New Sensory Methods and Sensory Attributes for New Products

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Sensory evaluation, as a science, has matured and continues to adapt to research and development needs through new methodology, new applications of current methodology, development of lexicons for product characterization and ultimately the combining of information from consumer and laboratory methods to understand more of the sensory truth. Some examples of recent developments in sensory evaluation with application to meat research are presented and include quality control methods, free choice profiling, time intensity methods, descriptive meat lexicons and data relationships between consumer and descriptive data.

Since sensory evaluation is a developing science, with new ideas about sensory testing methods and sensory attributes being reviewed and reported regularly, it is difficult for food scientists and technologists to keep up with the latest information. Historically, agricultural scientists have simply tested whether or not an improved yield or a shipping advantage was ***preferred*** when compared to a "control" sample. This simple approach is still in use, but has been widely replaced by controlled sensory tests designed to test specific responses to specific treatments.

Now regarded as a scientific discipline, sensory evaluation is structured to evoke, measure, analyze and interpret human responses to the sensory properties of foods and other materials, as they are perceived through the five senses. The science of sensory evaluation requires an understanding of a) **Sensory Test Methods** and their proper application to sensory questions and b) **Sensory Attributes** and their proper use in describing appearance, flavor and texture properties of samples and products.

The advances in sensory science have included combining a variety of sensory tools or methods to discover the whole truth about products and experimental variables. Sensory methods include two types of sensory tests—Discrimination Methods and Affective Methods. The discrimination (or analytical) tests, which include difference and descriptive methods, ***objectively*** determine if differences exist among samples. These discrimination tests determine the truth about product differences—either detectable differences or specifically what's detectable. On the other hand, affective tests measure pleasure responses, the ***subjective*** feel about a product, in terms of personal preference. These affective tests discover how consumers actually feel about a product's sensory properties. Table 1 lists the classic sensory methods by type of method: affective or discriminative.

Key Words: Sensory, Methods, Meat

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Table 1. Sensory Evaluation Methods.

Affective	Discriminative/Analytical
Quantitative	Difference
Preference	Overall - triangle, duo-trio difference-from-control
Acceptance	Attribute - rating, 3-AFC ranking
Consumer Diagnostics	
Qualitative	Descriptive
Focus Groups	Appearance
Interviews	Flavor
	Texture
Consumers / Subjective	Laboratory / Objective

The object of most sensory analysts is to determine the whole truth by studying differences and attributes in relation to consumer acceptance. However, they must understand that the consumer uses a screen of expectation, based on past experience or advertising, to filter sensory properties. The expectation influences how much a product's sensory properties are liked or disliked.

Some recent research in sensory evaluation has developed specific sensory approaches to solve problems or questions in quality control, in product development research and in academic research. Other research has provided new sensory lexicons for specific products or commodities. These lexicons enable scientists to communicate better with each other, with their clients and with the consumers. As part of their professional training, sensory analysts and food scientists who use sensory evaluation need to learn to use these lexicons and their corresponding definitions, references and examples.

In this paper, we will discuss new uses of standard sensory methods, review of new sensory methods, introduction to lexicons for meat products and the combining of sensory methods through data relationships.

Sensory Methods

Although some meat research is supported by sensory methods that resort to only acceptability or palatability ratings for appearance, flavor and texture, several researchers have moved ahead using more advanced sensory methods to determine specific sensory results from experimental effects.

Difference Tests

The use of the degree of difference test (also known as the difference-from-control test) in quality control application is a new application of an old method. For the degree of difference test, subjects use a scale (usually 10 points) to indicate the size of the difference between a control (or standard) and one or more production samples (Munoz, Civille and Carr, 1992). The degree of difference can be used not only to determine if one product is statistically and significantly different from the control, but also to determine the size of the difference. This information can be used to set a cutoff point in QC that may be larger than a significant difference, but still acceptable to ship. This practice allows management to set realistic criteria for quality in one or more plants. Since meat processing involves inherent variability in raw materials, a realistic sensory method such as the degree of difference has practical application. In Figures 1 and 2 are examples of sample score sheets for quality control evaluation of pork. The score sheet in Figure 1 requires one overall difference rating for each of the samples tested. In Figure 2, the difference from control is also evaluated for some of the individual sensory properties. These are usually selected because they represent attributes that vary frequently in production and because collecting such information allows manufacturing to identify ultimately the sources of variability. The evaluation includes appearance, flavor and texture attributes and identifies those characteristics that are "out-of-spec" so that the decisions can be made about the fate of the product, changes in the process or screening of raw material. Other modifications of difference scaling such as those developed by Gillette and Beckley (Figures 3 and 4), are used for evaluation of overall QC differences with some indication of appearance, flavor and/or texture sources of variability (Gillette and Beckley, 1992). More and more manufacturing facilities are using structured sensory tests such as these to determine the sensory quality of finished products, raw materials and in-process variables.

Descriptive Tests

Although descriptive analysis methods have been in use for decades, researchers have sought ways to obtain detailed descriptions with less training and practice for panelists. The new free-choice profiling method has been in use in Europe and several universities in the United States have experimented with it to determine its practical applications. In her Ph.D. thesis, D. Oreskovich compared results from a conventionally trained descriptive panel to results from a free-choice profiling panel for a flavor and texture analysis of pork. She concluded that the free-choice panel could discriminate and describe differences in pork treatment effects but the free-choice method did not describe attributes that characterize the unique properties of food (Oreskovich, 1994). Therefore, the free-choice profiling method provides less specific information about a product, since the results provided only relative differences among treatments.

Figure 1
Evaluation Form Difference-from-control.

Instructions:
- Test samples in the order shown below
- Test the control first before each coded sample
- Look at and taste each sample separately, chewing well until sample is ready to swallow
- Rate the difference overall incuding appearance, flavor, and texture
- Use the scale shown below

Sample Code	Degree of Difference-from-control
323	_____
276	_____
189	_____
545	_____

Degree of Difference Scale
0 = No difference
1
2
3
4
5
6
7
8
9
10 = extreme difference

from Muñoz, Civille, Carr, 1992

Figure 2
Final Evaluation Form Difference-from-control.

Instructions
- Test samples in the order shown below
- Test the control first and before each coded sample
- Rate the attribute differences for one sample
- Then rate the overall difference-from-control for that sample
- Use the rating scale shown below

Sample Code	Difference-from-Control Meat Chroma	Pork Flavor	Meat firmness	Overall diff.
823				
165				
372				
844				
309				

0 = no difference
2 = very slight difference
4 = slight difference
6 = moderate difference
8 = large difference
10 = extreme difference

from Muñoz, Civille, Carr, 1992

Figure 3
In-Plant Sensory Quality Control Ballot.

	OVERALL QUALITY SCORE										
Codes:	[ ] _____	1	2	3	4	5	6	7	8	9	10
	[ ] _____	Reject		Unacceptable			Acceptable				Match
	[ ] _____										
	[ ] _____										

If unacceptable or borderline, why?

NOT NEARLY ENOUGH	NOT ENOUGH	FLAVOR	TOO MUCH	MUCH TOO MUCH
[ ]	[ ]	Salt	[ ]	[ ]
[ ]	[ ]	Acid	[ ]	[ ]
[ ]	[ ]	Dairy	[ ]	[ ]
[ ]	[ ]	Butter	[ ]	[ ]
[ ]	[ ]	Onion	[ ]	[ ]
[ ]	[ ]	Garlic	[ ]	[ ]
[ ]	[ ]	Tomato	[ ]	[ ]
[ ]	[ ]	Pepper	[ ]	[ ]
[ ]	[ ]	Heat	[ ]	[ ]
[ ]	[ ]	Total	[ ]	[ ]
[ ]	[ ]	Other	[ ]	[ ]
		APPEARANCE		
[ ]	[ ]	Color	[ ]	[ ]
[ ]	[ ]	Uniformity	[ ]	[ ]
		OTHER		
[ ]	[ ]		[ ]	[ ]

from Gillette, M., and Beckley, J., 1992

One current application of a traditional descriptive method, Spectrum Descriptive Analysis, is used in the USDA work on warmed-over flavor of meat (Spanier, et al, 1988; St. Angelo, et al, 1988; Love, 1988). The use of clearly-defined terms with references can be used to track the oxidation of meat. Certain "on" notes such as cooked beef brothy and brown beef decrease as the "off" notes associated with oxidation, cardboard and painty increase (Table 2).

Another variant of descriptive analysis that is under increased study and use is the time intensity method. In cases where certain sensory attributes' intensities change over time, researchers have chosen to map the intensity as a function of time (see Figure 5) (Duizer, et al, 1994). This method has application in sensory flavor and texture evaluations over a specific time period and is likely to be useful in the development of low-fat products, including meats, in which the flavor or texture characteristics are manifested differently with different fat levels. A product's fat delivers certain fat-soluble flavor notes slowly, as it melts and mechanically breaks up. With more water-soluble flavors and changes in breakdown rate or types of breakdown due to lower fat content, the time intensity method is likely to define specific differences in flavor or texture development across time for low-fat products. A recent study on muscle tenderness using the time intensity method showed that duration of chew did not separate the samples as well as the measurements of area under the curve and Dec Area (the area under the curve after I max) (Duizer, et al, 1994).

Table 2. Effect of Storage on Flavor Character Notes in Ground Beef.

Storage time and sample description	Flavor note*		
	CBB	PTY	CBD
1 day of storage at 4°C followed by 2 days @ –20°C			
Refrigerated uncooked	6.3	0.3	0.5
Refrigerated cooked	3.6	2.5	2.3
3 days of storage			
Refrigerated (4°C) uncooked	4.6	1.8	1.6
Refrigerated cooked	3.0	4.0	3.5
Frozen (–20°C) uncooked	5.8	0.4	0.8
Frozen cooked	5.4	0.3	1.0

*CBB - cooked beef brothy, PTY - painty, CBD - cardboard
from Angelo, A.J. et al, 1988

Figure 4
In-Plant Sensory Quality Control Ballot-Completed.

OVERALL QUALITY SCORE

Codes:										
[SD]	5	1	2	3	4	5	6	7	8	9	10
[TN]	8	Reject		Unacceptable			Acceptable				Match
[GB]	9										
[ ]											

If unacceptable or borderline, why?

NOT NEARLY ENOUGH	NOT ENOUGH	FLAVOR	TOO MUCH	MUCH TOO MUCH
[ ]	[ ]	Salt	[ ]	[ ]
[ ]	[ ]	Acid	[ ]	[ ]
[SD]	[ ]	Dairy	[ ]	[ ]
[ ]	[ ]	Butter	[TN]	[ ]
[ ]	[ ]	Onion	[ ]	[ ]
[ ]	[ ]	Garlic	[ ]	[ ]
[ ]	[ ]	Tomato	[ ]	[ ]
[ ]	[ ]	Pepper	[SD]	[ ]
[ ]	[SD]	Heat	[ ]	[ ]
[ ]	[ ]	Total	[ ]	[ ]
[ ]	[ ]	Other	[ ]	[ ]
		APPEARANCE		
[ ]	[ ]	Color	[ ]	[ ]
[ ]	[ ]	Uniformity	[ ]	[ ]
		OTHER		
[ ]	[ ]	Black Specs	[ ]	[SD]

from Gillette, M., and Beckley, J., 1992

Affective Tests

The ultimate test of any product's sensory properties is the consumer test. Consumers render final judgment regarding whether or not they will purchase, prepare or eat a food product. Unfortunately, the proper consumer research, conducted in compliance with recommended guidelines for best results, can be quite costly. Whenever possible, most researchers choose to use laboratory tests as predictions of consumer responses. Data relationships between laboratory and consumer research help to reduce costs somewhat, but some consumer response is always necessary to determine the success of any product treatments. Good consumer research requires attention to four areas: subjects, location, test design and questionnaire design.

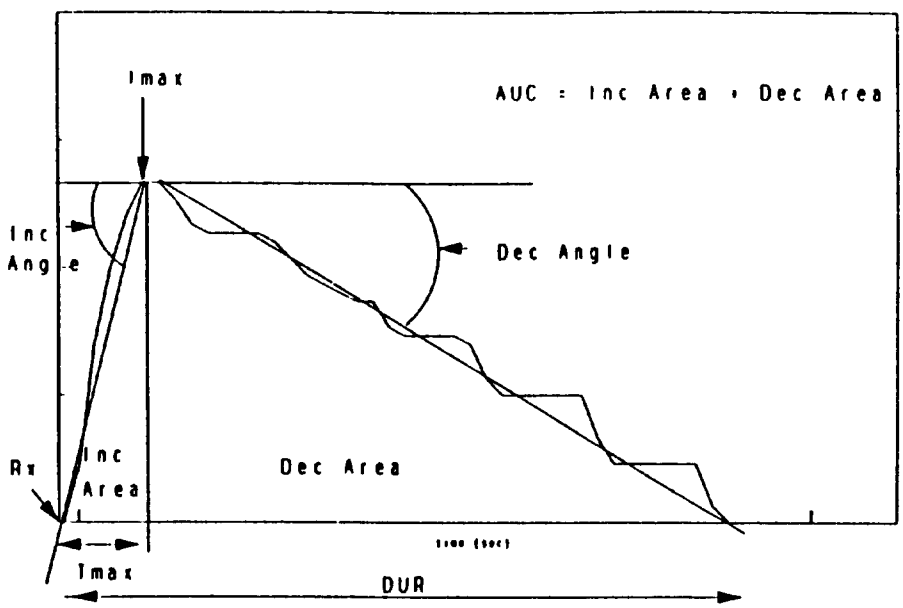
A minimum of about 100 subjects, who represent the consumer population, the population for whom the product is intended (users or potential users), is necessary. Consideration should also be given with some products to the consumer's age, gender, etc., as it may affect responses and representation of the intended consumer population.

The location or locations in which the test is conducted should represent the current or potential market in terms of geographic area (Northeast, Midwest, Southeast, Southwest, West), rural, suburban, urban groups or selected ethnic groups.

The test design takes into account the number of products each consumer in each location can test and may require some statistical support to develop.

The questionnaire asks the key questions, such as overall liking and liking questions for general appearance, flavor and texture. A questionnaire may also include attribute diagnostics. All of these pieces of information are important and can be central in developing data relationships to descriptive data in order to develop predictive models. An example of the type of questionnaire used in a sophisticated data relationship project by Muñoz, Bonnans and Chambers is shown in Tables 3.1 and 3.4 (1994).

Figure 5
Parameters and Their Definitions for Time-Intensity Curves.



Maximum intensity (Imax): the highest force to chew (in pixels) as input into the computer by each panelist
Time at maximum intensity (Tmax): time (in seconds) required to reach maximum force to chew
Duration (Dur): the time (in seconds) required to complete the test from first bite through to swallowing
Increase angle (Inc Angle): the angle (in degrees) of ascent from the start of the test to maximum intensity
Increase area (Inc Area): the area under the ascending portion of the curve from the start to maximum intensity
Decrease angle (Dec Angle): the angle (in degrees) of descent from maximum intensity to the last recorded value
Decrease area (Dec Area): the area under the descending portion of the curve from Imax to the last recorded value
Area under the curve (AUC): the total area under the curve
Reaction rate (Rx): the time (in seconds) at which the attribute being measured was first detected

from Duizer, L.M. et al, 1994

Table 3.1. Questionnaire.

NAME: _____

DATE: _____

SAMPLE #: _____

HOT DOGS

Please look at and taste product and answer the following questions.

OVERALL OPINION

Considering all the APPEARANCE, FLAVOR and TEXTURE characteristics of this hot dog, please *circle one number* below to indicate how much you LIKED or DISLIKED this product overall.

0	1	2	3	4	5	6	7	8	9	10
dislike extremely					neither like nor dislike					like extremely

What, specifically, did you like and dislike about this hot dog. (Use words, not sentences)

LIKES	DISLIKES
_____	_____
_____	_____
_____	_____

Tables 3-1 - 3.4 from Munoz, Bonnans and Chambers, 1994

Table 3.2.

OVERALL APPEARANCE

Considering all the APPEARANCE characteristics of this hot dog, please circle one number below to indicate how much you LIKE or DISLIKE the appearance of this product.

0	1	2	3	4	5	6	7	8	9	10
dislike extremely					neither like nor dislike					like extremely

OVERALL FLAVOR

Considering all the FLAVOR characteristics of this hot dog, please circle one number below to indicate how much you LIKE or DISLIKE the flavor of this product.

0	1	2	3	4	5	6	7	8	9	10
dislike extremely					neither like nor dislike					like extremely

OVERALL TEXTURE

Considering all the TEXTURE characteristics of this granola bar, please circle one number below to indicate how much you LIKE or DISLIKE the texture of this product.

0	1	2	3	4	5	6	7	8	9	10
dislike extremely					neither like nor dislike					like extremely

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Table 3.3.

Retaste the product as needed.
Please circle your response for both questions (LIKING and INTENSITY/STRENGTH) for each individual characteristic.

	LIKING											INTENSITY / STRENGTH										
Color	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	very light										very dark
Size	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	very small										very large
Hot Dog Flavor	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	none										intense
Spicy	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	none										intense
Smoky	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	none										intense
Salty	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	not salty										very salty

Table 3.4.

Retaste the product as needed.
Please circle your response for both questions (LIKING and INTENSITY/STRENGTH) for each individual characteristic.

Initial Firmness	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	not firm										very firm
Firmness	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely			nor dislike		neither like extremely					like	not firm										very firm
Chewiness	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	not chewy										very chewy
Juiciness	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	not juicy										very juicy
Skin Awareness	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	not aware										very aware
Greasy/ Oily	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10
	dislike extremely				neither like nor dislike						like extremely	not greasy										very greasy

Sensory Lexicons

The publication of lexicons for descriptive analysis has improved the quality of descriptive data by reducing variability among panelists within one panel, or between different panels working on the same product, as well as among researchers, customers and suppliers who work to develop, sell and use commodities and processed foods. The USDA has supported development of lexicons for meats, peanuts, poultry, catfish and other commodities (Johnsen, et al, 1986; Johnsen, et al, 1987; Johnsen, et al, 1988; Lyon, 1987). Table 4 lists the 12 descriptions and definitions for chicken flavor developed by B. Lyon and coworkers at the USDA Russell Research Center and Table 5 shows a similar list for beef flavor attributes and definitions developed at the USDA Southern Regional Research Center by P. Johnsen and coworkers.

The training of descriptive panelists has been vastly improved and the work of panel leaders has been organized even further by the development of these sensory lexicons. Along with these sensory lexicons for specific product categories, a new general lexicon for aroma and flavor has been

Table 4. Chicken Terms and Definitions.

TERM	DEFINITION
AROMATIC TASTE SENSATION ASSOCIATED WITH:	
Chickeny	Cooked white meat muscle
Meaty	Cooked dark meat muscle
Brothy	Chicken stock
Liver/Organy	Liver, serum, or blood vessels
Browned	Roasted, broiled, or grilled chicken patties (not seared, blackened or burned)
Burned	Excessive heating or browning (charred, seared)
Cardboard/Musty	Cardboard, paper, mold, or mildew (nutty, stale)
Warmed-Over	Reheated meat; not newly cooked nor rancid/painty
Rancid/Painty	Oxidized fat and linseed oil
PRIMARY TASTE ASSOCIATED WITH:	
Sweet	Sucrose, sugar
Bitter	Quinine or caffeine
FEELING FACTOR ON TONGUE ASSOCIATED WITH:	
Metallic	Iron/copper ions

from Lyon, B.G., 1987

Table 5. Beef Flavor Descriptions.

Aromatics	
Cooked Beef Lean	The aromatic associated with cooked beef muscle meat
Cooked Beef Fat	The aromatic associated with cooked beef fat
Browned	The aromatic associated with the outside of grilled or broiled beef (seared but not blackened/burnt)
Serum/Bloody	The aromatic associated with raw beef lean
Grainy/Cowy	The aromatic associated with cow meat and/or beef in which grain/feed character is detectable
Cardboard:	The aromatic associated with slightly stale beef (refrigerated for a few days only) and associated with wet cardboard and stale oils and fats
Oxidized/Rancid/ Painty	The aromatic associated with rancid oil and fat (distinctly like linseed oil)
Fishy	The aromatic associated with some rancid fats and oils (similar to old fish)
Tastes	
Sweet	Taste on the tongue associated with sugars
Sour	Taste on the tongue associated with acids
Salty	Taste on the tongue associated with sodium ions
Bitter	Taste on the tongue associated with bitter agents such as caffeine, quinine, etc.

from Johnsen, P. and Civille G.V., 1986

Table 6. Food Categories.

Chocolate/Nutty/ Woody/Coffee/Tea	Meat/Poultry Cured Processed
Dairy	Meat/Poultry - Uncured Fabricated Meats
Edible Oil	Meat/Poultry - Uncured Processed
Fermented Grain and Fruit Products	Meat/Poultry - Uncured RTC Poultry
Fish	Other
Fish Shellfish	Spices - Green Herbs
Fruit - Berries	Spices - Peppers
Fruit - Citrus	Spices - Roots
Fruit - Pome Fruit	Spices - Seeds
Fruit - Stone Fruit	Spices - Sweet
Fruit - Tropical	Sweet Aromatics
Grain	Vegetables

from ASTM (Civille & Lyon, ed., 1994)

developed by the Sensory Evaluation Committee E-18 of the American Society of Testing and Materials (Civille & Lyon, ed., ASTM, 1994). The over 650 entries include fruits, vegetables, grains, dairy products and the animal categories, which include meat and poultry. These product categories are shown in Table 6. Each term in the dictionary lists a definition, a reference with preparation details and additional product examples. These details for a select group of meat and dairy terms are shown in Table 7.

Table 7. Aroma and Flavor Lexicon for Sensory Evaluation. Terms, Definitions, References, and Examples

Term	Definition	Reference	Preparation	Example
Beef/Brothy Cooked	Aromatic associated with cooked beef muscle. Comb. beefy/brothy	Broiled beef tenderloin	Broil to medium rare	Broiled lean tenderloin
Liver/Organy	Aroma and flavor associated with cooked liver, organ meat, serum and/or blood salts.	Grilled liver Braunschweiger liver sausage	Grill until meat looks gray internally. Place in beaker at room temp.	
Painty	Aromatic associated with oxidized oil, similar to linseed oil.	Linoleic acid, Pentanal, Decatrienal, aged oil	Make a 1% solution of Linoleic Acid and alcohol, dilute with water.	Oil based paint, aged peanut butter
Pork, fat/ cooked	Aromatic associated with cooked pork fat	Fat portion from uncured pork	Trim fat from pork loin, grill until brown.	Pork sausage

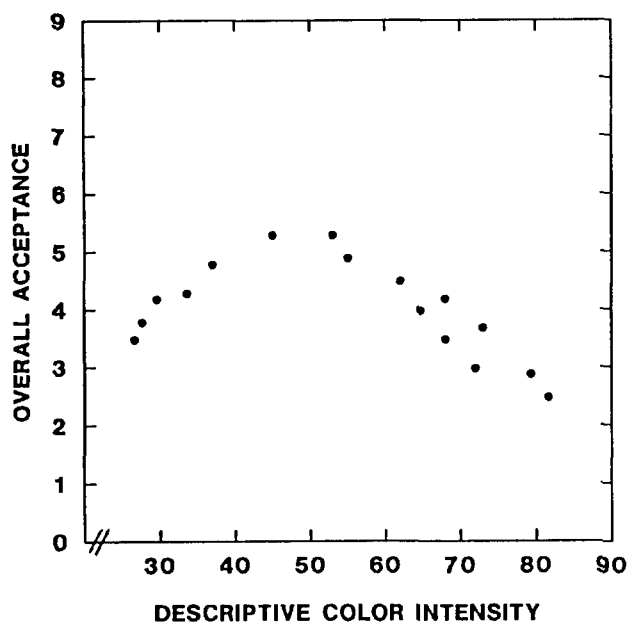
from ASTM (Civille & Lyon, ed., 1994)

Data Relationships

When understanding the effects of different variables on a meat product's appearance, flavor and texture, the most effective use of sensory evaluation is the establishment of data relationships between consumer responses, instrumental tests and descriptive sensory tests. One simple example is shown in Figure 6, where an optimum color range can be derived from the data, once a minimum acceptance rating is established. More importantly, the multivariate data from the Muñoz and Chambers (1993 and 1994) research showed that consumer attributes can be misleading. For example, although consumers asked for more spice, they actually disliked the spicy hot dogs (Figure 7). In addition, the consumer-integrated "hot dog" flavor term can be interpreted in terms of more beef, fat, cured meat, smoke, salt and sweet flavor. Such research permits the scientists to determine a model that explains consumer liking in descriptive and in some cases, instrumental measures. From these models, the researchers can improve the product, conduct further descriptive tests and predict the consumer outcome without the added expenses of more consumer testing.

Keep in mind that sensory tests utilized with technical care, creativity and a large dose of common sense can deliver more information for decision making, at a lower cost and in shorter time, than using one or two sensory tests alone and without developing interrelationships.

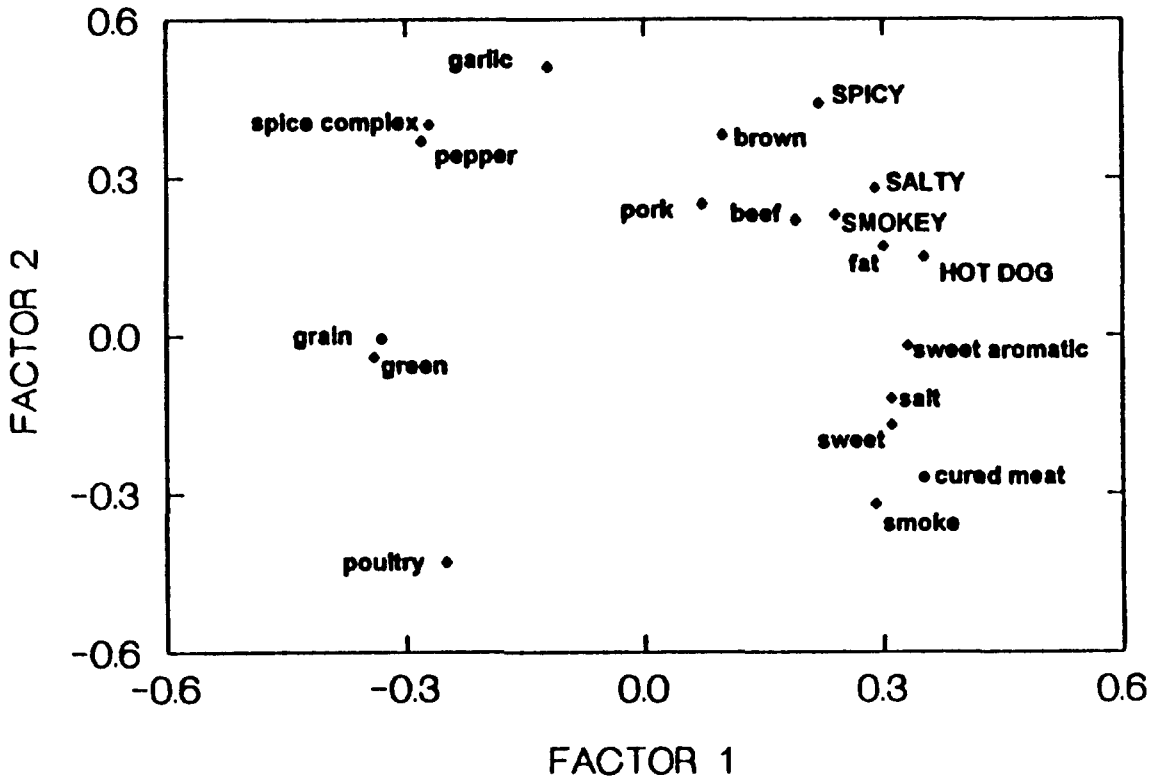
Figure 6



Scatter Plat showing the Curvilinear Relationship of overall consumer acceptance and descriptive (trained panel) color intensity of a cured meat product

Muñoz, A.M. and Chambers, E. 1993

Figure 7



PLS Plot Depicting the Modeling of consumer-perceived favor attributes (capitalized) by descriptive flavor attributes

Muñoz, A.M. and Chambers, E. 1993

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