified panelists through the two stages of screening. Employees or residents from the local community who meet the criteria of the prescreening and screening tests are trained as panelists.

Prescreening

A written questionnaire is distributed to interested participants to address the following:

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Availability—It is necessary to assure the availability of subjects during the orientation and training sessions. In addition, candidates should have relatively flexible jobs or schedules that will assure their availability for regular panel evaluations.

Health—General health questions are addressed to determine any problems that might affect the panelists' discrimination abilities during product evaluation (such as allergies or hypoglycemia). These questions differ depending on the task the panel will perform. For example, for both flavor- and texture-descriptive evaluations, the presence of dentures is investigated, as this might affect the panelist's performance.

General Product Attitudes and Sensory Awareness—The prescreening form addresses questions on consumer product habits, such as a restricted diet and the liking or disliking of specific foods. In this step those individuals unable or unwilling to taste or manipulate a given product or ingredient during product evaluations are disqualified. The prescreening form also addresses questions on products' characteristics. It allows the panel leader/administrator to obtain information on the panelists' verbal ability and their awareness of sensory properties.

Rating Ability—In the prescreening stage the candidates are tested for their ability to rate perceptions. Different shaded areas are shown for candidates to rate the amount/intensity of the dark/shaded component.

To qualify for the next screening phase, candidates should be available for all training sessions and for most of the evaluation sessions, indicate no major medical problems that may affect their perception abilities, answer 80% of all the questions on sensory properties, and assign scalar ratings that are within 10 to 20% of the correct value for all figures.

Screening

Prescreened panelists are scheduled to participate in the screening part of the program, which consists of two main parts, acuity tests and a personal interview.

Acuity Tests—A series of acuity tests is given to the participants to test their ability to detect and describe sensory characteristics and rate their intensities. Below is the description of the series of tests used to screen an appearance, flavor, and texture panel. Variations of these tests are used when people are screened for other modalities (for example, skinfeel and fabric feel), or are trained on only one sensory dimension.

1. BASIC TASTE TEST: Panelists are presented with a series of basic taste solutions to test their ability to identify the four basic tastes: sweet, salty, sour, and bitter. Any number of solutions (5 to 10) can be given to the candidates for the identification of the basic tastes present in those solutions. A minimum of 80% correct responses is required.
2. SCALING TEST AND USE OF REFERENCES: A series of solutions of a basic taste or another stimulus, varying in concentration, is presented to candidates. Two reference points are presented first with designated corresponding intensities. These references might have the concentration of test samples or concentrations not tested. After becoming familiar with the references, panelists evaluate the series of solutions and rate their intensities. This test provides an indication of the ability to discriminate and rate intensities. The panelists' ability to use intensity references is tested as well. Participants should assign ratings that are 10 to 20% of the correct value.
3. ODOR IDENTIFICATION TEST (DESCRIPTION TEST): A series of 5 to 10 different odorants are presented to panelists to test their ability to recognize and describe olfactory sensations. The stimuli demonstrate easily recognized characteristics, such as citrus, peppermint, rose, and so forth. The selection of these odorants varies depending upon the type of products to be evaluated. Ideally, some of the aromatics present in the products of

interest are included in the test. Panelists should be able to describe 80% of the stimuli using chemical, common, or related terms.

4. TEXTURE ACUITY: Three texture reference scales are presented monadically to participants who are being considered for texture evaluations. Examples of texture attributes tested are hardness, fracturability, and cohesiveness of mass. Panelists are presented with one scale at a time, with the products randomized. For each characteristic, the attribute and evaluation procedure is defined and two reference points may be provided. Based on this information, panelists are asked to rate the intensity or rank each of the products in the series. Panelists should be able to rate or rank all samples in the correct order (in the review of results, reversal of adjacent samples is allowed).
5. APPEARANCE ACUITY: Two or three appearance variables are selected for the acuity test. These variables should represent relevant characteristics in the product(s) to be tested, for example, color intensity, shininess, or surface uniformity. Within each attribute a series of four to five products representing a range of that characteristic are presented to the candidates to rate. The attribute is defined, and two intensity reference points may be presented to the candidates. Based on this information, each person rates or ranks the test samples provided. Panelists should be able to rate or rank all samples in the correct order (in the review of results, reversal of adjacent samples is allowed).
6. PRODUCT SPECIFIC ACUITY TEST (DETECTION): The acuity tests described above, odor identification, texture ratings, and appearance ratings, are sometimes augmented or replaced by a product specific acuity test, if the panel is to be trained in only one product category. A series of 10 to 15 difference tests (duo-trio or triangle tests) are prepared with samples representing formula and processing variables and with increasing levels of difficulty in the series. This test only provides information on the panelists' ability to discriminate differences. It does not test the panelists' ability to describe differences. The panelists selected are those achieving 50 to 60% correct responses in triangle tests or 70 to 80% in duo-trio tests.
7. OTHER TESTS: Most of the tests described above apply to flavor and texture panels. Other acuity tests not described here are used in screening a panel for fragrance, handfeel, or fabric feel evaluation.

Personal Interview—The panel leader/administrator conducts a personal interview with each of the participants to investigate interest in the program, availability and commitment to the program, major health issues not addressed previously, enthusiasm and general attitudes, verbal skills, and ability to work with a group.

Panelists Selection Based on Screening Tests

Fifteen candidates are selected for the training program based on the results of the acuity tests and interview. Panelists who pass the acuity tests and show interest and enthusiasm in the program, availability and commitment, a general positive attitude to new programs/tasks, and ability to interact and work with a group are selected. Panelists who do not show the above positive personality and attitude characteristics may not be selected despite their high acuity score.

Training of Panelists

An extensive and detailed training program is required for panelists to be able to discriminate, describe, and quantify the sensory characteristics of products following the Spectrum

method. The main objectives of this training program are (1) to expose the panel to the underlying dimensions of flavor, texture, and appearance attributes to ensure accurate evaluation of these characteristics and (2) to provide a similar frame of reference in terminology and scaling among all participants. A period of approximately three months is required for training a Spectrum panel in each of the sensory modalities (for example, flavor, texture). Training a panel for appearance evaluation requires less time than for either flavor or texture. The training program consists of two parts, general orientation sessions and practice sessions.

General Orientation

A general orientation session is scheduled at the beginning of the training. In most training programs a second orientation session is scheduled one or two months after the first session. The orientation sessions are conducted by a Spectrum panel leader/administrator. The first general orientation session, which requires three to four days of work with the panel, is designed to expose the panel to the underlying technical principles of appearance, flavor, and texture. These are the physiological principles and processes involved in sensory evaluation (for example, taste, olfaction, and chemical feeling factors for a flavor training program) and examples of different types and intensities of sensory stimuli.

In addition, a series of demonstrations are designed to expose the panel to the basic approach of the Spectrum method. Each demonstration consists of (1) a review of samples in the category and preliminary terminology development, (2) a review of product references and development of terminology and evaluation procedures, and (3) the product evaluation and discussion of results.

Review of Samples and Preliminary Terminology Development—The terminology development phase is an essential part of the Spectrum Descriptive Analysis procedure. A considerable amount of time, discussion, and reference samples are needed in this process to assure the development of the detailed and accurate terminology required for evaluations. A subset of the products to be tested and competitive products are presented to the panel initially. Panelists individually develop a list of terms that most adequately describe the perceived attributes of the product category. A brief discussion follows, where the panel leader records and organizes all terms provided by the individual panelists in such a way as to facilitate subsequent discussion (for example, fruity, cherry, berry, and benzaldehyde).

Review of References and Development of Terminology and Procedures—Following the first discussion, a series of products and references are presented to the panel for inspection. These products represent some of the sensory attributes in their simplest manifestation. The product references may include raw ingredients (including more than one supplier or source), semi-processed products, and finished products that include various types and sources of ingredients and processing variables. The raw ingredients are presented in more than one medium or condition to demonstrate the perceived differences among slightly different versions of the same attribute (for example, raw and cooked apples of different varieties). A considerable amount of preparation and collaboration with product development or manufacturing is required to obtain these product references.

A second, more extensive group discussion follows the inspection of product references. The panel leader monitors the discussion, specifically geared to establish the terms that describe the perceived sensory attributes of the product category. The inspection of all product references enables the panel to agree on the terms for product evaluation. Once agreement is reached, a ballot is developed listing the established terms in the order chosen by the panel (Figs. 1 and 2). In addition, detailed definitions are developed for the terms selected (Fig. 3). If additional product references and discussions are required, subsequent sessions may be needed to complete a ballot.

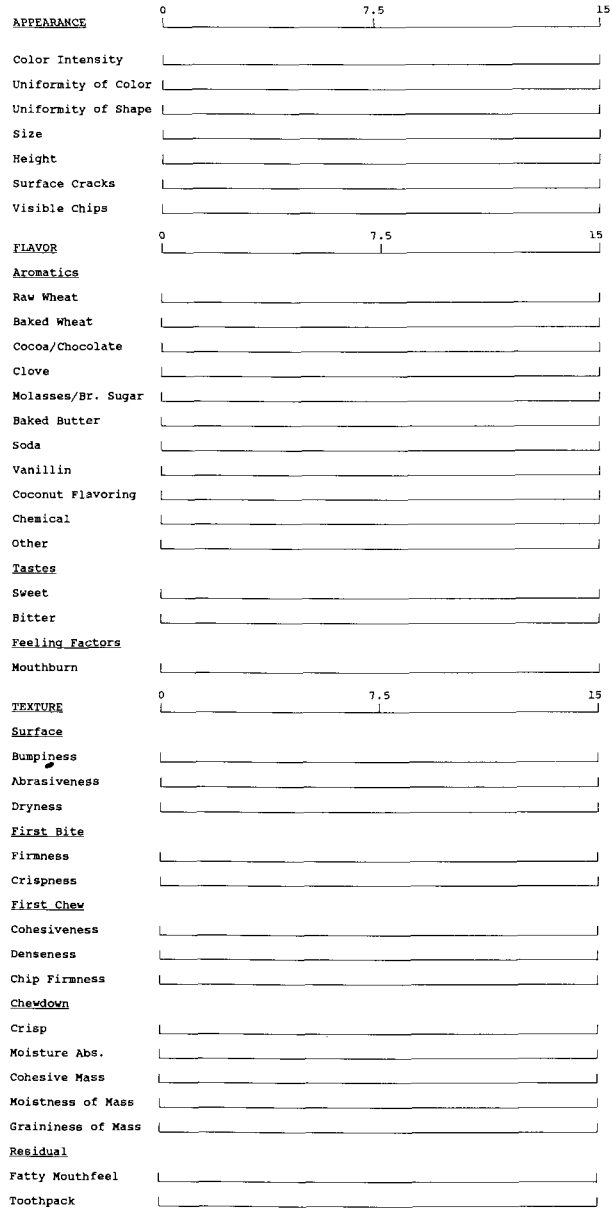

FIG. 1—*Example of a Spectrum ballot for chocolate chip cookies (appearance, flavor, and texture).*

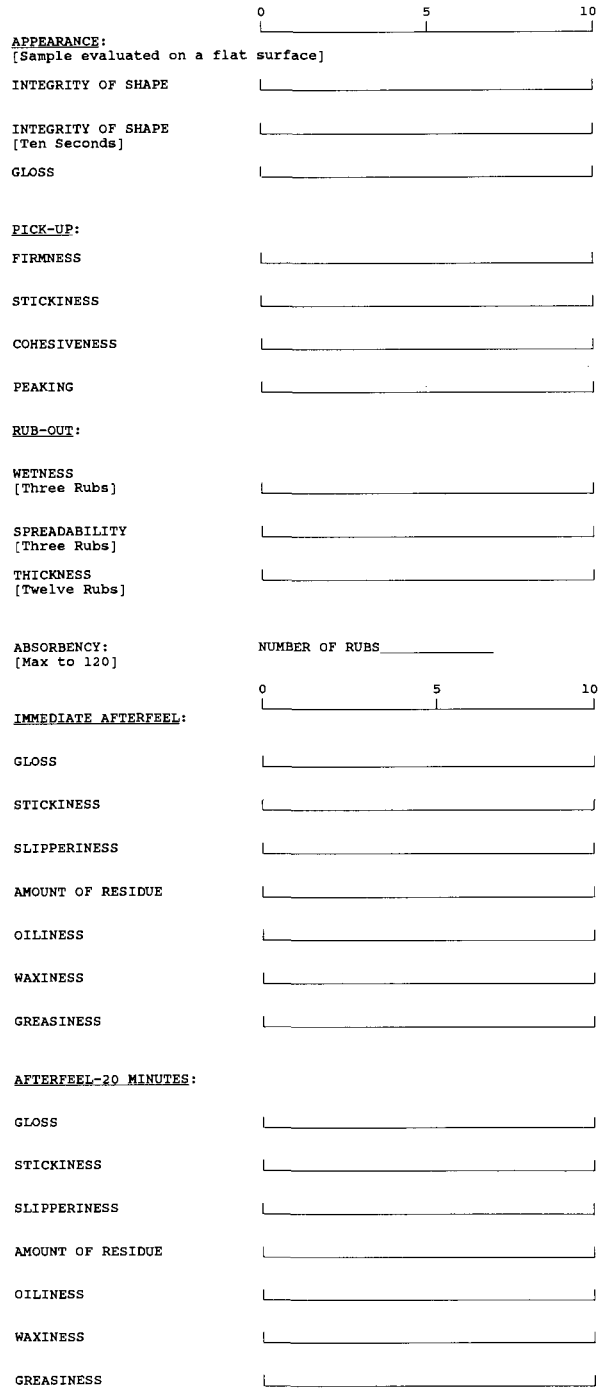

FIG. 2—*Example of a Spectrum ballot for hand and body lotions (appearance and skinfeel characteristics).*

APPEARANCE	
Color Intensity	Darkness or value of hue [light----------> dark]
Uniformity of Color	Eveness of the hue distribution [uneven----------> even]
Uniformity of Shape	Uniformity/regularity of the circular shape [uneven ----------> even]
Size	Width of the cookie [small----------> large]
Height	Height of cookie [low----------> high]
Surface Cracks	Amount of small breaks or fractures on the top surface [none----------> many]
Visible Chips	Amount of chips visible on the surface [none----------> many]
FLAVOR	
Aromatics	
Raw Wheat	The aromatic associated with white wheat flour which has not been heat treated.
Baked Wheat	The aromatic associated with white wheat which has been sufficiently heated to carmelize some of the starches and sugars.
Cocoa/Chocolate	Cocoa: aromatic associated with cocoa powders and/or compound coatings Chocolate: aromatic associated with chocolate liquor extracted from cocoa bean
Clove	The aromatic associated with eugenol/oil of clove.
Molasses/Brown Sugar/ Caramel	The aromatic associated with browned sugar or brown sugar/molasses.
Baked Butter	The aromatic associated with butter which has been heated in baking.
Soda	The aromatic associated with sodium bicarbonate.
Vanillin	The aromatic associated with ethyl vanillin.
Coconut Flavor	The aromatic associated with coconut meat or coconut milk.
Chemical	The aromatic associated with non-foods plastics, solvents, etc.
Basic Tastes	
Sweet	The taste on the tongue stimulated by sucrose and other sugars, such as fructose, glucose and other sweet substances such as aspartame.
Bitter	The taste on the tongue stimulated by substances such as quinine, and caffeine.
Feeling Factors	
Mouthburn	The burning sensation in the mouth caused by depletion of water in the oral mucous caused by high concentrations of salt, acid, sucrose and alcohol.

FIG. 3—*Definitions of sensory attributes of chocolate chip cookies.*

TEXTURE	
Surface	Feel surface of sample with lips and tongue.
Bumpiness	The overall amount of large bumpy areas in the surface [smooth----------->bumpy]
Abrasiveness	Degree of small particle roughness on the product's surface. [smooth----------> abrasive]
Dryness	The absence of moistness (oil and/or water) on the product's surface. [wet----------> dry]
First Bite	Place 1/2" piece between front teeth and bite down.
Firmness	Force required to bite through. [soft----------> firm]
Crispness	Force and sound with which the sample ruptures. [soggy----------> crisp]
First Chew	Place 1/2" piece between molars, bite through.
Cohesiveness	Degree to which the sample deforms rather than ruptures [breaks/ruptures----------deforms]
Denseness	Compactness of cross section. [airy----------> dense]
Chip Firmness	Force required to bite through chip. [soft----------> firm]
Chew Down	Place 1/2" piece between molars, chew 10-12 times.
Persistence of Crisp	Degree to which sample remains crispy throughout chew. [none----------> much]
Moisture Absorption	Amount of saliva absorbed by sample. [none----------> much]
Cohesiveness of Mass	Degree to which the chewed sample holds together. [loose mass----------> tight mass]
Moistness of Mass	Amount of moisture/wetness in chewed mass. [dry----------> moist]
Graininess of Mass	Amount of small particles in the chewed mass. [smooth----------> grainy]
Residual	Feel mouth and tooth surface with tongue.
Fatty Mouthfeel	Degree to which mouth feels fatty/greasy. [dry----------> fatty]
Toothpack	Amount of product packed in the teeth. [none----------> much]

FIG. 3—*Continued*

The evaluation procedures and specific test conditions are also established. This task is very important in texture evaluation, since test conditions (for example, sample size) and evaluation procedures affect texture assessments.

The demonstrations conducted during the general orientation are also designed to train the panel to quantify perceived intensities and to use intensity references. The scale used in the Spectrum method can be a 15-cm (or 10-cm) line scale, anchored at the end with the terms "none" and "extreme." Panelists indicate the perceived intensities by marking a vertical line on the scale. The distance from the left extreme (zero) to the mark is the score representing the intensity perceived. (Alternatively, panelists use 15 point scales measured to tenths, anchored from 0 = none to 15 = extreme.)

Intensity references for flavor, texture, skinfeel, and handfeel evaluation have been developed and are published elsewhere. During the general orientation sessions, panelists are exposed to these intensity reference scales to illustrate intensities covering the entire range of intensities for a particular attribute. The intensity ranges (for example, 0 to 15) covered by these references encompass the attribute intensities of most of the products in the class (for example, firmness or saltiness intensities in most foods, or afterfeel intensities in most skinfeel products). However, panelists may indicate higher intensities (greater than 15) for stronger stimuli. For example, Spectrum panels would rate the sweetness of corn syrup to be 22, which is higher than the sweetness of most foods (0 to 15).

Product Evaluation—Once the ballot has been finalized, two products are given to panelists to evaluate. This exercise allows the use and validation of the developed ballot and allows panelists to practice and apply the concepts and terminology developed. The panel leader/administrator leads a discussion to assess panelists' results, to clarify terminology and scale usage, and to discuss any problems.

The process described above is also followed during the practice sessions of the training program and during regular evaluation sessions once the panel is trained.

Practice Sessions

A series of demonstrations completed after the general orientation is designed for the panel to practice and apply the learned principles. These demonstrations cover a wide range of products. A total of 10 to 12 exercises are completed during three months of panel work. The approach followed for the development of terminology and product evaluation is similar to the one followed in the orientation session. Three tasks are completed in each exercise (3 to 4 h total): (1) the review of samples in the product category and preliminary terminology development, (2) the review of product references and establishment of terminology and evaluation procedures, and (3) the product evaluation and discussion of results. The approach followed for these three tasks is described above under general orientation.

Panel Leader

The panel leader is the person responsible for the preparation and administration of the practice sessions (training) and routine evaluation sessions. Her/his responsibilities are the administration of all the sample preparation, leadership of the group, monitoring of the panel's progress, and collection, analysis, and interpretation of the descriptive data. This person may be either a sensory professional assigned to this task or a member selected from the panel. Unless the sensory professional has experience in the Spectrum Descriptive Analysis Method, the panel leader's skills as panelist and leader are developed during the training program, under

the direction of a Spectrum panel trainer. After completion of the training and practice programs the panel leader assumes responsibility from the Spectrum panel trainer.

Conditions for Panel Operation

Optimally, two rooms are required for the operation of a Spectrum descriptive panel. The panel orientation sessions and discussions are conducted in a room that facilitates group interaction. Individual evaluations are conducted in sensory booths. Both rooms should have the features required for maintaining adequate testing controls, such as appropriate illumination, ventilation, temperature, and humidity controls. Sample preparation and presentation should be followed under controlled conditions. The amount of samples evaluated in a session depends upon the type of products evaluated and the experimental design used.

Procedure for Product Evaluation

Eight to twelve trained descriptive panelists participate in descriptive projects. A routine descriptive session consists of three phases: (1) panel orientation (ballot development), (2) product evaluation, and (3) data analysis and interpretation.

Panel Orientation

One or more sessions is (are) required for the development and establishment of terminology. Several sessions are required for a new product. Subsequent evaluations of the same product category require only one session to review variables and to modify the established evaluation sheet to address new characteristics. The following is accomplished in this (these) session(s): (1) the inspection of a subset of the products to be evaluated and competitive products for preliminary terminology development, (2) the review of product references, and (3) the establishment of the final ballot. Examples of a standard ballot for a food product (Fig. 1, chocolate chip cookies) and a skinfeel product (Fig. 2, hand and body lotions) are presented. Figure 3 is an example of the list of definitions established for the terms described in Fig. 1.

Product Evaluation

Panelists evaluate test samples in individual sensory booths following the established ballot and under controlled testing conditions. Depending on the amount of samples to be evaluated and the experimental design followed, more than one evaluation session may be required. A total of two to three replications is required in the evaluation of each sample. Individual scores are collected and analyzed.

Data Analysis

The type of data analysis completed depends on the project objective and the experimental design used. Since in descriptive analysis the effects of interest are usually panelists, products, and the panelists by product interaction, the standard analysis completed is a split-plot analysis of variance test. However, other analyses are used for other experimental designs. A variety of uni- and multivariate data analysis techniques are used in the many applications of Spectrum descriptive data.

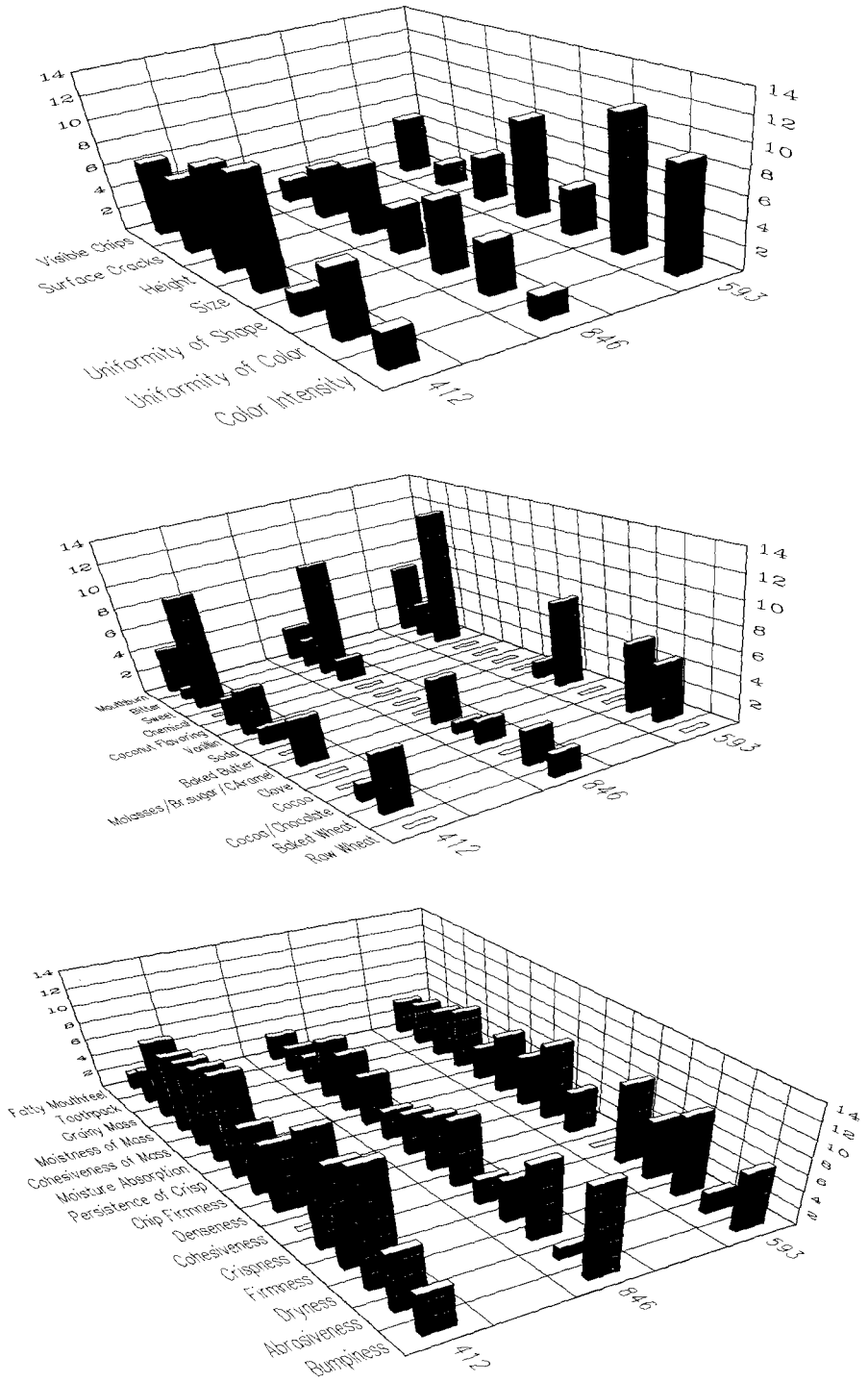

FIG. 4—*Histograms of Spectrum data of cookie attributes: (a) appearance, (b) flavor, and (c) texture.*

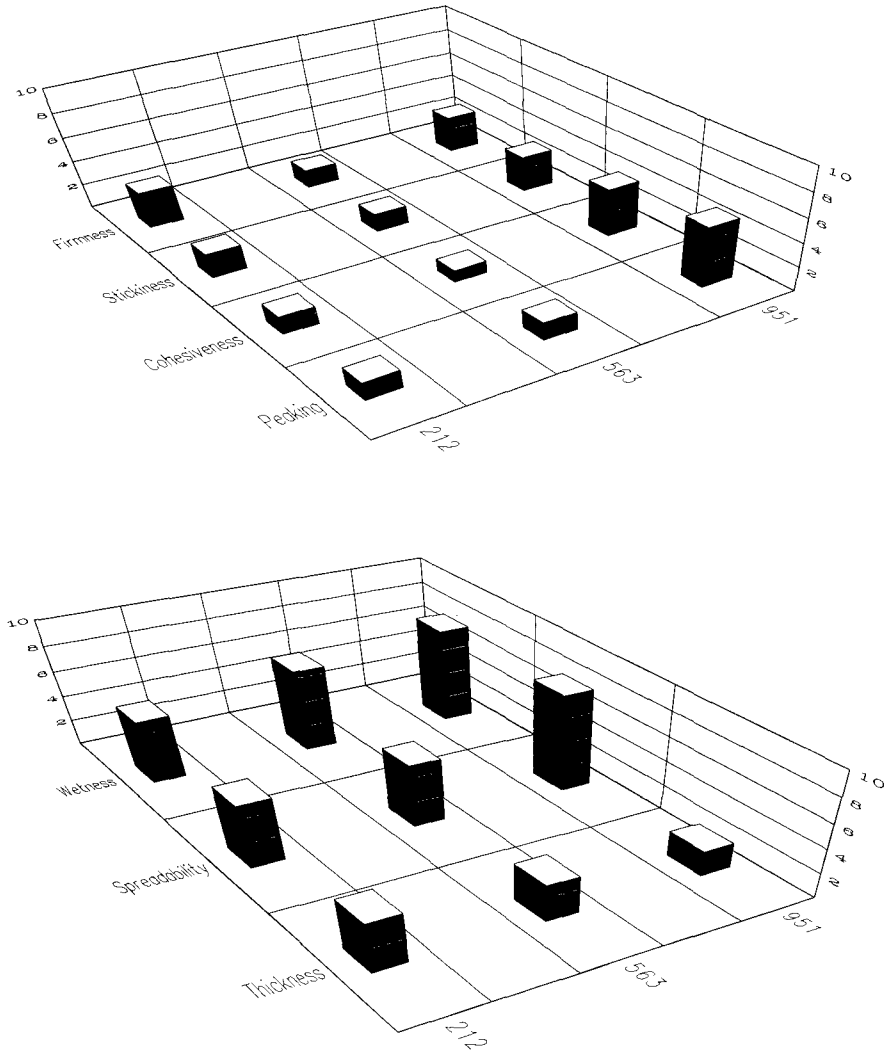

FIG. 5—*Histograms of Spectrum data of lotion attributes: (a) Pick-up characteristics and (b) Rub-out characteristics.*

Test Report

A standard Spectrum report consists of the following main parts: (1) test objective; (2) sample identification; (3) source, storage, preparation and presentation procedures for test samples and references; (4) sensory test design, including conditions of test and evaluation procedure; (5) data analysis and presentation results (tabular or graphical, see Table 1 for tabular and Figs. 4 and 5 for examples of graphed Spectrum data); and (6) data interpretation, conclusions, and recommendations. Appendices are included in the report to provide specific information on data analysis, attribute definitions, and references.

TABLE 1—*Skinfeel spectrum results for three hand lotions.*

	Products		
	212	563	951
Attribute:			
Appearance:			
Integrity of shape	4.1	5.9	4.9
Integrity of shape [10 s]	3.3	5.3	4.3
Gloss	7.2	6.7	6.6
Pick-up:			
Firmness	2.8	3.0	1.3
Stickiness	2.2	2.9	1.1
Cohesiveness	1.7	4.6	0.7
Peaking	1.6	5.8	0.9
Rub-out:			
Wetness	5.1	6.3	7.4
Spreadability	5.1	5.3	7.8
Thickness	4.5	4.0	2.5
Absorbency [Rubs]	33.0	66.0	64.0
Immediate Afterfeel:			
Gloss	4.5	2.4	2.5
Stickiness	3.7	2.3	2.2
Slipperiness	4.0	4.3	4.2
Amount of residue	3.1	1.3	1.2
Oiliness	1.1	0.1	0.4
Waxiness	0.9	1.0	1.1
Greasiness	2.0	0.6	0.8
Afterfeel – 20 min.:			
Gloss	0.9	0.5	0.5
Stickiness	0.6	0.1	0.2
Slipperiness	6.1	7.9	7.7
Amount of residue	0.5	0.1	0.2
Oiliness	0.2	0.0	0.1
Waxiness	0.6	0.3	0.4
Greasiness	0.5	0.0	0.4

Bibliography

Meilgaard, M., Civille, G. V., and Carr, B. T. *Sensory Evaluation Techniques,* Boca Raton, FL, CRC Press, 1987.

Johnsen, P. B., Civille, G. V., Vercellotti, J. R., Sanders, T. H., and Dus, C. A. "Development of a Lexicon for the Description of Peanut Flavor," *Journal of Sensory Studies,* Vol. 3, No. 1, 1988, pp. 9–17.

Sanders. T. H., Vercellotti, J. R., Blankenship, P. D., Crippen, K. L., and Civille, G. V. "Interaction of Maturity and Curing Temperature on Descriptive Flavor of Peanuts," *Journal of Food Science,* Vol. 54, No. 4, 1989, pp. 1066–1069.

Johnsen, P. B. and Kelly, C. A. "A Technique for the Quantitative Sensory Evaluation of Farm Raised Catfish," *Journal of Sensory Studies,* Vol. 4, No. 3, 1990, pp. 189–199.

Civille, G. V. and Dus, C. A. "Development of Terminology to Describe the Handfeel Properties of Paper and Fabrics," *Journal of Sensory Studies,* Vol. 5, No. 1, 1990, pp. 19–32.

Rutledge, K. P. and Hudson, J. M., "Sensory Evaluation: Method for Establishing and Training a Descriptive Analysis Panel," *Food Technology,* Vol. 44, No. 12, 1990, pp. 78–84.

Civille, G. V. and Dus, C. A., "Evaluating Tactile Properties of Skincare Products: A Descriptive Analysis Technique," *Cosmetics and Toiletries,* Vol. 106, 1991, pp. 83–88.

Oreskovich, D. C. and Klein, B. P. "Development of a Standardized Language for Evaluating the Flavor and Texture of Pork by Descriptive Analysis," technical paper presented at the Annual Meeting of the Institute of Food Technology, Dallas, TX, 1991.

4

The Texture Profile

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Introduction

This document describes the characteristics and procedures of the *original* texture profile method as developed by General Foods technical staff in 1963 [*1–3*]. The development of the texture profile method was based on adaptation of rheological principles to sensory evaluation and on the overall concept of the flavor profile method.

Since its origination, the texture profile method has undergone several modifications and extensions [*4–12*]. Among the most important are:

- The development of more precise definitions and evaluation procedures.
- The development of new reference scales.
- The use of various scaling procedures.
- The collection of individual scores without consensus.
- The statistical analysis of data.
- The adaptation of the method to nonfood products.

This chapter is intended as an introduction to the texture profile method. No attempt has been made in this document to incorporate the many modifications of the method that have evolved with time. However, some of these modifications will be pointed out. For a better understanding of these modifications and their applications, the reader is referred to the reference section appended to this chapter.

Principle

Texture profiling is based on the principle that, similar to flavor, texture is comprised of a number of different parameters (or attributes). The intensity and order of appearance of all these attributes are also evaluated in this method.

The texture profile method is based on a system of classification and definitions of textural characteristics. The original classification of textural characteristics and its relationship to popular terminology is shown in Table 1. Following this classification, the various texture attributes evaluated in the texture profile method are grouped in these categories:

- Mechanical attributes.
- Geometrical attributes.
- Attributes related to moisture and fat content.

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TABLE 1—*Relationship between textural properties and popular nomenclature.*[a]

MECHANICAL CHARACTERISTICS Primary Parameters	Secondary Parameters	Popular Terms
Hardness		soft → firm → hard
Cohesiveness	brittleness	crumbly → crunchy → brittle
	chewiness	tender → chewy → tough
	gumminess	short → mealy → pasty → gummy
Viscosity		thin → viscous
Springiness		plastic → elastic
Adhesiveness		sticky → tacky → gooey
GEOMETRICAL CHARACTERISTICS Class		Examples
Particle size and shape		Gritty, grainy, coarse, etc.
Particle shape and orientation		Fibrous, cellular, crystalline, etc.
OTHER CHARACTERISTICS Primary Parameters	Secondary Parameters	Popular Terms
Moisture content		dry → moist → wet → watery
Fat content	oiliness	oily
	greasiness	greasy

[a] Printed with permission. See Ref. *2.*

The mechanical characteristics are probably the most important in determining the manner in which the food handles outside the mouth and behaves during manipulation and mastication in the mouth. The mechanical characteristics manifest themselves as the reaction of the food to applied stress. They are measured by the sense of kinesthesis, that is, the sensation of position, movement, and tension of body parts perceived through nerve endings in muscles, tendons, and joints. The mechanical characteristics are divided into five primary and three secondary parameters [*2,10*]. The primary parameters are hardness, cohesiveness, viscosity, springiness, and adhesiveness. The first four are related to forces of attraction between particles of food that oppose disintegration, while adhesiveness is related to surface properties. The secondary parameters are composed of two or more of the primary parameters and are fracturability, chewiness, and gumminess.

The physical and sensory definitions of the mechanical texture attributes are given in Table 2. The sensory definition is developed from the physical, or rheological definition. In any texture assessment, it is essential that a detailed evaluation procedure be developed. Among others, this procedure should specify the amount of product used, the manipulation procedure to be followed, the number of manipulations required, and/or the state of the product at the time of evaluation. The sensory techniques for evaluating mechanical texture characteristics are found in Table 3.

The geometrical characteristics fall into two general categories:

1. Those related to the size and shape of particles, such as gritty and grainy.
2. Those related to the shape and orientation, such as fibrous and flaky.

These attributes reflect the perception of highly organized structures of different geometrical arrangements within the product. The geometrical characteristics are perceived by the sense of touch (tactile) in the skin of the lips, tongue, mouth cavity, and throat. Some geometrical properties are perceived visually and may also be evaluated as appearance attributes.

The last category in the classification comprises the mouthfeel attributes related to the perception of moisture and fat content and the rate and manner of their release or absorption.

Table 4 lists examples of common texture attributes (mechanical, geometrical, and fat/moisture) evaluated in foods and their definitions. These definitions should be slightly modified, dependent on the type of food evaluated.

In the texture profile method, the quantification of the sensory intensity of textural attributes is based on standard reference scales [*3*]. The existence of such scales makes texture profiling a unique sensory technique and is greatly responsible for its reliability and reproducibility.

The standard scales comprise a series of specific foods that exhibit a given characteristic as their most outstanding textural feature and specific intensities. The foods are arranged in the order of increasing intensity of the specific textural attribute. Table 5 shows, as an example, the standard hardness scale [*7*]. The basic standard scales aim at covering the entire intensity

TABLE 2—*Definitions of mechanical texture characteristics.*[a]

	Physical	Sensory
Primary properties		
hardness	Force necessary to attain a given deformation.	Force required to compress a substance between molar teeth (in the case of solids) or between tongue and palate (in the case of semi-solids).
cohesiveness	Extent to which a material can be deformed before it ruptures.	Degree to which a substance is compressed between the teeth before it breaks.
viscosity	Rate of flow per unit force.	Force required to draw a liquid from a spoon over the tongue.
springiness	Rate at which a deformed material goes back to its undeformed condition after the deforming force is removed.	Degree to which a product returns to its original shape once it has been compressed between the teeth.
adhesiveness	Work necessary to overcome the attractive forces between the surface of the food and the surface of the other materials with which the food comes in contact.	Force required to remove the material that adheres to the mouth (generally the palate) during the normal eating process.
Secondary properties		
fracturability	Force with which a material fractures: a product of high degree of hardness and low degree of cohesiveness.	Force with which a sample crumbles, cracks, or shatters.
chewiness	Energy required to masticate a solid food to a state ready for swallowing: a product of hardness, cohesiveness, and springiness.	Length of time (in sec) required to masticate the sample, at a constant rate of force application, to reduce it to a consistency suitable for swallowing.
gumminess	Energy required to disintegrate a semi-solid food to a state ready for swallowing: a product of a low degree of hardness and a high degree of cohesiveness.	Denseness that persists throughout mastication; energy required to disintegrate a semi-solid food to a state ready for swallowing.

[a] Printed with permission. See Ref *5*.

TABLE 3—*Sensory techniques for evaluating mechanical texture characteristics.*[a]

Characteristic	Technique
Hardness	Place sample between molar teeth and bite down evenly, evaluating the force required to compress the food.
Cohesiveness	Place sample between molar teeth, compress and evaluate the amount of deformation before rupture.
Viscosity	Place spoon with sample directly in front of mouth and draw liquid from spoon over tongue by slurping, evaluating the force required to draw liquid over the tongue at a steady rate.
Springiness	Place sample either between molar teeth (if it is a solid) or between the tongue and the palate (if it is a semi-solid) and compress partially; remove force and evaluate the degree and quickness of recovery.
Adhesiveness	Place sample on tongue, press it against the palate, and evaluate the force required to remove it with the tongue.
Fracturability	Place sample between molar teeth and bite down evenly until the food crumbles, cracks, or shatters, evaluating the force with which the food moves away from the teeth.
Chewiness	Place sample in the mouth and masticate at one chew per second at a force equal to that required to penetrate a gum drop in ½ second, evaluating the number of chews required to reduce the sample to a state ready for swallowing.
Gumminess	Place sample in the mouth and manipulate with the tongue against the palate evaluating the amount of manipulation necessary before the food disintegrates.

[a] Printed with permission. See Ref *5*.

range of a given textural attribute encountered in foods using a multiproduct spectrum. This makes them very useful as training tools and as conveyors of the general concept. These scales can be expanded when profiling a specific product(s) to cover the whole texture range. Descriptions of the basic standard scales [*3*] and the modified and new scales [*4,7*] are available in the literature.

Panelists

The texture profiling technique requires a carefully selected, trained, and maintained panel. It is only with a proper panel that the technique can be the useful and reliable tool that it is intended to be.

Selection

The prospective panelists are selected for their interest, availability, general good health, ability to detect and describe differences, ability to apply abstract concepts, positive attitude, and ability to work with others [*5,6,13,14*].

It is most important that prospective panelists have a high degree of interest in being trained and in participating in panel work. Both the candidates and their supervisor must agree that, once trained, the individual must be available for panel work several times a week. This is a serious and long-term commitment that must derive from the appreciation of the role and usefulness of descriptive sensory analysis.

The prospective panelists must be free of medical problems that interfere with food testing and texture evaluation. They should have natural dentition and exhibit good oral health. They must have the ability to detect and describe the textural characteristics present in a product

using verbal descriptors, to quantify their intensity, and to use texture references. Since descriptive analysis depends heavily on the recall of references and their characteristics, the capacity for abstract reasoning is quite important.

Finally, the candidates must be able to work well as members of a team, must be sensitive

TABLE 4—*Examples of texture terms used in sensory texture profiling.*

Terms	Definitions
Adhesiveness	Force required to remove the material that adheres to a specific surface.
Adhesiveness to lips	Degree to which the product adheres to the lips following slight compression.
Adhesiveness to palate	Force required to remove the product completely from the palate with the tongue following complete compression between tongue and palate.
Adhesiveness to teeth	Amount of product adhering to the teeth after mastication.
Self-adhesiveness in the mouth	Force required to separate individual pieces with the tongue.
outside the mouth	Force required to separate individual pieces with the back of a spoon (contents of a standard cup placed on a plate).
Bounce	Resilience, rate at which the sample returns to the original shape after partial compression.
Chewiness	Number of chews (at 1 chew/sec) needed to masticate the sample to a consistency suitable for swallowing.
Coarseness	Degree to which the mass feels coarse during product mastication.
Cohesiveness	Degree to which the sample deforms before rupturing when biting with molars.
Cohesiveness of mass	Degree to which the bolus holds together after product mastication.
Denseness	Compactness of cross section of the sample after biting completely through with the molars.
Dryness	Degree to which the sample feels dry in the mouth.
Fracturability	Force with which the sample crumbles, cracks or shatters. Fracturability encompasses crumbliness, crispness, crunchiness, and brittleness.
Graininess	Degree to which a sample contains small grainy particles.
Gumminess	Energy required to disintegrate a semi-solid food to a state ready for swallowing.
Hardness	Force required to deform the product a given distance, that is, force to compress between molars, bite through with incisors, compress between tongue and palate.
Heaviness	Weight of product perceived when first placed on tongue.
Moisture absorption	Amount of saliva absorbed by product.
Moisture release	Amount of wetness/juiciness released from sample.
Mouthcoating	Type and degree of coating in the mouth after manipulation (for example, fat/oil).
Roughness	Degree of abrasiveness of product's surface perceived by the tongue.
Slipperiness	Degree to which the product slides over the tongue.
Smoothness	Absence of any particles, lumps, bumps, etc. in the product.
Springiness	Degree to which the product returns to its original size/shape after partial compression (without failure) between the tongue and palate or teeth.
Swallow, ease of	Degree to which the chewed mass can be readily swallowed.
Tooth packing	Degree to which the product sticks in the teeth.
Uniformity	Degree to which the sample is even throughout.
Uniformity of chew	Degree to which the chewing characteristics of the product are even throughout mastication.
Uniformity of bite	Evenness of force through bite.
Viscosity	Force required to draw a liquid from a spoon over the tongue.
Wetness	Amount of moisture perceived on product's surface.

TABLE 5—*Standard hardness scale.*[a]

Scale Value	Product	Type/Brand	Manufacturer/ Distributor	Sample Size	Temperature
1.0	cream cheese	Philadelphia	Kraft	½-in. cube	40 to 45°F
2.5	egg white	hard-cooked, 5 min	· · ·	¼-in. cube	room
4.5	American cheese	yellow, pasteurized	Land O' Lakes	½-in. cube	40 to 45°F
6.0	olive	stuffed, spanish type, pimento removed	Goya Foods	1 piece	room
7.0	frankfurter	beef franks, cooked 5 min in boiling water	Hebrew National Kosher Foods	½-in. slice	room
9.5	peanut	Planter, cocktail type in vacuum tin	Nabisco Brands	1 piece	room
· · ·	carrot [7]	uncooked, fresh, unpeeled	· · ·	½-in. slice	room
11.0	almond	Planter, shelled	Nabisco Brands	1 piece	room
14.5	hard candy	Life Savers	Nabisco Brands	1 piece	room

[a] Printed with permission. See Ref 7.
NOTE: 1 in. = 25.4 mm. 1°F = −17.2°C.

to the opinions of others, yet willing to maintain and defend their own opinions. They must project a positive attitude even in the face of adversities and failures.

In the original texture profile method, only one acuity test was used. This test involved testing for the ability to detect differences in hardness. The candidates were presented with four reference foods from the original standard hardness scale (for example, peanuts, carrots, almonds, and rock candy) in a random order and were asked to arrange them in an increasing order of hardness. Successful candidates should be able to place all four items in the correct order. Currently, the screening of texture panelists includes more than one texture attribute. The attributes are selected to cover the most important texture attributes of the product category(ies) of interest.

More important than the physiological ability is the psychological attitude of panelists. It is important in panel selection to be certain that the panel has the appropriate psychological attitude. To screen candidates for proper attitude, it is necessary to interview them individually.

A working texture profile panel usually consists of six to ten members. It is possible and desirable, however, to train about ten people at a time to allow for alternates and normal attrition. Approximately 25 candidates should be screened for this panel. Experience has shown that this number will yield the desired group size for training. Panelists may be derived from either inside (for example, employees) or outside (for example, residents of the local community) of the work place.

Training

Training a panel involves exposing it to the concepts of texture evaluation using appropriate examples and reference samples. The result should yield a group that can express a common sensory experience by the use of uniform terminology. Training consists of two phases: orientation and practice sessions. The orientations usually take two weeks of daily sessions, each lasting 3 to 6 h, followed by about 4 to 6 months of hourly practice sessions 4 to 5 times a week.

Most texture descriptive panel training programs require 40 to 100 h of training, depending on the complexity of the products, the number of attributes to be covered, and the level of training desired [*14*].

The important aspect of panel training is to provide a structured framework of learning based on demonstrated facts, and to allow the panelist to grow both in skills and confidence [*14*].

The training procedures should cover:

- The basic concepts of texture.
- The principles of the texture profile method.
- The use of reference scales to demonstrate specific texture characteristics and the procedure to quantify their intensities.
- The evaluation of practice samples.
- The expansion of the basic method to specific products.

In learning each texture attribute, each attribute should be defined (Table 4), the evaluation technique should be carefully explained (Table 3), and reference standards should be presented to each panelist for evaluation [*7*]. The trainer may wish to first present three or four samples of each scale to convey the general concept of that attribute and of scaling. The complete scale should be introduced later in the program.

Table 3 shows examples of the sensory techniques used for the evaluation of several texture attributes. The techniques should explicitly specify how the product is placed in the mouth, whether it is acted upon by the teeth (and which teeth) or by the tongue, and what particular sensation is to be evaluated.

In order to reinforce the understanding of textural characteristics and to build the panel's confidence, panelists should practice the use of the scales throughout their training. Samples from each scale should be prepared and submitted together with one or two other carefully prepared foods. The panel should then be instructed to rate the intensity of each of the "unknowns." For example, using the standard hardness reference scale [*7*] as an example, the "unknown" sample having a hardness half way between olive and frankfurter should be rated midway between these two. This exercise gives practice in perception and discrimination. It helps to build confidence since the intervals in each scale are large, and "unknown" samples can be rated with relative ease.

Any disagreements among panel members should be discussed at length. This practice usually can identify and resolve any existing problems in understanding definitions and evaluation techniques.

Once the panel is able to indicate the relative degree of difference with some agreement and consistency using the reference scales, they can be introduced to the complete texture scales to rate intensities. The scale of choice in the early days of this technique was the five point profile scale:

0 = not detectable,
)(= just detectable, threshold,
1 = slight,
2 = moderate,
3 = strong, large.

Currently, other scales are used. Among them are line or category (numerical) scales, such as 10- or 15-point scales (that is, 0 = none and 15 = strong or extreme).

For the second half of the training process, several sessions are conducted where the panel

works with samples that represent a very wide spread of each texture attribute(s). These evaluations allow the panel to practice the terms and the scales, and help the panelists to gain confidence both as individuals and as a group.

As the panel improves its skills, samples representing smaller differences within a product class are evaluated. The panel refines its discriminatory skills and rating abilities. This is the stage at which the panel begins training in the description of a particular food type. The panel is encouraged to refine the procedures for evaluation and the terminology to allow for proper identification and description of the product's textural parameters.

The final stage of training may involve testing a variety of products with more complex texture properties (for example, multi-phased products such as apple pie) or with small texture differences, or both.

During the entire training program, the panelists should discuss the results after each session, resolve problems or controversies, and request to review additional reference foods, if needed. This type of interaction is essential for developing the common and precise terminology, procedures for evaluation, and scaling techniques typical of a finely tuned texture panel [*14*].

Throughout the training, each panelist reports his/her results verbally to the panel leader. On this basis, the leader holds a discussion to determine the consensus of the panel. Individual results are posted on a blackboard or flip chart to aid in the discussion. Such open discussions enables the leader/trainer to see if the panel as a whole, or particular individuals, need clarification of specific concepts or procedures. Samples might be reviewed in order to resolve any disagreement among panel members or misconceptions by one or more individuals. Formal records of panel performance should be kept from the 3rd or 4th month of the training period and constantly thereafter.

The performance of any panel is related to three factors: (1) the reliability of the panel as a whole to duplicate its findings from one evaluation to another, (2) the ability of an individual panel member to duplicate his/her findings from one evaluation to another, and (3) the ability of panel members to agree with one another [*5*]. Panel performance can be measured and controlled in several ways such as using blind controls, duplicate samples, or frequent review of individual and group results.

Maintenance

Just like any other valuable laboratory tool, once organized and trained, the panel must be maintained. It must continue to have a high degree of motivation, interest, and objectivity.

Individual panelists should be recognized for their contributions to a successful group effort. This should be done by both the panel leader and management. Many groups follow the practice of serving snacks, candy, or a refreshing beverage at the end of each panel session, and having a dinner party for the panel at the end of the year, or at the completion of a particularly demanding project.

Panel members should understand the objectives of the work and the importance of the panel. They should be continually kept informed of the progress of the project and of their contribution to it.

The Panel Leader

In the traditional texture profile method, the panel leader is a sensory professional who is responsible for the operation of the panel and the analysis and reporting of panel results. The panel leader is a trained panel member who can participate in panel evaluations only when the project objective and sample identification are not known by him/her. The manner of selecting the panel leader may vary depending on the panel's functions and frequency of use.

Currently, the panel leader may be selected from the panel membership near the end of the training period; or the panel leadership may rotate among panel members.

The responsibilities of the panel leader include:

- Defining the test objective.
- Interacting with the test requestor.
- Designing tests.
- Scheduling panels.
- Supervising sample and reference preparation.
- Conducting panels/acting as panel leader.
- Resolving discrepancies.
- Recording and compiling panel results (data).
- Interpreting and reporting results.

The panel leader should interact with the person who requested the testing to make sure that this is an appropriate application of the method and determine the nature and number of samples to be tested, as well as the proper preparation procedure. The panel leader also is responsible for the selection of reference standards and verifying that all samples and references are accurately prepared and presented. Additional tasks include notifying panelists of meeting times and assuring the availability of panel and preparation facilities.

Following the independent analysis of the samples, the panel leader should monitor panelist behavior and then *moderate* the discussion that follows. Finally, the panel leader is responsible for recording and compiling the data, analyzing the results, and preparing the panel reports for the requestor.

General Conditions for Texture Profile Sessions

Texture profile panel sessions typically take place at a round table setting. Currently, however, evaluations may be conducted in panel booths. The test room, and booths if used, must be controlled for temperature, humidity, and fresh air flow. It is usually desirable to be able to control the intensity of light, and if possible, the color of the light. Utensils must be tasteless and odor free, and of a nondistracting color, shape, and size.

All samples to be presented to panelists must be standardized as to portion size, shape, and color by controlling preparation procedures and serving methods. This is particularly important when the test product has wide natural variability, such as fresh meat. One of the most important functions of the panel leader is to design the procedures for each panel session to meet the specific requirements of the product being tested (see ASTM Practice for Establishing Conditions for Laboratory Sensory Evaluation of Foods and Beverages [E 480]).

Procedure for Product Evaluation

The routine evaluation of the textural characteristics of food products is completed in two phases: orientation and product evaluation. This procedure is followed once the texture profile panel is fully trained and calibrated. The format of this procedure is the same for any product category. The established textural attributes, the definitions, and evaluation procedures for those attributes, however, are specific to each product category or product evaluated.

Orientation

The panel meets with the panel leader for one or more orientation sessions to complete the development of the ballot and evaluation techniques. A series of samples of the product type

are provided to the panel for inspection. These samples might be commercial products or available prototypes. Profilists are asked to inspect the samples and subsequently to develop the list of textural attributes that would fully characterize the mechanical, geometrical, fat, and moisture properties of the samples, the manipulation stage at which they would be assessed, and the evaluation procedures that would be followed for each attribute. This process is completed by each panelist independently.

A group discussion moderated by the panel leader follows to structure a consensus ballot and evaluation procedures based on the individual techniques that each panelist developed. In this process, reference samples might be presented to the panel either to review texture characteristics that are important to the product class, to clarify attribute definitions, or to resolve disagreements or misunderstandings. These consensus protocols and ballots are used by all panel members in the ensuing formal product evaluation.

		Sample 825	Sample 613
I.	FIRST CHEW		
	Hardness		
	Adhesiveness		
	Cohesiveness		
	Smoothness		
II.	CHEWDOWN		
	Chewiness		
	Gumminess		
	Adhesiveness		
	A. RO Mouth		
	B. Teeth		
	Cohesiveness Mass		
	Denseness		
	Moisture Absorbtion		
	A. Rate		
	B. Amount		
	Crystalline		
III.	BREAKDOWN		
	Description of Breakdown		
IV.	RESIDUAL		
	Ease of Swallow		
	Chalkiness		
	Grittiness		
	Toothpacking		

SCALE:

0	= Not Dectectable	1-2	= Slightly-Moderate
)(	= Just Dectectable, Threshold	2	= Moderate
)(-1	= Very slight	2-3	= Moderately Large
1	= Slight	3	= Strong, Large, Very

FIG. 1—*Example of a texture profile ballot for caramels.*

The following points are considered in developing the consensus ballot:

- The terms in the ballot include all the characteristics relevant to the product.
- Terms that have the same meaning have been combined or deleted.
- Attributes that change throughout the evaluation process are quantified at several mastication stages.

In the orientation session(s) the standardization of the procedures for preparation, handling, and presentation of the samples is established with input from all panel members. These techniques also should reflect the manner in which the food is normally consumed. Attention to the following factors is given in the establishment of procedures:

- The way the food is introduced into the mouth, for example, bitten with the front teeth, removed from the spoon by the lips, or placed whole in the mouth.
- The way the food is broken down, for example, if chewed with the teeth only, if manipulated between the tongue and palate, or if partially broken down by the teeth and then manipulated by the tongue to complete the breakdown.
- The rate at which the product is manipulated (for example, one chew/second).
- The condition of the food before swallowing.

Figures 1 and 2 show examples of consensus ballots as developed by a texture profile panel following the above procedure. Tables 6 and 7 are the evaluation techniques developed and used with ballots of Figs. 1 and 2, respectively.

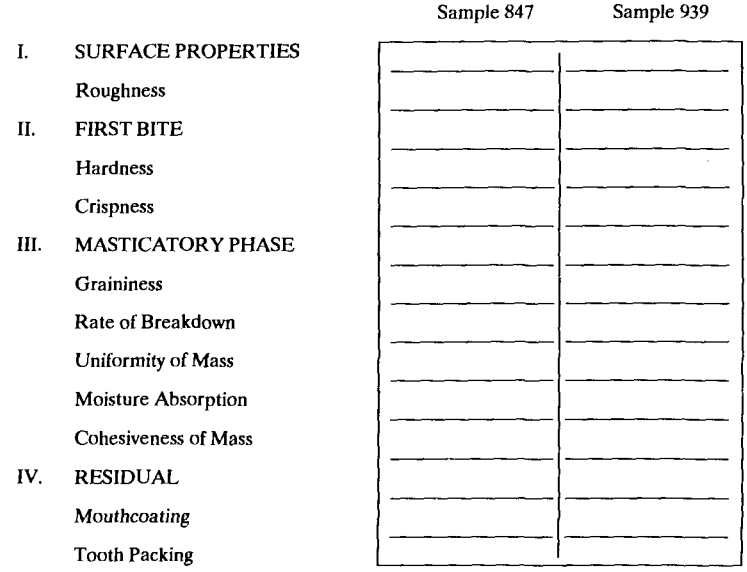

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FIG. 2—*Example of a texture profile ballot for a corn-based snack.*

Product Evaluation

Each profilist evaluates the test samples independently following the consensus evaluation procedures established in preliminary sessions (Tables 6 or 7). The intensity of each of the texture attributes is scored using a profile or other scale such as a line or category scale (Fig. 1 or 2).

Data Collection/Analysis

In the traditional method, the individual profilist scores for each attribute are tallied on a blackboard or flip chart. The values are then reviewed and discussed by the panel to reach a consensus. The actual value reported for each attribute is the consensus of the panel response. It may be the average, but it need not be. For example, if all values except one cluster around one part of the scale, the outlying value may be discarded rather than have the one value "pull" the score away from the response recorded by the majority of the panel members.

When disagreements exist among the panelists, the attributes, references, and definitions are reviewed. After review and discussion, the samples in question may be reevaluated in an attempt to arrive at consensus. Currently, texture profile results are often collected and treated as individual panelists results. These are analyzed statistically when line or nonprofile category scales are used.

TABLE 6—*Definitions and evaluation procedures for the evaluation of the texture characteristics of caramels.*

I. First Chew

Place sample between molar teeth, bite and evaluate for:

1. **Hardness:** Force required to bite through sample.
2. **Adhesiveness:** Degree sample sticks to teeth.
3. **Cohesiveness:** Degree to which sample deforms rather than ruptures.
4. **Smoothness:** Degree to which sample is free of grits and/or grains.

II. Chewdown

Place sample between molar teeth, chew and evaluate for:

1. **Chewiness:** Number of chews necessary to prepare sample for swallowing.
2. **Gumminess:** Amount of energy required to disintegrate sample to a state ready for swallowing.
3. **Adhesiveness:** Degree to which sample sticks to (a or b) during chewing.
   a. Roof of Mouth (10–15 chews)
   b. Teeth
4. **Cohesiveness of mass:** Degree to which sample holds together.
5. **Denseness:** Compactness of sample.
6. **Moisture Absorption:** Degree to which sample absorbs saliva.
   a. Rate
   b. Amount
7. **Crystalline:** Degree to which sample is granular.

III. Breakdown

Description of breakdown: Describe changes occurring during breakdown.

IV. Residual

After swallowing sample evaluate for:

1. **Ease:** Degree to which prepared sample is readily swallowed.
2. **Chalkiness:** Degree to which mouth feels dry or chalky after all of sample has been swallowed.
3. **Grittiness:** Degree to which mouth contains small particles after all of sample has been swallowed.
4. **Toothpacking:** Degree to which sample remains in teeth.

TABLE 7—*Definitions and evaluation procedures for the evaluation of the texture characteristics of a corn-based snack.*

I. Surface Properties
Holding the chip between thumb and index finger drag the tongue across the surface and evaluate:

Roughness: The degree of abrasiveness of the surface as perceived by the tongue.

II. First Bite
Place the chip between the incisors and using a steady force, bite through the chip to evaluate:

Hardness: The force required to bite through the sample.
Crispness: The amount of snap, as measured by force and noise, released from the chip upon the first bite.

III. Masticatory Phase
Place one chip in the mouth and chew until the pieces are uniformly broken down, saliva hydrates the sample and the mass (chewed sample) is ready for swallowing.

Graininess: The amount of small particles perceived by the tongue when the mass is gently compressed between the tongue and palate.
Rate of Breakdown: The speed with which the sample breakdowns to be ready for swallowing.
Uniformity of Mass: The degree to which the mass is uniform after chewing—just before swallowing.
Moisture Absorption: The amount of saliva absorbed by the sample.
Cohesiveness of Mass: The degree to which the mass holds together after chewing—just before swallowing.

IV. Residual Phase
The following parameters are measured after the sample has been swallowed.

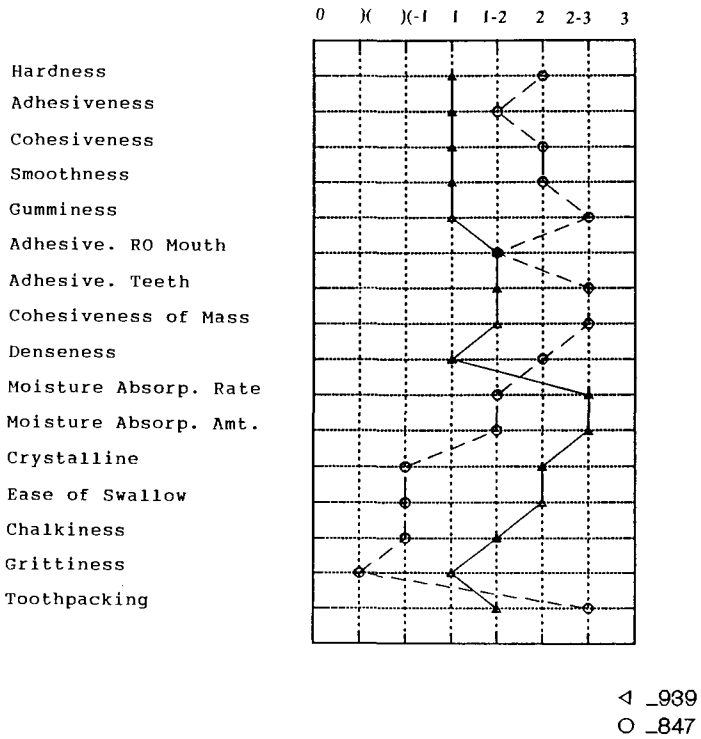
Oily Film: The amount of oily coating left on the surfaces of the oral cavity, tongue and teeth.
Tooth Packing: The amount of sample left within the crevasses of the teeth after swallowing.

Test Report

Reports should include the objectives of the study, identification of the samples, the ballot (Figs. 1 and 2) and summary of the techniques used (Tables 6 and 7) in enough detail so that the test can be repeated if necessary. Usually tables, charts, and graphs are used to present data in the report. Figures 3 and 4 are examples of typical texture profile graphs. Since there are some objections to this type of graph there are other graphical representations that are currently used (for example, histograms).

Differences and similarities among test samples are reported and discussed; they are analyzed and interpreted according to the variables being tested. Suggestions for changes or proposals for additional testing may also be included in the report.

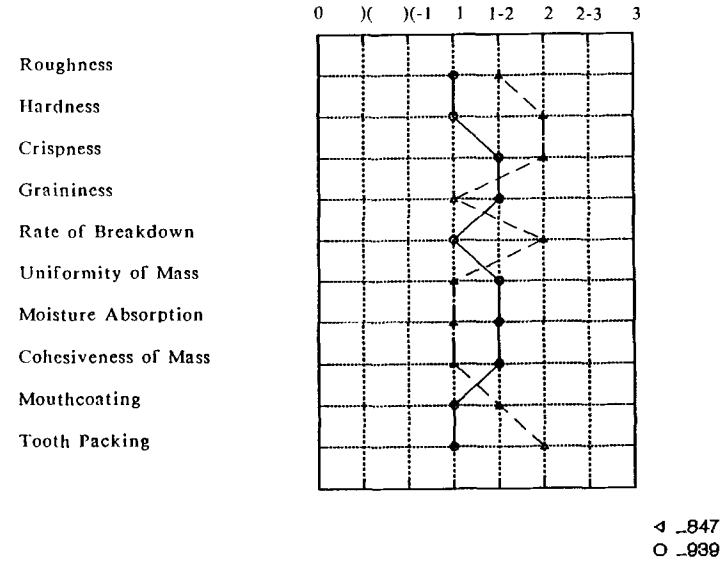
When frequent tests are done on the same product or product category, a standardized report form may be developed and utilized to present data from a series of tests. This most expediently compares data from different time periods or experimental variables.



SCALE:

0	= Not detectable
)(	= Just detectable, threshold
)(-1	= Very slight
1	= Slight
1-2	= Slightly-moderate
2	= Moderate
2-3	= Moderately large
3	= Strong, large

FIG. 3—*Graphic representation of the texture profile results for caramels.*



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1	= Slight
1-2	= Slightly-moderate
2	= Moderate
2-3	= Moderately large
3	= Strong, large

FIG. 4—*Graphic representation of the texture profile results for a corn-based snack.*

References

[1] Brandt, M. A., Skinner, E. Z., and Coleman, J. A., "Texture Profile Method," *Journal of Food Science,* Vol. 28, 1963, pp. 404–409.

[2] Szczesniak, A. S., "Classification of Textural Characteristics," *Journal of Food Science,* Vol. 28, 1963, pp. 385–389.

[3] Szczesniak, A. S., Brandt, M. A., and Friedman, H. H., "Development of Standard Rating Scales for Mechanical Parameters of Texture and Correlation Between the Objective and the Sensory Methods of Texture Evalaution," *Journal of Food Science,* Vol. 28, 1963, pp. 397–403.

[4] Bourne, M. C., Sandoval, A. M. R., Villalobos, M. C., and Buckle, T. S., "Training a Sensory Texture Profile Panel and Development of Standard Rating Scales in Columbia," *Journal of Texture Studies,* Vol. 6, 1975, pp. 43–52.

[5] Civille, G. V. and Szczesniak, A. S., "Guidelines to Training a Texture Profile Panel," *Journal of Texture Studies,* Vol. 4, 1973, pp. 204–223.

[6] International Standard Organization, *Sensory Analysis—Methodology—Texture Profile Analysis.* ISO Committee draft ISO/CD11036, 1990.

[7] Muñoz, A. M., "Development and Application of Texture Reference Scales," *Journal of Sensory Studies,* Vol. 1, 1986, pp. 55–83.

[8] Schwarz, N., "Adaption of the Sensory Texture Profile Method to Skin Care Products," *Journal of Texture Studies,* Vol. 6, 1975, pp. 33–42.

[9] Skinner, E. Z., "The Texture Profile Method," *Applied Sensory Analysis of Foods,* Vol. I, H. Moskowitz, Ed., CRC Press Inc., Boca Raton, FL, 1988.
[10] Szczesniak, A. S. "General Foods Texture Profile Revisited—Ten Year Perspective," *Journal of Texture Studies,* Vol. 6, 1975, pp. 5–17.
[11] Szczesniak, A. S. "Classification of Mouthfeel Characteristics of Beverages," *Food Texture and Rheology,* P. Sherman, Ed., Academic Press, New York, 1979.
[12] Szczesniak, A. S., Love, B. J., and Skinner, E. Z., "Consumer Texture Profile Techniques," *Journal of Food Science,* Vol. 40, 1975, pp. 1253–1256.
[13] ASTM Committee E-18, *Guidelines for the Selection and Training of Sensory Panel Members. STP 758,* American Society for Testing and Materials, Philadelphia, 1981.
[14] Meilgaard, M., Civille, G. V., and Carr, B. T., *Sensory Evaluation Techniques,* Vol. II, CRC Press Inc., Boca Raton, FL, 1987.
[15] Civille, G. V. and Liska, I. H., "Modifications and Application to Foods of the General Foods Sensory Texture Profile Technique," *Journal of Texture Studies,* Vol. 6, 1975, pp. 19–31.

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HOOTMAN

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