

DESCRIPTIVE ANALYSIS OF COMMERCIALY AVAILABLE CREAMY STYLE PEANUT BUTTERS¹

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ABSTRACT

This study was undertaken to establish category and product descriptive characteristics of commercial creamy style peanut butters for use in subsequent modeling of consumer response. An established descriptive lexicon for peanut flavor was modified with additional appearance and texture terminology to describe these samples. To determine the full category space for the appearance, flavor and texture characteristics for commercial creamy style peanut butters, a highly trained descriptive panel screened 42 brands. A subset of 22 peanut butters was identified which represented the available range of appearance, flavor and texture variations and determined the product category. These 22 commercial creamy style peanut butters were subsequently evaluated and quantitatively described using 4 appearance, 19 flavor and 12 texture descriptors. Using both hierarchical clustering and principal component

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analysis, 4 logical associative groupings of products were identified: store and name brands, natural brands, reduced fat brands, and some store or name brands with unique or unusual appearance, flavor or texture characteristics. Omission of products with redundant characteristics within a factor grouping enabled further reduction to 15 products for subsequent quantitative consumer testing to establish a model for descriptive analysis as a predictor of consumer research responses.

INTRODUCTION

Consumer product companies regularly use sensory tests, such as descriptive analysis and consumer research, to study ingredient effects, processing variables and storage changes on the perceived properties and the consumer acceptance of their products. Applications of such sensory tests will continue to be accepted and useful for industry to assess the effects of these variables on their products.

An emerging technique in sensory evaluation is the use of multifaceted category research studies for product category appraisals (Barnes *et al.* 1991; Munoz and Chambers 1993; Roberts and Vickers 1994; Munoz *et al.* 1996). Separate individual category studies are conducted (e.g., descriptive analysis, consumer research, and/or instrumental) and then the data are merged. Information obtained through a multifaceted category research study can be used to gain a more thorough understanding of the product category in terms of product characteristics and consumer responses to those characteristics. Further, the information can be used to establish a database that may be used to interpret category consumer responses using laboratory or descriptive analysis data.

One major goal of sensory evaluation in general, and of descriptive analysis in particular, is the objective description of a product in terms of perceived sensory attributes. The set of descriptive analysis terms enables differentiation among products, specification of the sensory properties of the products, and sufficient characterization to permit its recognition or identification. The terms should be orthogonal, that is, uncorrelated with one another. For example, in texture work, panelists are often initially confused by hardness and denseness terms, because many products increase in hardness as they become more compact. Discussion of products that differ widely and sometimes independently in these attributes demonstrates to the panelists the lack of correlation between the two texture terms (Civille and Lawless 1986).

Descriptive analysis data can be used in several applications: (1) interpretation of other sensory data, (2) correlation with instrumental measures, either physical or chemical, (3) quality monitoring, (4) product development, and (5) product maintenance.

A search of the literature revealed no papers on the descriptive analysis of commercial peanut butter. An article regarding consumer acceptance has been published (Anon. 1995); however, it dealt with liking ratings, not descriptive terminology and intensities.

The objectives of this research were to (1) increase understanding of the commercial peanut butter product category by determining the product characteristics in each of the products and the category as a whole, (2) identify products with the most distinctive product characteristics that still fall into the category and (3) establish a descriptive analysis database that can be used to interpret consumer responses that will be collected through a separate category study.

MATERIALS AND METHODS

The Spectrum™ Descriptive Analysis method was used to evaluate the samples (Meilgaard *et al.* 1991). Sensory attributes (appearance, flavor and texture) were rated using a 15-point intensity scale. Absolute or universal scales were used to rate the perceived intensities, which allowed for comparison of the relative intensities among attributes within a product and among the products tested.

Research was conducted in four phases: (1) initial product screening, (2) panel orientation (lexicon modification and ballot development), (3) product evaluation, and (4) data analysis and interpretation.

Initial Product Screening

In April 1997, 42 brands of commercially available, creamy style peanut butter were evaluated by a subset of the panelists to determine the range of appearance, flavor and texture characteristics in the product category. A descriptive analysis lexicon was modified and a ballot (Fig. 1) was generated during this session that allowed for the evaluation and characterization of each product. To test the effect of specific product attributes, such as roughness, a sample or samples with that attribute were included in the study. Since conclusions can only be drawn over the intensity range for any attribute, the full range of attribute intensities were included by choosing appropriate samples. From the 42 initial brands, 22 peanut butters were selected to represent the range of appearance, flavor and texture attributes with little repetition.

Sample			
Judge			
Visual Appearance		Feeling Factors	
Color Hue		Astringent	
Color Intensity		Heat/Burn	
Chroma			
Gloss		Textural Properties	
Visible Particles		Roughness	
Flavor Properties		First Compression	
Roasted Peanuty		Firmness	
Raw Beany		Cohesiveness	
Dark Roast		Denseness	
Sweet Aromatics		Adhesiveness	
Woody/Hulls/Skins			
Fruity Fermented		Manipulation	
Phenolic		Mixes with Saliva	
Cardboardy		Adhesiveness of Mass	
Burnt		Cohesiveness of Mass	
Musty		Roughness of Mass	
Green		Loose Particles	
Painty		Oily Film	
Soy		Chalky Film	
Basic Tastes			
Salt			
Sweet			
Sour			
Bitter			

FIG. 1. MODIFIED DESCRIPTIVE ANALYSIS BALLOT

Panel Orientation (Lexicon Modification)

Eight judges, with extensive experience (2-10 years) in descriptive analysis of peanut products, participated in this study. The panel was composed of personnel from Sensory Spectrum, Inc., The Pillsbury Company, USDA-ARS, and Department of Food Science at North Carolina State University.

Since a lexicon was established for peanut flavor (Johnsen *et al.* 1988) and all panelists were familiar with this lexicon and the Spectrum™ Descriptive Analysis method, only two descriptive orientation sessions to review the variables and to modify the established lexicon to include any new characteristics, were needed.

Panel orientation was held for all the panelists to familiarize themselves with the sample range and to agree on the common terminology (Table 1 — Appearance, Table 2 — Flavor and Table 3 — Texture). From this orientation, the descriptive lexicon was modified to measure the intensity of 35 attributes that were necessary to describe the similarities and differences in appearance, flavor and texture for the sample set. The initial flavor lexicon for the description of peanut flavor (Johnsen *et al.* 1988) was expanded to include the attributes of fruity-fermented and soy flavor. Fruity-fermented was added to the lexicon due to detection of the aromatic associated with fermented grains present in one of the samples tested (Sanders *et al.* 1989). Soy flavor was added as an attribute to the lexicon because the reduced fat samples in the product category demonstrated that character. Phenolic replaced chemical plastic and musty replaced earthy as more refined descriptive attributes relative to the sample set. Grainy, fishy and skunky/mercaptan, as well the feeling factor metallic, were removed from the established lexicon as these descriptors were not present in the evaluated sample set. Visual appearance and textural attributes were described by using Spectrum™ Terminology for Descriptive Analysis as defined in Meilgaard *et al.* 1991.

TABLE 1.
APPEARANCE TERMINOLOGY — APPEARANCE OF PEANUT BUTTER

Color

Description:	<i>The actual color name or hue, such as red, blue, etc. The description can be expressed in the form of a scale range, if the product covers more than one hue.</i>
	[Yellow-----Black]
Intensity:	<i>The intensity or strength of the color from light to dark.</i>
	[Light-----Dark]
Chroma:	<i>The chroma or purity of the color, ranging from dull, muddied to pure, bright color.</i>
	[Dull-----Bright]
Gloss:	<i>Amount of light reflected from the product's surface.</i>
	[Dull-----Shiny]
Visible Particles:	<i>The amount of particles in the surface.</i>
	[None-----Extreme]

TABLE 2.
FLAVOR TERMINOLOGY — FLAVOR OF PEANUT BUTTER

[None-----Extreme]

1. Aromatics

Roasted Peanuty:	<i>The aromatic associated with medium-roast peanuts and having fragrant character such as methyl pyrazine.</i>
Raw Beany:	<i>The aromatic associated with light-roast peanuts and having legume-like character.</i>
Dark Roast:	<i>The aromatic associated with dark-roasted peanuts and having very browned or toasted character.</i>
Sweet Aromatics:	<i>The aromatics associated with sweet material such as caramel, vanilla, molasses, and fruit.</i>
Woody/Hulls/Skins:	<i>The aromatics associated with base peanut character (absence of fragrant top notes) and related to dry wood, peanut hulls, and skins.</i>
Fruity-Fermented:	<i>The aromatics characterized by fermentation (alcohol) and/or reminiscent of fruit.</i>
Phenolic:	<i>The aromatic associated with plastic and burnt plastic.</i>
Cardboardy:	<i>The aromatic associated with somewhat oxidized fats and oils and reminiscent of cardboard.</i>
Burnt:	<i>The aromatic associated with very dark roast, burnt starches and carbohydrates.</i>
Musty:	<i>The aromatic associated with wet dirt and mulch.</i>
Green:	<i>The aromatic associated with uncooked vegetables, grass and twigs.</i>
Painty:	<i>The aromatic associated with linseed oil and oil based paint.</i>
Soy:	<i>The aromatic associated with raw or cooked soybean.</i>

2. Basic Tastes

Salty:	<i>The taste on the tongue associated with sodium ions.</i>
Sweet:	<i>The taste on the tongue associated with sugars.</i>
Sour:	<i>The taste on the tongue associated with acids.</i>
Bitter:	<i>The taste on the tongue associated with bitter agents such as caffeine and quinine.</i>

3. Chemical Feeling Factors

Astringent:	<i>The chemical feeling factor on the tongue, described as puckering/dry and associated with tannins or alum.</i>
Heat/Burn:	<i>The burning sensation in the mouth caused by certain substances, such as capsaicin from red or piterin from black peppers; mild heat or warmth is caused by some brown spices.</i>

TABLE 3.
TEXTURE TERMINOLOGY — ORAL TEXTURE OF PEANUT BUTTER

1. Surface

Roughness: *Amount of particles in surface.*
[Smooth-----Rough]

2. First Compression

Firmness: *Force to compress sample.*
[Soft-----Firm]

Cohesiveness: *Amount of sample deforms rather than shears/cuts.*
[Shears/Short-----Deforms/Cohesive]

Denseness: *Compactness of the cross section.*
[Airy-----Dense/Compact]

Adhesiveness (palate): *Amount of force to remove sample from roof of mouth.*
[No Force-----High Force]

3. Breakdown

Mixes with Saliva: *Amount of saliva which mixes with sample.*
[No Mixture-----Complete Mixture]

Adhesiveness of Mass: *Degree sample sticks to palate; force to remove from palate.*
[No Force-----Large Force]

Cohesiveness of Mass: *Degree mass holds together.*
[Loose Mass-----Cohesive Mass]

Roughness of Mass: *Amount of particles on the surface of the mass.*
[Smooth-----Rough]

4. Residual

Loose Particles: *Amount of particles left on mouth surface.*
[None-----Extreme]

Oily Film: *Amount of oil film on oral surfaces.*
[None-----Extreme]

Chalky Film: *Amount of chalk film on oral surfaces.*
[None-----Extreme]

In a category review, conclusions can be drawn only about or from the space tested. Therefore, all variables and variable ranges of interest should be included in the product space. Since this test was not based on designed variables, the products chosen to test and define the product space were a comprehensive array of commercially available, creamy style peanut butters readily available in Minneapolis, Minnesota; College Station, Texas; and Raleigh, North Carolina.

Product Evaluation

In October 1997, the eight panelists evaluated the previously selected sample subset of commercial creamy style peanut butters using the modified lexicon of 4 appearance, 19 flavor and 12 texture attributes. Products were prepared in 1 oz. plastic cups in 20-g amounts immediately prior to evaluation. The panelists evaluated 5 to 6 samples once during each 90-min session. The 4 sessions were separated by at least 1 h to eliminate flavor and texture carryover and fatigue. Samples were not swallowed, and the judges were asked to rinse well between each sample. For cleaning, they used room-tempered water, carbonated water and dry, unsalted crackers. Panelists were seated in a specially constructed panel room free from noise and odors.

Data Analysis and Interpretation

Data were analyzed using both univariate and multivariate statistical analysis. Analysis of variance was used to determine significant sample effects and other relevant model effects (Gacula and Singh 1984). In a multifaceted category research study, the information on sample effects and mean separation is used to examine specific differences among the products tested, and is helpful when interpreting the sample mapping from principal component and cluster analyses (Munoz *et al.* 1996). Waller Duncan mean separation analysis was also completed to study individual significant differences among the samples. Principal Component Analysis (PCA) is a multivariate technique used to understand attribute and attribute-sample relationships. This technique generates a reduced set of factors (a linear combination of the original variables) to explain most of the original data variability (Tabachnick and Fidell 1983; Burgard and Kuznicki 1990). To determine if groups of products exist that have similar characteristics within the group and different characteristics from other groups, cluster analysis was used. Cluster analysis joins groups of products that score similarly for a variety of characteristics. Hierarchical Clustering was used to gain further grouping insights. This technique is based on the average distance of one product or group of products from another product or groups of products, in the multidimensional space (Massart and Kaufman 1983).

RESULTS AND DISCUSSION

Univariate Analyses

Descriptive analysis determined the attributes that both differentiated some samples from each other, as well as those attributes that grouped products with similar attributes. The method of analysis used for the descriptive data was Analysis of Variance (ANOVA) and was conducted using Statistical Analysis System (SAS 1989). The effects measured were sample, judge and the sample \times judge interaction. The analysis revealed significant differences across the samples tested ($F=69.4$, $P \leq 0.0001$). Analysis also showed significant differences among the samples for all of the descriptors tested, except burnt (Table 4 — Appearance, Table 5 — Flavor, Table 6 — Texture). These significant differences validated the diversity of the sample set and defined a wide product space.

Largest differences were among the basic tastes and texture attributes, with saltiness, sweetness and adhesiveness of mass being the largest points of differentiation for the sample set. Roughness, cohesiveness, denseness, adhesiveness, mixes with saliva, cohesiveness of mass, roughness of mass and chalky film were also attributes that differentiated among samples. The appearance descriptors, glossiness and visible particles, along with the flavor attribute, soy, showed similarities among some products and differentiation across others.

The texture attributes of firmness and oily film, the appearance attributes of color intensity and chroma, and all of the flavor attributes, except for soy and the basic tastes of salty and sweet, had smaller intensity differences in the overall profiles of the peanut butters. However, a narrow intensity range does not always mean that a descriptor doesn't differentiate among the samples. For example, the flavor descriptor dark roast, while having a narrow intensity range can greatly change the perceived sensory properties of the sample.

Multivariate Analyses

Principal Component Analysis (PCA) was used to study attribute relationships, since attributes that are highly correlated with each other group together in the same main factor. This technique was useful in understanding the product category, the products included in the test set, and the descriptive attributes. The product attribute averages over panelists were used as raw data, rather than the individual observations (panelists' scores).

TABLE 4.
 APPEARANCE SAMPLE MEANS, MEAN RANGES, F VALUES, AND STATISTICAL SIGNIFICANCES OF CREAMY STYLE PEANUT BUTTER FROM THE HIGHLY TRAINED DESCRIPTIVE ANALYSIS EVALUATION GROUPED BY PRINCIPAL COMPONENT ANALYSIS CLUSTERS

APPEARANCE	Color Intensity	Chroma	Gloss	Visible Particles
Cluster 1				
Krema Natural	7.6 ^{bc}	6.5 ^a	7.4 ^{bc}	5.4 ^d
Smuckers Reduced Fat	8.1 ^a	6.5 ^a	6.8 ^c	5.7 ^{cd}
Hannaford Natural	7.7 ^b	6.4 ^a	8.4 ^a	6.4 ^b
Smuckers Natural	8.2 ^a	6.4 ^a	7.6 ^b	7.3 ^a
Cluster 2				
Best Yet Reduced Fat	7.0 ^g	5.4 ^{de}	5.3 ^g	3.7 ^e
Peter Pan Smart Choice	7.7 ^b	6.2 ^{ab}	5.3 ^g	2.2 ^{gh}
Jif Reduced Fat	6.9 ^g	5.4 ^{de}	4.9 ^g	1.9 ⁱ
Cluster 3				
Food Lion	5.3 ^j	3.4 ^j	2.4 ⁱ	2.1 ^{hi}
Deep South	6.2 ⁱ	5.2 ^{efg}	5.9 ^{de}	2.3 ^{gh}
Flavorite	7.0 ^g	5.4 ^{de}	5.2 ^g	2.5 ^g
Better Valu	7.3 ^{cde}	5.5 ^{de}	5.4 ^{ef}	2.2 ^{gh}
Kroger Just Right	7.1 ^{efg}	5.7 ^{cd}	6.1 ^d	2.0 ^{hi}
Hannaford No Salt	7.3 ^{def}	5.7 ^{cd}	5.4 ^{ef}	2.3 ^{gh}
Cluster 4				
Reeses	6.5 ^h	4.9 ^{gh}	4.8 ^g	2.6 ^g
Peter Pan	7.3 ^{cde}	5.9 ^{bc}	5.2 ^g	2.6 ^g
Jif	6.6 ^h	4.7 ^h	5.4 ^{ef}	2.4 ^{gh}
Hill Co. Fare	6.5 ^h	5.3 ^{ef}	5.0 ^g	2.7 ⁱ
Kroger	6.4 ^{hi}	4.3 ^j	5.1 ^g	2.1 ^{hi}
Best Yet	6.9 ^g	5.6 ^{cd}	5.4 ^{ef}	2.4 ^{gh}
Hy-Top	7.4 ^{bcd}	6.1 ^b	5.3 ^{efg}	2.2 ^{gh}
Skippy	7.5 ^{bcd}	6.0 ^{bc}	5.1 ^g	2.0 ^{hi}
Peter Pan Whipped	7.1 ^{efg}	5.0 ^{gh}	3.8 ^h	5.9 ^c
Mean Ranges				
	5.3 - 8.2	3.4 - 6.5	2.4 - 8.4	1.9 - 7.3
F Value				
	32.45	28.76	30.46	107.6
Significance				
	0.0001	0.0001	0.0001	0.0001

Means in the same column sharing the same letter are not significantly different at $P < 0.05$.

The attribute sample maps (or perceptual maps) in Fig. 2 and 3, the corresponding PCA factor loadings, and correlation analysis were used to reach conclusions on attribute relationships. A combined appearance and texture PCA was run separately from the flavor PCA, since flavor and texture are independent of each other and since several appearance attributes were related to visual texture.

Combined Appearance and Texture PCA Mapping

For the combined appearance and texture PCA (Fig. 2), three factors explained 83.2% of the data variability. The main sample differences and similarities, as well as attribute relationships, were explained by the first two factors (explaining 71.6% of the total variability). Figure 2 shows the appearance and texture descriptive attribute-sample map of these two factors. Principal Component (PC) 1, which explained 53.3% of the variance was characterized mainly by the texture terms — adhesiveness, adhesiveness of mass, roughness, and roughness of mass. Also, this component contained all of the appearance attributes (color, chroma, glossiness and visible particles) and the texture attribute of loose particles. PC2 (18.3% of the variance) was characterized by variation in chalky film and firmness and countered by oily film and mixes with saliva. The third factor (PC3), not shown, explained 11.6% more of the variance, and was characterized by cohesiveness and denseness.

Flavor PCA Mapping

Four factors explained 72.3% of the data variability for the flavor PCA (Fig. 3). The main sample differences and similarities, as well as attribute relationships, were explained by the first three factors (explaining 60.1% of the total variability). Figure 3 shows the flavor descriptive attribute-sample map of the first two factors. PC1 (23.9% variance) was characterized mainly by the attributes — roasted peanutty, raw beany, dark roast and sweet taste. PC2 (20.9% variance) was characterized positively by sweet aromatics and woody/hulls/skins and negatively by the off-flavor musty. Additionally, PC3 and PC4 (27.5% variance) were characterized by off-flavor attributes, such as burnt, painty, green, phenolic and fruity-fermented found in only a few samples.

Graphing of the first two PCs for the combined attributes for appearance and texture (Fig. 2) and flavor (Fig. 3) served to visually separate the peanut butter samples into four distinct groups: store and name brands (●), natural brands (⊙); reduced fat brands (◆) and store or name brands with unique or unusual appearance, flavor or texture attributes (▲).

TABLE 5. (continued)

FLAVOR (Aromatics)	Phenolic	Card-boardly	Burnt	Musty	Green	Painty	Soy
Cluster 1							
Krema Natural	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	0.0 ^h
Smuckers Reduced Fat	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	2.7 ^{bc}
Hannaford Natural	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.1 ^b	0.0 ^h
Smuckers Natural	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	0.0 ^h
Cluster 2							
Best Yet Reduced Fat	0.1 ^c	0.0 ^c	0.3 ^a	0.0 ^c	0.0 ^b	0.0 ^b	4.0 ^a
Peter Pan Smart Choice	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	3.1 ^b
Jif Reduced Fat	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	3.1 ^b
Cluster 3							
Food Lion	0.0 ^d	0.4 ^{ab}	0.1 ^{ab}	0.0 ^c	0.0 ^b	0.0 ^b	2.3 ^c
Deep South	0.0 ^d	0.3 ^{bc}	0.0 ^b	0.0 ^c	0.0 ^b	1.1 ^a	1.6 ^d
Flavorite	0.0 ^d	0.4 ^{ab}	0.0 ^b	0.3 ^b	0.1 ^{ab}	0.1 ^b	1.0 ^{def}
Better Valu	1.4 ^a	0.1 ^{bc}	0.0 ^b	1.5 ^a	0.4 ^a	0.1 ^b	0.0 ^h
Kroger Just Right	0.0 ^d	0.1 ^{bc}	0.0 ^b	0.1 ^{bc}	0.0 ^b	0.1 ^b	0.8 ^{efg}
Hannaford No Salt	0.0 ^d	0.7 ^a	0.0 ^b	0.0 ^c	0.3 ^{ab}	0.0 ^b	0.8 ^{efg}
Cluster 4							
Reeses	0.0 ^d	0.6 ^a	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	0.0 ^h
Peter Pan	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	1.0 ^{def}
Jif	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	0.0 ^h
Hill Co. Fare	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	0.0 ^h
Kroger	0.0 ^d	0.2 ^{bc}	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	0.1 ^{gh}
Best Yet	0.8 ^b	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	1.4 ^{de}
Hy-Top	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	0.6 ^{gh}
Skippy	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	0.0 ^h
Peter Pan Whipped	0.0 ^d	0.0 ^c	0.0 ^b	0.0 ^c	0.0 ^b	0.0 ^b	0.9 ^{ef}
Mean Ranges	0.0 - 1.4	0.0 - 0.7	0.0 - 0.3	0.0 - 1.5	0.0 - 0.4	0.0 - 1.1	0.0 - 4.0
F Value	45.54	3.45	1.77	37.69	1.81	17.04	23.54
Significance	0.0001	0.0001	0.026	0.0001	0.0215	0.0001	0.0001

TABLE 5. (continued)

FLAVOR (Basic Tastes and Feeling Factors)	Salt	Sweet	Sour	Bitter	Astringent	Heat/Burn
Cluster 1						
Krema Natural	2.8 ⁱ	3.6 ^j	3.3 ^a	3.2 ^{abc}	3.9 ^a	0.0 ^b
Smuckers Reduced Fat	9.5 ^{efgh}	5.1 ⁱ	2.8 ^b	2.8 ^{def}	3.9 ^a	0.0 ^b
Hannaford Natural	9.8 ^{efg}	4.2 ^j	2.5 ^{bc}	3.1 ^{abcd}	3.8 ^{ab}	0.0 ^b
Smuckers Natural	11.0 ^b	3.8 ^j	2.8 ^b	3.3 ^{ab}	3.4 ^{abc}	0.0 ^b
Cluster 2						
Best Yet Reduced Fat	9.6 ^{efgh}	11.7 ^{ab}	2.1 ^{cd}	2.1 ^{hjk}	3.9 ^a	2.3 ^a
Peter Pan Smart Choice	10.2 ^{cd}	11.9 ^a	1.9 ^{def}	2.3 ^{ghj}	3.1 ^{cd}	0.0 ^b
Jif Reduced Fat	9.9 ^{def}	11.7 ^{ab}	1.8 ^{def}	1.9 ^{ij}	3.4 ^{abc}	0.0 ^b
Cluster 3						
Food Lion	9.3 ^{gh}	10.3 ^c	1.6 ^{defg}	2.4 ^{ghj}	3.1 ^{cd}	0.0 ^b
Deep South	10.9 ^b	11.2 ^b	1.4 ^{ghi}	1.9 ^{ij}	2.4 ^{efg}	0.0 ^b
Flavorite	11.9 ^a	9.2 ^{def}	1.9 ^{de}	3.1 ^{bcd}	2.5 ^{efg}	0.0 ^b
Better Valu	10.0 ^{de}	9.5 ^{de}	1.6 ^{efg}	2.5 ^{gh}	2.7 ^{de}	0.0 ^b
Kroger Just Right	5.4 ^k	7.4 ⁿ	1.4 ^{gh}	2.8 ^{cdef}	3.3 ^{bc}	0.0 ^b
Hannaford No Salt	3.0 ⁱ	9.5 ^{de}	0.9 ⁱ	2.6 ^{gh}	2.7 ^{de}	0.0 ^b
Cluster 4						
Reeses	8.5 ^j	9.8 ^{cd}	1.7 ^{defg}	3.5 ^a	2.5 ^{ef}	0.0 ^b
Peter Pan	10.9 ^b	10.3 ^c	1.4 ^{ghi}	2.1 ^{jk}	2.5 ^{efg}	0.0 ^b
Jif	9.9 ^{def}	8.8 ^g	0.8 ^j	1.8 ^{kl}	2.3 ^{efg}	0.0 ^b
Hill Co. Fare	10.3 ^{cd}	9.4 ^{def}	1.3 ^{ghi}	2.1 ^{hjk}	2.3 ^{efg}	0.0 ^b
Kroger	9.4 ^{gh}	8.4 ^g	1.5 ^{efgh}	2.4 ^{ghj}	2.4 ^{efg}	0.0 ^b
Best Yet	8.7 ^j	7.6 ⁿ	1.3 ^{ghi}	2.7 ^{efg}	2.1 ^{fg}	0.0 ^b
Hy-Top	9.9 ^{def}	8.9 ^{fg}	1.3 ^{ghi}	2.1 ^{jk}	2.1 ^{fg}	0.0 ^b
Skippy	9.1 ^h	7.4 ⁿ	1.1 ^{hij}	1.6 ^k	2.0 ^d	0.0 ^b
Peter Pan Whipped	10.6 ^{bc}	9.8 ^{cd}	1.3 ^{ghi}	2.0 ^k	2.4 ^{efg}	0.0 ^b
Mean Ranges	2.8-11.9	3.6-11.9	0.8 - 3.3	1.6 - 3.5	2.0 - 3.9	0.0 - 2.3
F Value	127.51	80.99	11.47	11.18	10.33	121.30
Significance	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Means in the same column sharing the same letter are not significantly different at $P < 0.05$.

Cluster Analysis

The descriptive analysis data were subjected to complete linkage cluster analysis with Pearson distance, using Systat (Systat 1997). Clustering was used to classify the peanut butters based on how they were perceived for appearance, flavor and texture. The variables were not weighted, because it was not known which of the specific attributes were more important in characterizing the peanut butter. Results are shown in the dendrogram (Fig. 4). The cluster analysis indicated that four groups of similar products were tested in this study and the dendrogram shows four clusters that indicate the related products. The products in the same cluster are more similar to each other than to other products in the study. Although the branches in the dendrogram represent the Pearson distance between the products or clusters, no information was provided by the dendrogram on the specific attribute differences among the products.

The four clusters have been designated as store and name brands, natural brands, reduced fat brands and store and name brands with unique or unusual appearance, flavor or texture. Interpretation of the clusters was done by inspecting the product means for identification of similarities and differences that existed within a cluster.

The following clusters of products resulted from the cluster analysis of the descriptive analysis data.

Cluster 1: The natural peanut butters (Krema Natural, Smucker's Reduced Fat Natural, Hannaford Natural and Smucker's Natural) were characterized as having a glossy appearance and many visible and loose particles. The flavor of these samples was described as high in dark roast and low in sweet taste. High roughness and roughness of the mass characterized these samples and differentiated this grouping from the rest of the samples.

Cluster 2: Best Yet Reduced Fat, Peter Pan Smart Choice and Jif Reduced Fat were grouped together based on presence of soy and sweet aromatics, a chalky film and low mixes with saliva ratings. The texture of products in this set was firmer, denser and more cohesive for both first compression and during manipulation; therefore, the products required more manipulation in the mouth to breakdown or mix with saliva.

Cluster 3: The store or name brand peanut butters with unique appearance, flavor or texture attributes (Food Lion, Deep South, Flavorite and Better Valu) were grouped together not on similarities, but that each had one or more unique characteristics. Food Lion, Deep South and Flavorite were characterized by unique appearance and flavor attributes. Food Lion was described as low in chroma and gloss, as well as low roasted peanutty, raw beany and a sweet taste.

TABLE 6.
TEXTURE SAMPLE MEANS, MEAN RANGES, F VALUES, AND STATISTICAL SIGNIFICANCES OF CREAMY STYLE PEANUT BUTTER FROM THE HIGHLY TRAINED DESCRIPTIVE ANALYSIS EVALUATION GROUPED BY PRINCIPAL COMPONENT ANALYSIS CLUSTERS

Texture	Roughness	Firmness	Cohesiveness	Denseness	Adhesiveness
Cluster 1					
Krema Natural	5.7 ^c	6.6 ^{gh}	5.3 ^h	14.9 ^b	13.8 ^a
Smuckers Reduced Fat	6.1 ^c	6.6 ^{bc}	9.0 ^a	15.1 ^{ab}	13.3 ^{ab}
Hannaford Natural	6.9 ^b	5.9 ^g	7.7 ^{cd}	15.0 ^b	13.6 ^{ab}
Smuckers Natural	7.8 ^a	5.7 ^{gh}	6.8 ^{gh}	15.0 ^b	12.9 ^{bc}
Cluster 2					
Best Yet Reduced Fat	3.4 ^{de}	6.5 ^{bcd}	8.5 ^{ab}	15.4 ^a	12.4 ^{cd}
Peter Pan Smart Choice	2.7 ^{fg}	6.1 ^{def}	7.9 ^{bcd}	15.0 ^b	11.9 ^{de}
Jif Reduced Fat	2.1 ^{hi}	5.9 ^g	7.7 ^{cd}	15.0 ^b	11.7 ^{def}
Cluster 3					
Food Lion	3.2 ^{ef}	7.3 ^a	4.4 ^j	14.9 ^b	9.1 ⁱ
Deep South	3.9 ^d	5.7 ^{gh}	6.3 ^{hi}	14.8 ^b	11.5 ^{def}
Flavorite	2.5 ^{gh}	7.0 ^{ab}	6.9 ^{gh}	14.9 ^b	11.4 ^{ef}
Better Valu	1.7 ^{ijklm}	5.9 ^g	7.3 ^{defg}	15.0 ^b	10.9 ^g
Kroger Just Right	1.4 ^{lm}	4.5 ^k	8.1 ^{bc}	14.9 ^b	11.6 ^{def}
Hannaford No Salt	1.4 ^{klm}	6.0 ^{efg}	6.7 ^{gh}	14.8 ^b	11.1 ^{ef}
Cluster 4					
Reeses	2.2 ^{gh}	6.3 ^{cd}	7.2 ^{defg}	14.8 ^b	9.0 ⁱ
Peter Pan	1.6 ^{ijklm}	5.8 ^{gh}	6.8 ^{gh}	14.8 ^b	9.4 ^{hi}
Jif	1.4 ^{klm}	6.0 ^{ef}	7.4 ^{cd}	14.8 ^b	9.6 ^{hi}
Hill Co. Fare	1.9 ^{gh}	5.5 ^{gh}	7.1 ^{defg}	14.9 ^b	10.1 ^{gh}
Kroger	1.5 ^{ijklm}	5.2 ^j	6.9 ^{gh}	15.0 ^b	10.1 ^{gh}
Best Yet	2.0 ^{hijk}	5.8 ^g	7.1 ^{defg}	15.0 ^b	9.8 ^{hi}
Hy-Top	1.6 ^{ijklm}	6.0 ^{ef}	7.1 ^{efg}	14.9 ^b	10.0 ^{gh}
Skippy	1.3 ^m	5.7 ^{gh}	7.0 ^{efg}	15.0 ^b	9.8 ^{hi}
Peter Pan Whipped	1.6 ^{ijklm}	4.7 ^k	6.1 ⁱ	10.6 ^c	7.7 ⁱ
Mean Ranges	1.3 - 7.8	4.5 - 7.3	4.4 - 9.0	10.6 - 15.4	7.7 - 13.8
F Value	63.21	11.21	10.02	46.79	20.74
Significance	0.0001	0.0001	0.0001	0.0001	0.0001

TABLE 6. (continued)

Texture	Mixes with Saliva	Adhesiveness of Mass	Cohesiveness of Mass	Roughness of Mass
Cluster 1				
Krema Natural	5.1 ⁿ	10.4 ^b	8.6 ^b	4.7 ^c
Smuckers Reduced Fat	5.6 ^{mn}	11.4 ^a	9.4 ^a	6.4 ^b
Hannaford Natural	6.8 ^{kl}	8.9 ^c	7.3 ^{el}	6.6 ^{ab}
Smuckers Natural	6.8 ^k	9.1 ^c	6.8 ^g	6.9 ^a
Cluster 2				
Best Yet Reduced Fat	6.0 ^m	9.3 ^c	7.4 ^{de}	4.4 ^c
Peter Pan Smart Choice	6.4 ^{kl}	6.1 ^d	7.9 ^c	3.3 ^{de}
Jif Reduced Fat	6.6 ^{kl}	5.9 ^d	7.8 ^{cd}	2.8 ^{el}
Cluster 3				
Food Lion	7.4 ^l	2.6 ^{kl}	4.8 ^{jk}	2.5 ^l
Deep South	9.4 ^{bcd}	4.4 ^l	5.2 ^h	3.4 ^d
Flavorite	8.4 ^{lgh}	4.9 ^l	5.4 ^h	1.8 ^g
Better Valu	9.2 ^{bcdde}	3.8 ^g	4.8 ^{jk}	1.3 ^{hi}
Kroger Just Right	7.9 ^{hi}	5.4 ^e	6.9 ^{ig}	1.2 ^{hi}
Hannaford No Salt	8.4 ^{elgh}	3.6 ^{gh}	4.5 ^{klm}	1.1 ^{hi}
Cluster 4				
Reeses	8.1 ^{gh}	2.3 ^m	4.0 ⁿ	2.0 ^g
Peter Pan	9.5 ^{bcd}	2.8 ^{kl}	4.2 ^{lmn}	1.4 ^h
Jif	9.8 ^b	3.7 ^g	4.9 ^l	0.9 ⁱ
Hill Co. Fare	9.0 ^{cdel}	4.0 ^g	4.6 ^{kl}	1.3 ^{hi}
Kroger	8.8 ^{dehg}	3.1 ^l	5.2 ^{hi}	1.1 ^{hi}
Best Yet	9.7 ^{bc}	3.2 ^{hi}	4.4 ^{klmn}	1.1 ^{hi}
Hy-Top	9.6 ^{bcd}	2.9 ^{jk}	4.6 ^{klm}	1.2 ^{hi}
Skippy	9.9 ^b	2.6 ^{kl}	4.1 ^{mn}	1.0 ^{hi}
Peter Pan Whipped	11.3 ^a	1.9 ^m	4.0 ⁿ	2.0 ^g
Mean Ranges	5.1 - 11.3	1.9 - 11.4	4.0 - 9.4	0.9 - 6.9
F Value	27.31	234.2	71.56	113.06
Significance	0.0001	0.0001	0.0001	0.0001

TABLE 6. (continued)

Texture	Loose Particles	Oily Film	Chalky Film
Cluster 1			
Krema Natural	2.8 ^c	1.6 ^{ab}	3.7 ^c
Smuckers Reduced Fat	1.9 ^d	1.0 ^{cd}	5.1 ^{ab}
Hannaford Natural	3.3 ^b	1.7 ^{ab}	3.1 ^c
Smuckers Natural	3.8 ^a	1.4 ^{abc}	2.3 ^{de}
Cluster 2			
Best Yet Reduced Fat	4.4 ^b	0.8 ^{de}	5.8 ^a
Peter Pan Smart Choice	0.0 ^f	1.3 ^{bc}	4.4 ^b
Jif Reduced Fat	0.1 ^{ef}	1.3 ^{bc}	3.0 ^{cd}
Cluster 3			
Food Lion	0.0 ^f	0.6 ^a	3.3 ^c
Deep South	0.3 ^a	1.6 ^{ab}	1.8 ^{ef}
Flavorite	0.1 ^{ef}	1.6 ^{ab}	1.7 ^{efg}
Better Valu	0.0 ^f	1.7 ^{ab}	1.9 ^{ef}
Kroger Just Right	0.0 ^f	1.9 ^a	2.3 ^{de}
Hannaford No Salt	0.0 ^f	1.3 ^{bc}	1.7 ^{efg}
Cluster 4			
Reeses	0.1 ^{ef}	1.2 ^{bcd}	1.9 ^{ef}
Peter Pan	0.1 ^{ef}	1.4 ^{abc}	1.7 ^{efg}
Jif	0.0 ^f	1.4 ^{abc}	1.0 ^g
Hill Co. Fare	0.0 ^f	1.5 ^{ab}	1.6 ^{fg}
Kroger	0.0 ^f	1.5 ^{ab}	1.7 ^{efg}
Best Yet	0.1 ^f	1.4 ^{abc}	1.6 ^{efg}
Hy-Top	0.0 ^f	1.4 ^{abc}	1.5 ^{fg}
Skippy	0.0 ^f	1.5 ^{ab}	1.1 ^g
Peter Pan Whipped	0.0 ^f	1.4 ^{abc}	1.4 ^{fg}
Mean Ranges			
	0.0 - 3.8	0.6 - 1.9	1.0 - 5.8
F Value			
	138.47	3.21	21.77
Significance			
	0.0001	0.0001	0.0001

Means in the same column sharing the same letter are not significantly different at $P < 0.05$.

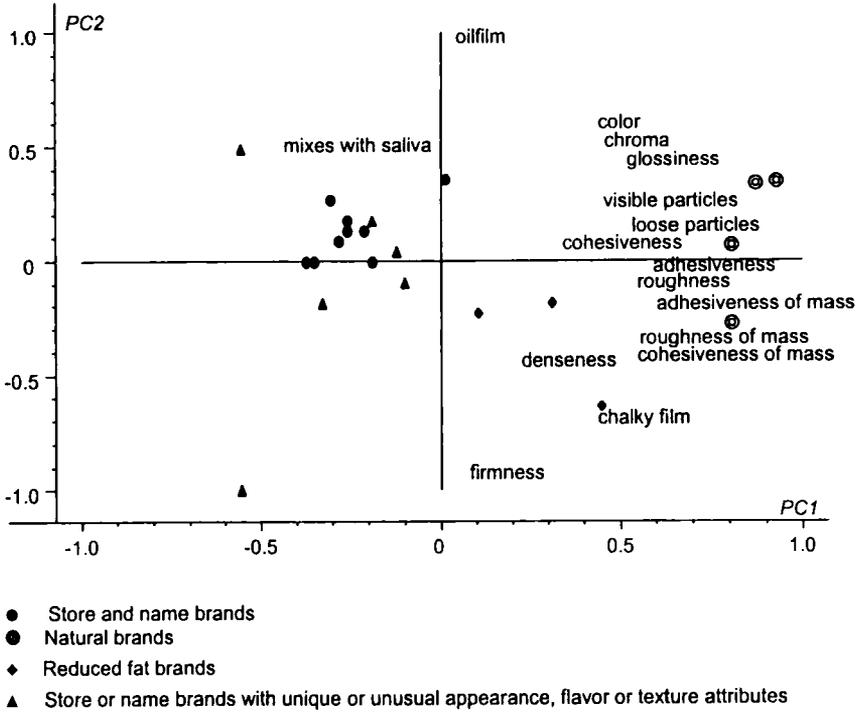


FIG. 2. PRINCIPAL COMPONENT ANALYSIS (Pc1 VS Pc2) FOR THE COMBINED APPEARANCE AND TEXTURE ATTRIBUTES OF THE TRAINED PANEL RATINGS FOR CREAMY STYLE PEANUT BUTTERS

Texturally, Food Lion was firm, low in cohesiveness, and high in chalky film. Low chroma and grayish color, as well as raw beany, fruity fermented and painty were descriptors for Deep South. The texture of Deep South was both rough and adhesive during first compression and during manipulation and low in cohesion. Flavorite had dark color intensity, low roasted peanutty, dark roast and sweet aromatics, and high woody/hulls/skins, soy and salty taste. Texturally, Flavorite was firmer and high in both adhesiveness and adhesiveness of mass. Appearance of Better Valu was dark in color intensity, but had similar flavor attributes to the Flavorite product. Better Valu also contained phenolic and musty off-flavors. Texturally, Better Valu was high in both adhesiveness and cohesiveness for both first compression and during manipulation.

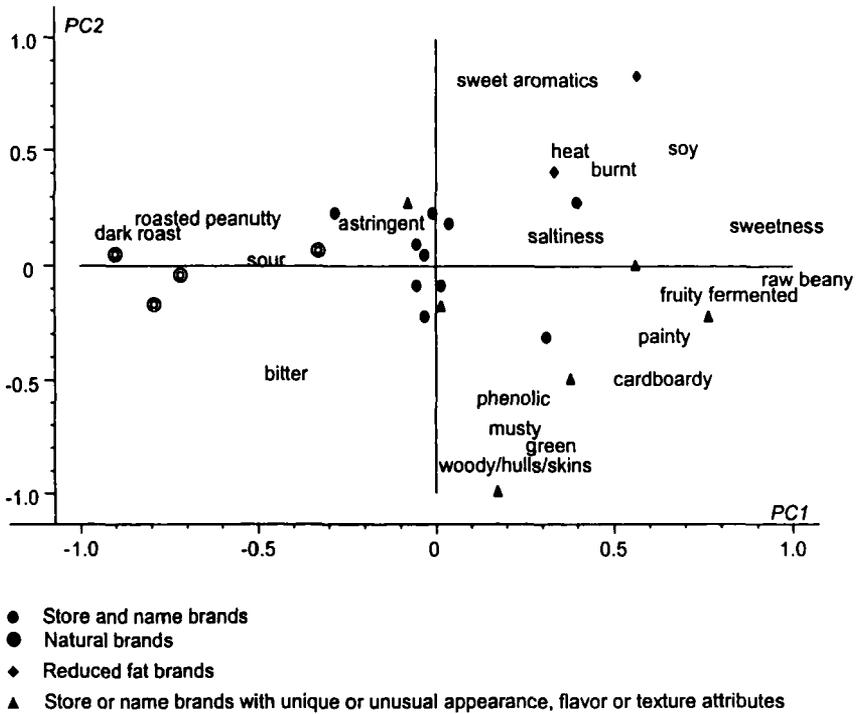
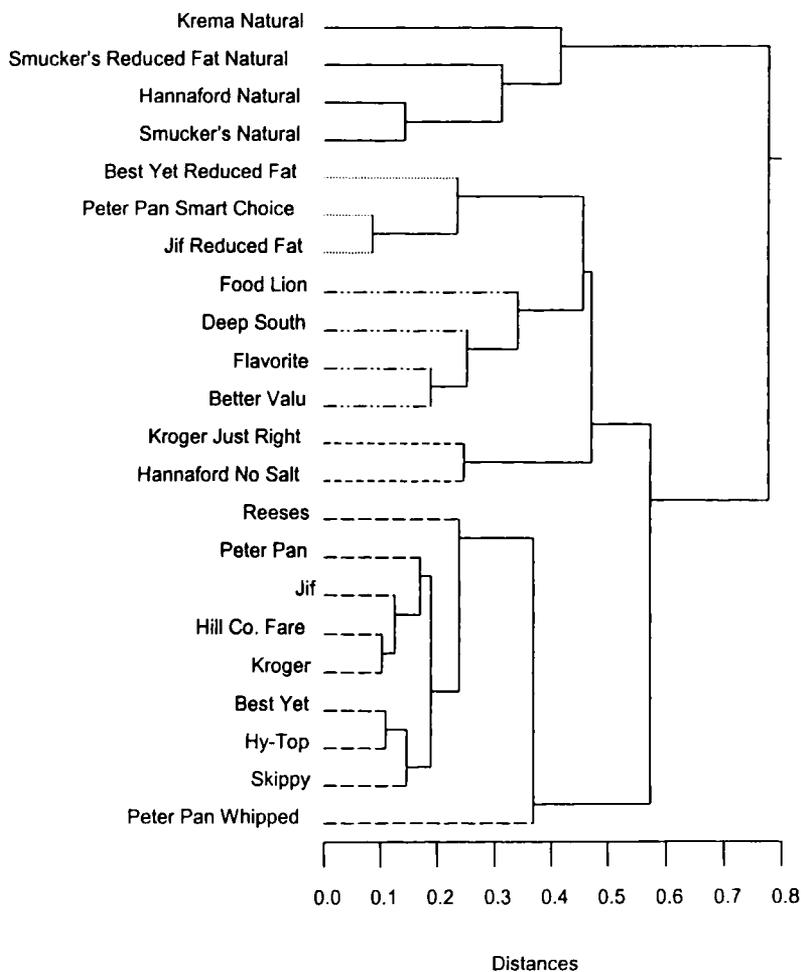


FIG. 3. PRINCIPAL COMPONENT ANALYSIS (Pc1 VS Pc2) FOR FLAVOR ATTRIBUTES OF THE TRAINED PANEL RATINGS FOR CREAMY STYLE PEANUT BUTTERS

Cluster 4: Reeses, Peter Pan, Jif, Hill Co. Fare, Kroger, Best Yet, Hy-Top, and Skippy were grouped together into the combined store and name brand category. Similar intensities of color, chroma, glossiness and low visible particles characterized the appearance of these samples. Flavor was described as moderate to high in roasted peanutty, sweet aromatics and the basic tastes of sweet and salty. Low intensities of roughness, roughness of mass, adhesiveness, and adhesiveness of mass characterized these products. Peter Pan Whipped was also grouped in this cluster; however, it was similar only in the flavor attributes.

Both the reduced salt products, Kroger Just Right and Hannaford No Salt, were low in the intensity of salty taste, but grouped within the combined name brand and store brand category.

Table 7 identifies the final set of commercial products tested and the products selected for continuation into the consumer study.



- _____ Cluster 1 - Natural brands
- Cluster 2 - Reduced fat brands
- . - . - . Cluster 3 - Store and name brands with unique or unusual appearance, flavor or texture
- Cluster 4 - Store and name brands

FIG. 4. HIERARCHICAL CLUSTER TREE OF THE DESCRIPTIVE ANALYSIS DATA

TABLE 7.
 PRODUCTS SELECTED FOR EVALUATION IN THE DESCRIPTIVE ANALYSIS
 CATEGORY STUDY

<u>No.</u>	<u>Product</u>	<u>Manufacturer/Distributor</u>
1	Best Yet	Scrivner, Inc.
2	Best Yet Reduced Fat❖	Scrivner, Inc.
3	Better Valu❖	Federated Group, Inc.
4	Deep South❖	Deep South Products
5	Flavorite	Preferred Products, Inc.
6	Food Lion❖	Food Lion, Inc.
7	Hannaford Natural	Hannaford Brothers Co.
8	Hannaford – No Salt Added❖	Hannaford Brothers Co.
9	Hill Co. Fare	H-E-B, Inc.
10	Hy-Top	Federated Group, Inc.
11	Jif❖	Procter & Gamble
12	Jif Reduced Fat❖	Procter & Gamble
13	Krema Natural❖	Krema Group, Ltd.
14	Kroger	The Kroger Company
15	Kroger Just Right❖	The Kroger Company
16	Peter Pan	Hunt Wesson, Inc.
17	Peter Pan Smart Choice❖	Hunt Wesson, Inc.
18	Peter Pan Whipped❖	Hunt Wesson, Inc.
19	Reeses❖	Hershey Chocolate U.S.A
20	Skippy❖	CPC International Inc.
21	Smucker's Natural❖	J.M. Smucker Company
22	Smucker's Reduced Fat Natural❖	J.M. Smucker Company

❖ Denotes samples selected for future consumer research category study

CONCLUSIONS

The objective of the descriptive analysis component of the multifaceted category research study was to document the product attributes and intensities for commercially available, creamy style peanut butters. The first step of the study was the selection of attributes to include in the descriptive lexicon. The attributes selected for further examination determined the sample set, as the second step. The final step was to analyze the data to determine the product sensory differences and similarities.

Evaluation of 42 commercially available, creamy style peanut butter brands revealed a wide range of appearance, flavor and texture within the product category. The natural brands were characterized by darker color intensity, brighter chroma, glossiness and visible particles. Flavor of the natural brands

was low sweet and high sour taste, while the texture was rated the roughest and most adhesive for the first compression and during manipulation. The attributes of soy flavor, sweet taste and chalky film described the reduced fat peanut butters, while the store brands were depicted by the higher incidence of off-flavors. Generally, name brands had higher intensities of roasted peanutty, dark roast and sweet aromatics and lower intensity of woody/hulls/skins than most of the store brands.

Determination of the sensory characteristics displayed in each of the products and in the category as a whole increased the overall understanding of the commercial creamy peanut butter category. Four product groupings, each with distinctive product characteristics, were identified: store and name brands, natural brands, reduced fat brands and store and name brands with unique or unusual appearance, flavor or texture characteristics. Based on the data analyses, 15 of the 22 commercial products were selected for a separate consumer category study. Sufficient ranges in appearance, flavor and texture differences that characterized the peanut butter category established a database that could be used to interpret the category's consumer responses that will be collected through a separate category study.

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