OVERALL ACCEPTABILITY AND SENSORY PROFILES OF UNSTABILIZED PEANUT BUTTER AND PEANUT BUTTER STABILIZED WITH PALM OIL

L.A. GILLS and A.V.A. RESURRECCION[1]

Center for Food Safety and Quality Enhancement
Department of Food Science and Technology
University of Georgia, Griffin Campus
Griffin, GA 30223-1797

Accepted for Publication April 20, 2000

ABSTRACT

Descriptive analysis (D) was used to compare sensory attribute intensities of peanut butter stabilized in palm oil (PO) and unstabilized peanut butter (UPB) to consumer acceptance scores (C). A relationship ($R^2=0.5$) existed between the ratings of consumer attribute overall and descriptive attribute spreadability and brown color; color (C) and brown color (D) and oiliness (D); oiliness (C) and brown color (D), stickiness (D), oiliness (D) and spreadability (D); and spreadability (C) with spreadability (D). There were no linear relations between the consumer terms texture and flavor with any of the descriptive attributes. Significant differences existed between the treatments in the descriptive attributes of brown color, raw flavor, hardness, gumminess and spreadability. Significant differences also existed between treatments for all of the consumer attributes.

INTRODUCTION

Peanut butter is manufactured through a series of steps including shelling, blanching, dry roasting and fine grinding (Woodroof 1983). It is during the grinding stage in which the stabilizer, generally hydrogenated fat, is added. However, hydrogenated fat produces peanut butters that are firmer in texture than in the unstabilized product. Unstabilized peanut butter contains no type of stabilizer and therefore free oil separates readily from the peanut butter and was stated by Weiss (1970) to become rancid in only a few days. The amount of oil released during grinding of the peanuts depends on how finely the peanuts are ground, therefore coarsely ground peanuts have less free oil to separate and in

[1] Send all correspondence to: Anna V.A. Resurreccion. (Same address as above.) TEL: (770) 412-4736/4745 ext. 130, FAX: (770) 229-3216; E-mail: aresurr@cfsqe.griffin.peachnet.edu

this way some unstabilized peanut butters are partially "stabilized" (Weiss 1970).

Companies have also favored a hardened form of vegetable oils for the stabilization of peanut butter. One form of hydrogenated rapeseed and cottonseed oils (Fix-X, Procter and Gamble, Cincinnati, OH) is a dry granular stabilizer. It is odorless with a bland, neutral flavor and at levels between 1.5 and 2% will stabilize a smooth grind peanut butter well.

Palm oil has been studied as a possible stabilizer for peanut butter (Hinds *et al.* 1994). One of the reasons why unhydrogenated palm oil may be advantageous over the traditional hydrogenated vegetable oil is because it does not have the trans fatty acids present in hydrogenated stabilizers used in peanut butter. Upon hydrogenation, trans isomers of fatty acids are formed, which have been associated with higher risks of coronary heart disease (Willett *et al.* 1993). Hinds *et al.* (1994) found that peanut butter stabilized with palm oil resulted in softer textures compared to those stabilized with a commercial hydrogenated stabilizer and predicted that peanut butter stabilized with between 2.0 and 2.5% palm oil would prevent oil separation in peanut butter for more than one year at temperatures between 21-24C. However, research on the textural properties or the consumer acceptance of a peanut butter stabilized with palm oil is lacking.

Sensory and instrumental texture profile analysis (TPA) allows for the quantitative description of the textural attributes in a variety of products. Trained panelists qualitatively and quantitatively describe a product's behavior in the mouth (Civille and Szczesniak 1973) through its mechanical, geometrical and fat and moisture characteristics from first bite through complete mastication (Brandt *et al.* 1963).

Relating consumer acceptance and trained descriptive panel data is essential because consumers can provide information on a product's acceptance or consumer perception of its integrated attributes, but are not able to use words and numbers accurately to describe specific product characteristics that only a descriptive panel can provide. Conversely, the trained panel provides a precise, reliable qualitative and quantitative information on a product's attributes, but not its acceptance (Munoz and Chambers 1993). Together, consumer and descriptive data can provide information on (1) attributes in product formulation and reformation for guidance to achieve high consumer acceptance, (2) critical attributes that affect consumer acceptance, (3) use of laboratory data to predict consumer responses, (4) product attributes that signal consumer responses of interest, and (5) interpretation and understanding of consumer terminology (Munoz and Chambers 1993).

The objective of this study was to relate consumer acceptance scores with descriptive analysis attribute intensity scores of unstabilized peanut butter and peanut butter stabilized with palm oil. Specific objectives were to: (1) characterize and compare attribute intensities of unstabilized peanut butter and

peanut butters stabilized with palm oil and hydrogenated vegetable oils, and (2) to compare acceptability of unstabilized peanut butter and peanut butter stabilized with palm oil and hydrogenated vegetable oils.

MATERIALS AND METHODS

Experimental Design

Peanut butters were prepared using four levels by weight of palm oil (PO) as a stabilizer. A peanut butter using hydrogenated vegetable oil (Fix-X, Procter & Gamble, Cincinnati, OH) as a stabilizer was used as a control. Treatments included peanut butter samples with 1.5, 2.0 and 2.5% palm oil (PO1.5, PO2.0 and PO2.5, respectively), 1.5% hydrogenated vegetable oils (HVO) and peanut butter with no stabilizer (UPB) added. Five samples including the control were prepared in two processing replications for a total of ten samples.

Sample Preparation

Shelled runner type medium peanut kernels were purchased (1997 crop, McCleskey Mills, Smithville, GA) and stored at 7C until time of processing. Peanuts were roasted in 22 kg batches in a gas roaster (Model L5, Probat Inc., Memphis, TN) preheated at 177C and maintained at 138C for ten min. Samples were collected from the roaster every five minutes and the color lightness, L, value was measured until a roast level corresponding to a color lightness, L, of 49.2 for medium roast (Johnsen *et al.* 1988) was attained. Peanuts were then cooled for five minutes in a perforated cooling tray, 65 cm inside diameter × 12 cm deep, then passed through a dry blancher (Model EX, Ashton Food Machinery Co., Inc., Newark, NJ) to remove testa. Peanuts were visually inspected for damaged kernels, which were separated and disposed. Kernals with any remaining testa were passed through the blancher an additional time. Blanched peanuts (40 kg batches) were weighed (Toledo Scale Co., Toledo, OH) and ground through a colloid mill (Morehouse Industries, Los Angeles, CA) set at a stone clearance of 0.25 mm (10 notches) and maintained at 77C with steam. The following ingredients 1% salt (Astor Plain Salt, Jacksonville, FL); 6% corn syrup solids (Star-Dri® 42R, A.E. Staley Manufacturing, Decatur, IL); and stabilizer consisting of 1.5, 2.0 or 2.5% PO (Palm Oil Research Institute of Malaysia, Kuala Lumpur, Malaysia) or 1.5% HVO (Fix-X, Procter & Gamble, Cincinnati, OH) added by weight, were manually mixed into peanut butter and passed through the colloid mill an additional time. Approximately 222 g of peanut butter were filled into glass jelly jars (Ball Corporation, Muncie, IN) and stored at ambient temperature (approximately 21C).

Physicochemical Measurements

Color. Color measurements, color lightness, L, redness, a, and yellowness, b, were made on each replication of the five treatments of peanut butter using a tristimulus colorimeter (Gardner Laboratory XL-800 series with a XL-845 circumferential sensor, Pacific Scientific, Bethesda, MD). The colorimeter was calibrated using a standard yellow tile (L=79.56, a=-2.17, b=22.98). Enough sample to cover the bottom of the colorimeter sample cup, a depth of 10 mm, was placed in sample cup and color lightness, L, a and b values were recorded. Four measurements were taken for each sample while rotating the cup a quarter of a turn each time. The average of four measurements was recorded. L*, a*, b*, chroma and hue angle were calculated.

Moisture. Moisture content of the peanut butters was determined by weighing approximately 2 g of peanut butter from each sample and placing it into preweighed metal moisture dishes lined with aluminum liners and lids. Uncovered dishes were placed in a vacuum oven at 30 mm Hg and 70C for 12 h to reach a constant weight. Dishes were covered, then placed in a desiccator for 45 min to reach ambient temperature, at which time the dishes and lids were reweighed. Moisture content of the peanut butters was determined by the amount of moisture lost after vacuum drying (AACC 1983a).

Oil. Approximately 2 g of peanut butter from each sample representing each of the five treatments and the replications of each treatment were placed into oil extraction thimbles. Oil was extracted with petroleum ether (b.p. 35-60C, J.T Baker, Phillipsburg, NJ) using a Goldfisch apparatus (Labconco, Kansas City, MO) for 22 h. Fat extraction beakers containing the fat were then dried in a vacuum oven (Model 524, Precision Scientific, Chicago, IL) at 30 mm Hg and 70C for 2 h to reach constant weight. Beakers were then placed into a desiccator for 45 min to allow to cool to ambient temperature, at which time beakers were weighed. Percent crude fat content of the peanut butters was determined by the amount of oil extracted divided by the weight of the dried sample multiplied by 100 (AACC 1983b).

Sensory Methods

Descriptive Analysis Panels. Eight trained panelists (Civille and Szczesniak 1973) used a combination (Einstein 1991) of the Spectrum, Quantitative Descriptive Analysis (QDA) and Texture Profile techniques to evaluate a total of five samples, in a total of four test sessions in one day. Prospective members of the descriptive panel were recruited from a pool of previously trained and untrained consumers who had participated in sensory tests at the Center for Food Safety and Quality Enhancement was well as students

from the center. Prospective panelists had no dentures (Civille and Szczesniak 1973) or food allergies, did not smoke, were available for all sessions (ASTM 1981) and ate peanut butter at least once a month. To qualify, potential panelists were screened on their ability to rank in order of hardness four food items in increasing hardness from the hardness scale, (Meilgaard *et al.* 1991) including frankfurter (Hebrew National Kosher Foods, Bronx, NY), peanuts (Planters, Nabisco Foods, Inc., Winston-Salem, NC), almonds (Blue Diamond, Sacramento, CA) and hard candy (LifeSavers, Nabisco Foods, Winston-Salem, NC). Eight panelists, seven females and one male, all between the ages of 18-64 were recruited. The panelists indicated they ate peanut butter an average of twice a month.

Training. Panelists were trained on Texture Profile Analysis techniques (Civille and Szczesniak 1973) in five training sessions for two hours each day for a total of ten hours. During the first day of training, panelists were given an overview of sensory evaluation and an introduction to the use of the computers to be used for data collection. On the second day panelists developed and defined textural descriptive terms (Table 1) that they felt described two samples of peanut butter, a premium brand (Jif, Procter & Gamble, Cincinnati, OH) and freshly prepared UPB, purchased at a local farmers market (Dekalb, GA). To save time in training, panelists were provided with a list of color and flavor terms and definition (Table 1) from a lexicon of desirable and undesirable peanut flavors found in peanut butter (Johnsen *et al.* 1988). To minimize training time, the lexicon was presented to panelists to provide a list of attributes, previously used to describe the flavor of peanut butter. Panelists then decided on a final list of flavor and texture terms that was comprehensive with definitions understood by all panelists. During the second day panelists also determined those references (Table 2) to be used to help them explain the color, flavor and textural terms that were developed. Each panelist rated the attribute intensity of each reference by first evaluating the reference for a particular attribute and then giving it an intensity rating between 0 and 150 using flashcards. The mean intensity rating was calculated and used as the attribute intensity rating for that particular reference.

Calibration of the panel was conducted by first obtaining an average panel rating and those panelists not rating within 10 points of the average were asked to reevaluate the sample and adjust their rating until a consensus was reached. Consensus scores were obtained on a sample peanut butter (Jif, Proctor & Gamble, Cincinnati, OH) to be used as a warm-up sample and presented to each panelist as the initial sample during training and testing sessions (Plemmons 1977). During the remaining three days of training, panelists practicing evaluating samples of peanut butter using a computerized ballot (Compusense, Version 2.4 Compusense, Inc., Guelph, Ontario, Canada), with sixteen

TABLE 1.
TERMS USED IN DESCRIPTIVE ANALYSIS OF PEANUT BUTTER

Attribute	Definition
Appearance	
Brown Color	The intensity or strength of brown color from light to dark
Aromatics	
Raw[3,5]	The aromatic associated with raw peanuts[2]
Roasted Peanutty[3,4]	The aromatic associated with medium roasted peanuts[2]
Oxidized[3]	The aroma associated with stale peanuts[3]
Tastes	
Sweet[3,5]	The taste associated with sucrose solutions[3]
Bitter[3,5]	The taste associated with caffeine solutions[3]
Salty[5]	Degree of the taste sensation associated with sodium chloride solutions[5]
Texture	
Prior to Mastication	
Stickiness	The degree to which sample adheres to lips
Graininess	The amount of particles or granules present or perceived in sample
First Bite	
Hardness[6]	The force required to compress the sample between the tongue and palate[6]
Masticatory	
Adhesiveness[6]	The force required to remove the sample from the palate[6]
Gumminess[6]	Energy required to disintegrate the sample to a state ready for swallowing
Residual	
Oiliness	Amount of oil perceived in mouth after the sample is expectorated
Mouthcoating	Amount of residual peanut butter perceived in mouth after sample is expectorated
Mouth Dryness	Drying sensation on palate
Spreadability	Ease of spread of sample on a cracker

[1]Attribute listed in order perceived by panelists; [2]Johnsen *et al.* 1980; [3]Muego and Resurreccion 1992; [4]Muego *et al.* 1990; [5]Resurreccion 1988; [6]Szczesniak *et al.* 1963

TABLE 2.
STANDARD REFERENCES AND INTENSITIES USED IN DESCRIPTIVE ANALYSIS OF PEANUT BUTTER

Attribute	Reference	Intensity[1](mm)
Brown Color	Corrugated Cardboard, L*=53.60, a*=7.85, b*=24.27 (Safco Products Company, New Hope, MN)	65
Raw	Raw medium Florunner peanuts[2]	85
Roasted Peanutty	Roasted peanuts[2]	65
Oxidized	Shortening (Hunt-Wesson, Inc., Fullerton, CA)	60
Sweet	2.0% sucrose in double deionized water	20
	5.0% sucrose in double deionized water	50
	10.0% sucrose in double deionized water (ICN Biomedicals, Inc., Cleveland, OH)	100
Bitter	0.05% caffeine in double deionized water	20
	0.08% caffeine in double deionized water (Fisher Scientific, Fairlawn, NJ)	50
Salty	0.2% sodium chloride in double deionized water	25
	0.35% sodium chloride in double deionized water (Fisher Scientific, Fairlawn, NJ)	50
Stickiness	Cheese Sauce, cheddar flavor (Kroger Co., Cincinnati, OH)	20
Graininess	Cream of Wheat (Nabisco Inc., East Hanover, NJ)	120
Hardness	Kraft Philadelphia cream cheese[3] (Kraft Foods, Inc., Glenview, IL)	20
Adhesiveness	Kraft Philidelphia cream cheese[4]	45
Gumminess	Jif peanut butter (Procter & Gamble, Cincinnati, OH)	45
Oiliness	Cheese Sauce, cheddar flavor (Kroger Co., Cincinnati, OH)	20
	Kraft Mayonnaise (Kraft Foods, Inc., Glenview, IL)	50
Mouthcoating	Phillips Milk of Magnesia (Bayer Corporation, Morristown, NJ)	65
Mouth Dryness	Phillps Milk of Magnesia (Bayer Corporation, Morristown, NJ)	55
Spreadability	Kraft Philadelphia cream cheese (Kraft Foods, Inc., Glenview, IL)	95
	Kraft Mayonnaise (Kraft Foods, Inc., Glenview, IL)	145

[1] Rated on a 150 mm unstructured line scale with anchors at 12.5 mm and 137.5 mm.
[2] Muego and Resurreccion 1992; [3] Meilgaard *et al.* 1991; [4] Szczesniak *et al.*1963.

attributes, listed vertically, in their order of appearance. Panelists rated intensities using a light pen on a 150 mm unstructured line scale, appearing on a computer video display, with anchors at 12.5 and 137.5 mm points, and a heading consisting of the attribute term and its definition. The panelist's numerical rating for that attribute would then appear next to it indicating that the attribute had been rated and they could proceed on to rate the next attribute. All attributes were rated for intensity before a panelist could proceed to the next sample.

Individual panelist's ratings were analyzed for mean ratings and standard deviations after each session, and results were distributed to each panelists prior to the next session. Panelist ratings within 10 points of the mean were considered to be calibrated. The group as a whole was considered to be calibrated if the group's standard deviations were within 10 points from the mean attribute rating. Panelists continually evaluated and calibrated themselves on samples of peanut butter during the remaining three days of training.

Consumer Panels. A consumer sensory laboratory test (Resurreccion 1998) was conducted at the Center for Food Safety and Quality Enhancement, Griffin, GA, using 50 panelists. Consumers were recruited from a list of consumers who had previously participated in consumer tests at the Center. Consumers that qualified were between the ages of 18-64, had no food allergies and ate peanut butter at least once a month.

Test Procedures

All panelists were required to complete and sign a consent form approved by the University of Georgia Institutional Review Board. Consumers received an honorarium of ten dollars per test session at the conclusion of the test. All tests were performed at the Center for Food Safety and Quality Enhancement, Griffin, Ga. Samples were evaluated in environmentally controlled partitioned booths illuminated with two 50-watt indoor reflector flood lamps, which provided 33 watts/square meter of light at the surface of the peanut butter.

Descriptive Analysis. One hour before each test, twenty grams of each peanut butter sample were placed into 28.57 g (1 oz) capacity plastic cups with lids, coded with a three digit random number. Samples were served at ambient temperature (25C). Five samples were evaluated during each session for a total of four test sessions in one day. Every panelist evaluated a total of twenty samples, including duplications from two processing replications for each of the five treatments. Panelists were instructed to use one teaspoon of sample when evaluating flavor attributes and one teaspoon when evaluating each of the stages of textural evaluation — prior to mastication, first bite, masticatory and residual

(Civille and Szczesniak 1973) for a total of four teaspoons. Panelists were also instructed to expectorate and rinse with water after each sample. Crackers were provided for rating spreadability. Panelists evaluated each attribute using a computer ballot (Compusense, Version 2.4 Compusense, Inc., Guelph, Ontario, Canada) and light pen as described previously. The definitions for each attribute that appeared above each line scale are shown in Table 1. During every session each panelist was provided with standard references. A scoresheet identifying the attribute intensity (Table 2) of each reference was posted in each booth. A compulsory fifteen minute break was taken between each session, to minimize fatigue.

Consumer Test. On the day of testing, panelists came to the sensory laboratory for a test scheduled and conducted hourly from 9:00 am to 5:00 pm except for 12:00, 2:00 and 3:00 pm. No more that ten consumers were present at any given time period. One hour before each test samples consisting of ten grams of peanut butter were placed in 28.6 g (1 oz) cups, with lids, coded with a three digit random number. Consumers were presented with samples in a balanced sequential monadic order. Each consumer evaluated five treatments in one session with two sessions for ten samples, including a processing replication. A compulsory five minute break was taken after the fifth sample. Consumers rated their overall liking of the sample and acceptance of color, flavor, texture, oiliness and spreadability on a 9 point hedonic scale, where 1 = dislike extremely 5 = neither like nor dislike and 9 = like extremely, using pencil and paper ballots.

Statistical Analysis

SAS statistical software was used (SAS Institute Inc., Cary, NC, version 6.12) to analyze all data results. Cluster analysis was used to determine if any of the trained panelists were outliers. Ratings of one trained panelist, constantly an outlier, were deleted from all analysis. Consumer ratings were visually examined to determine consumers with erratic rating behaviors (Stone and Sidel 1993) that were consistently rating the same number for an attribute.

Analysis of variance, using the general linear model procedure (PROC GLM) was used to determine significant differences between treatments for each given attribute. The model included the main effects of treatment, panelist and replication and all interactions, including treatment × panelist, treatment × replication and panelist × replication. Those interactions that were not significant were eliminated from the model statement and reanalyzed using only the main effects and significant interactions in the model (O'Mahony 1986). The process of pooling the insignificant interactions into error, eliminating the insignificant interactions from the model statement, was repeated until all

interactions left in the model were significant. The final model for the attributes sweet, salty, gumminess, hardness and mouthdryness included all main effects and only the interaction of panelists and replication. The model for oxidized, roasted, bitter, stickiness, adhesiveness, oiliness and spreadability were included all main effects only, as there were no significant interaction terms. The model for the consumer terms flavor and texture included all main effects, treatment, panelist and replication and only the interaction of panelist and treatment. The model for consumer terms overall, color, oiliness and spreadability included the main effects and two interactions, panelists with treatment and panelists with replication. Fisher's Least Significant Difference (LSD) test was performed to determine which treatment means were significantly different ($\alpha=0.05$).

To determine if descriptive terms can be used to predict consumer attribute ratings, regression analysis (PROC REG) was performed to determine any linear relations between consumer and descriptive attribute intensity ratings. Residual plots were then examined for nonconstant variance or acceptable fit of a linear model. Consumer ratings for acceptance of overall, color, flavor, texture, oiliness and spreadability were used as dependent values and all descriptive attributes, color, raw, roasted, oxidized, sweet, salty, bitter, stickiness, graininess, hardness, adhesiveness, gumminess, oiliness, mouthcoating, mouth dryness and spreadability were used as independent variables. Regression analysis was performed on those models with coefficient of determinations (R^2) greater than or equal to 0.5, to determine parameter estimates.

RESULTS AND DISCUSSION

Physiochemical Measurements

Color. Color measurements are presented in Table 3. As expected there were no significant differences between treatments in color lightness, L*, a* and b*. After grinding peanuts into peanut butter, the L value decreased, the peanut butter became darker than the roasted peanut, L endpoint of 49.2 due to the heat treatment maintained during processing.

Moisture and Fat. There were no significant differences ($\alpha=0.05$) in the moisture content of treatments (Table 3). Percent crude fat differed between samples. PO2.5 were significantly highest in crude fat compared to PO1.5, PO2.0, HVO and UPB. UPB had significantly lower crude fat than all samples. This was expected because PO2.5 had a higher percentage of palm oil added than PO1.5 and PO2.0. UPB was significantly lowest in crude fat than any other treatment because no palm oil was added. All of the treatments had a fat content of under 55%, the maximum amount of fat allowed in peanut butter (Woodroof 1983).

TABLE 3.
PHYSICOCHEMICAL MEASUREMENTS OF UNSTABLIZED AND STABILIZED PEANUT BUTTERS[1]

Stablizer[2]/ Treatment	Moisture	Crude Fat	L[3]	L*[3]	a*[4]	b*[5]	Chroma[6]	Hue Angle[7]
0% Palm Oil	1.35 ± 0.14	49.87 ± 0.23c	47.75 ± 0.14	54.89 ± 0.14	10.60 ± 0.61	43.98 ± 0.23	45.24 ± 0.08	76.44 ± 0.81
1.5% Palm Oil[8]	1.32 ± 0.00	51.09 ± 0.26b	47.61 ± 0.05	54.76 ± 0.05	11.11 ± 1.01	46.32 ± 3.53	47.64 ± 3.19	76.44 ± 2.18
2.0% Palm Oil	1.24 ± 0.20	51.00 ± 0.38b	47.63 ± 2.25	54.77 ± 2.23	10.87 ± 1.68	46.56 ± 0.14	47.82 ± 0.52	76.87 ± 1.92
2.5% Palm Oil	1.11 ± 0.03	52.17 ± 0.22a	47.21 ± 1.75	54.34 ± 1.73	10.68 ± 0.91	45.84 ± 0.98	47.07 ± 1.16	76.90 ± 0.80
1.5% Hydrogenated vegetable oils[9]	1.34 ± 0.05	51.26 ± 0.13b	48.17 ± 0.74	55.31 ± 0.74	11.06 ± 0.04	44.71 ± 1.26	46.06 ± 1.23	76.10 ± 0.33

1 Means in a column not followed by the same letter are significantly different (α=0.05) as determined by Fisher's least significant difference (LSD) mean separation test. Means in a column not followed by a letter are not significantly different. Means based on two replications.
2 Percent added on a weight by weight basis.
3 Measures the lightness of the peanut butter from 0=dark to 100=light.
4 Measures colors in the region of green to red.
5 Measures colors in the region of blue to yellow.
6 Chroma = $[(a^*)^2 + (b^*)^2]^{1/2}$
7 Hue Angle = $\tan^{-1} b^*/a^*$
8 Palm Oil Research Institute of Malaysia, Kuala Lumpur, Malaysia
9 Fix-X, Proctor & Gamble, Cincinnati, OH

Sensory Analysis

Descriptive Tests. There were no significant differences between the treatments in the flavor attributes of roasted, oxidized, sweet, salty and bitter (Table 4). As expected, no differences in roasted flavor were found between samples. The formulation with 2.5% PO was not sufficiently different to cause changes in the roasted flavor. Oxidized flavor was not different among treatments. The rating of 19 to 21 indicates an oxidized flavor that is hardly detectable. This is expected in fresh samples. Bitterness was highest in PO1.5 and lowest in PO2.5. Significant differences were expected to be nonexistent in the basic tastes because all treatments of peanut butters were roasted under the same conditions and all ingredients except for stabilizer were added in the same amounts. The fact that significant differences did exist suggests that palm oil can mask certain flavors and tastes and enhance others. Flavor release differences may also be due to differences in stabilizer and the perceived raw flavor in PO1.5 was significantly higher than PO2.5 and HVO. However, PO2.0 and UPB were not significantly different from any of the samples. HVO had significantly less intense brown color than peanut butters stabilized with PO and UPB. PO consists of a high level of carotenoid and provides a colorant for margarine and yellow fat. The pigment may have contributed to a higher intensity in brown color of the samples containing PO. The sensory profiles for brown color, flavor and taste attributes are shown in spider plots (Fig. 1a).

Only hardness, gumminess and spreadability exhibited significant differences between treatments (Table 5). HVO were significantly harder than PO1.5, PO2.0 and PO2.5, which were similar in hardness. Hinds *et al.* (1994) found in their study that all samples containing PO were at least 5% softer than those containing HVO when stored at similar temperatures. There was no significant difference between HVO and UPB although HVO was rated higher than UPB. This was unexpected because the samples were visibly different and according to Gills (1998), and instrumental measurements (maximum force of penetration using the Instron Universal Testing Machine) indicated HVO was harder (range = 0.15-0.45 N/cm^2) than UPB (range = 0.01-0.05 N/cm^2). HVO were significantly more gummy than all samples prepared with PO, however UPB were similar in gumminess to all samples prepared with PO and HVO. As expected, HVO were significantly less spreadable on crackers than all other samples.

The sensory profiles of textural attributes of all treatments are shown in Fig. 1b. The sensory profiles of the textural attributes of HVO were different from the sensory profiles of peanut butters stabilized with PO and UPB. HVO were harder to spread on a cracker than peanut butters stabilized with PO and UPB. HVO were also more gummy. However, although adhesiveness appears

TABLE 4.
MEAN INTENSITY RATINGS OF COLOR AND FLAVOR ATTRIBUTES OF UNSTABILIZED AND STABILIZED PEANUT BUTTERS[1]

Stabilizer[2]/ Treatment	Brown Color	Raw	Roasted	Oxidized	Sweet	Salty	Bitter
0% Palm Oil[3]	53.10±3.66a	26.42±10.56a	50.64±10.56	21.48±6.22	29.68±7.32	39.53±13.98	22.39±5.68
1.5% Palm Oil	53.77±3.38a	30.78±15.36a	46.91±9.91	21.04±6.19	28.86±7.61	39.59±14.53	25.35±4.56
2.0% Palm Oil	53.80±5.14a	27.63±12.11ab	49.34±8.37	20.35±5.68	30.59±8.64	41.22±14.78	24.77±6.16
2.5% Palm Oil	53.59±3.52a	24.90±11.35b	49.46±8.24	19.40±4.79	28.52±7.74	38.28±15.33	24.25±5.56
1.5% Hydrogenated vegetable oils[4]	51.08±5.02b	24.66±10.45b	50.64±5.68	19.91±5.68	29.79±6.26	38.84±13.69	24.63±6.19

[1] Mean intensities in a column not followed by the same letter are significantly different (α=0.05) as determined by Fisher's least significant difference (LSD) mean separation test. Means in a column not followed by a letter are not significantly different. Ratings are based on a 150 mm scale with anchors at 12.5 mm and 137.5 mm for slight and strong respectively. Eight trained descriptive panelists rated each attribute for each treatment a total of four times (2 processing replications in duplicate) at day zero.

[2] Percent added on a weight by weight basis.

[3] Palm Oil Research Institute of Malaysia, Kuala Lumpur, Malaysia.

[4] Fix-X, Procter & Gamble, Cincinnati, OH.

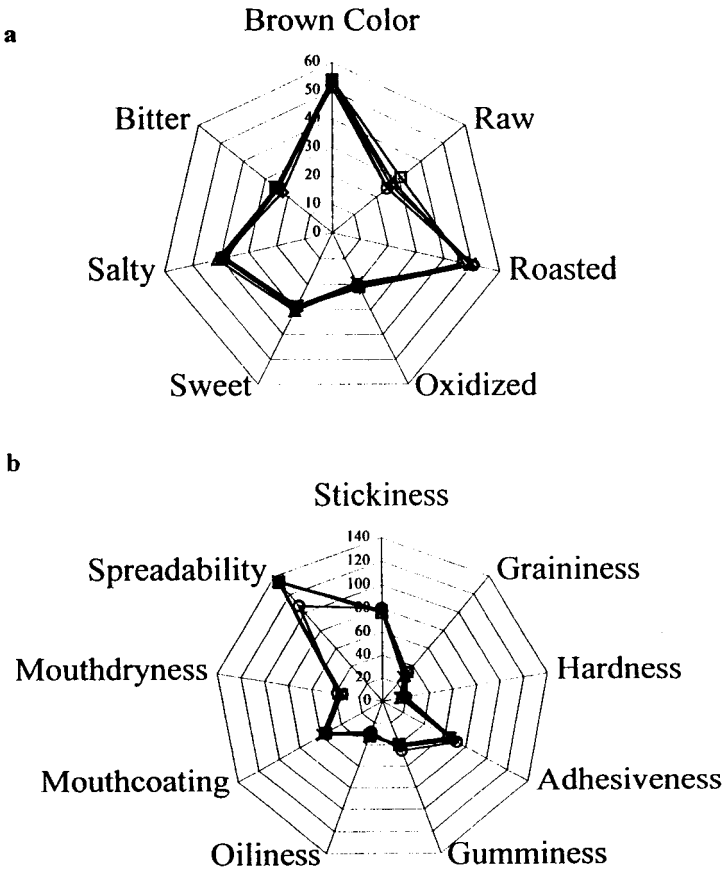

FIG. 1. MEAN INTENSITY RATINGS FOR (a) COLOR, FLAVOR AND (b) TEXTURE ATTRIBUTES OF UNSTABILIZED AND STABILIZED PEANUT BUTTERS

Where diamonds represent unstabilized, squares represent 1.5% palm oil, triangles represent 2.0% palm oil and crosses represent 2.5% palm oil and circles represent peanut butter stabilized with hydrogenated vegetable oils. Ratings are based on a 150 mm scale. Eight trained descriptive panelists rated each attribute for each treatment a total of four times (2 processing replications in duplicate) at day zero.

TABLE 5.
MEAN INTENSITY RATINGS OF TEXTURE ATTRIBUTES OF UNSTABILIZED AND STABILIZED PEANUT BUTTERS[1]

Stabilizer[2]/ Treatment	Stickiness	Graininess	Hardness	Adhesiveness	Gumminess	Oiliness	Mouthcoat	Mouthdryness	Spreadability
0% Palm Oil[3]	78.61±16.11	30.33±15.97	17.94±8.01ab	67.94±18.86	42.26±12.94ab	30.14±7.45	54.11±7.42	34.13±6.96	133.52±12.49a
1.5% Palm Oil	76.66±12.73	32.66±17.62	16.95±8.64bc	63.59±17.38	39.96±12.00b	31.39±10.10	54.97±9.28	34.56±8.40	133.44±12.47a
2.0% Palm Oil	76.42±16.38	28.61±15.74	15.38±6.92c	64.94±15.77	40.74±12.11b	32.44±10.14	56.08±7.99	36.65±5.84	133.52±12.48a
2.5% Palm Oil	78.24±14.29	27.31±15.34	14.88±7.55c	65.15±19.72	40.06±13.41b	31.33±12.70	58.21±10.31	37.11±9.74	134.56±12.68a
1.5% Hydrogenated vegetable oils[4]	80.18±12.74	32.31±16.18	19.91±7.48a	71.35±11.84	45.8610.14a	28.43±6.08	55.33±7.21	38.16±8.08	107.37±15.73b

[1] Mean intensities in a column not followed by the same letter are significantly different (α=0.05) as determined by Fisher's least significant difference (LSD) mean separation test. Means in a column not followed by a letter are not significantly different Ratings are based on a 150 mm scale with anchors at 12.5 mm and 137.5 mm for slight and strong. Eight trained descriptive panelists rated each attribute for each treatment a total of four times (2 processing replications in duplicate) at day zero.

[2] Percent added on a weight by weight basis

[3] Palm Oil Research Institute of Malaysia, Kuala Lumpur, Malaysia

[4] Fix-X, Procter & Gamble, Cincinnati, OH

to vary in Fig. 1b, there was not a significant difference in adhesiveness between the peanut butters (Table 5).

Consumer Tests. Mean consumer ratings of sensory attributes are shown in Table 6. Only HVO had a mean rating above the "like slightly" point on the hedonic scale. Overall, consumer acceptance ratings were highest for HVO compared with UPB and samples stabilized with PO. Consumers also rated spreadability of HVO highest. None of the remaining samples had a mean rating above the "like slightly" point on the scale. The color of all samples was liked by consumers. The color of HVO was rated higher than those stabilized with PO and UPB, except for PO2.0. The flavor of HVO, PO2.0 and PO2.5 were liked more than UPB and PO1.5. The texture of HOV was liked the best. It was rated above a 6. Samples stabilized with PO were not significantly different from each other in texture and ranged from 5.2 to 5.6. PO2.0 and PO2.5 were rated significantly higher in texture than UPB. The texture of UPB was not significantly less preferred than PO1.5. The oiliness of HVO was rated the highest. The high rating indicated that the consumers liked the oiliness better than PO and UPB. The oiliness of PO1.5 and PO2.0 were least liked. UPB and PO2.5 were neither liked nor disliked. The profiles for consumer ratings of sensory attributes are shown in Fig. 2. A difference in profiles of HVO and peanut butter stabilized with PO and UPB can clearly be seen. HVO were rated high in all sensory attributes. However, significant differences only occurred between HVO, UPB and peanut butter stabilized with PO in texture, oiliness, spreadability and overall liking. There were no significant differences in color and flavor acceptance of HVO, UPB and peanut butter stabilized with PO.

Linear Regression

The coefficient of determination (R^2) provides an easily understood numerical measure of the degree of association between Y, the response variable and X, the predictor or regressor variable, it tells how much of the variation in Y is attributable to the variation in X (O'Mahony 1986). A linear relationship exists between the consumer attributes of overall acceptance, and liking of color, oiliness and spreadability and the descriptive attributes of color, stickiness, oiliness and spreadability (Table 7). However, there was no linear relation between consumer liking of texture and flavor with any of the descriptive terms. Overall acceptance had a negative linear relation with descriptive terms brown color and spreadability. As the perceived intensity of brown color and spreadability increases, the consumer acceptance of the peanut butter decreases. However, the coefficients of determination was not high, $R^2=0.58$ and 0.55, respectively, indicating that there was not a strong linear relation. Consumer liking of color had a negative linear relation with descriptive terms brown color

TABLE 6.
MEAN CONSUMER RATINGS OF SENSORY ATTRIBUTES OF UNSTABILIZED AND STABILIZED PEANUT BUTTERS[1]

Stabilizer[2]/ Treatment	Overall	Color	Flavor	Texture	Oiliness	Spreadability
0% Palm Oil[3]	5.6±2.0b	7.0±0.6b	5.8±2.0c	5.2±2.1c	5.3±1.9b	5.8±2.0b
1.5% Palm Oil	5.6±2.0b	6.9±0.8b	6.0±1.9b	5.3±2.2bc	4.9±2.1c	5.8±2.0b
2.0% Palm Oil	5.8±1.8b	7.0±0.7ab	6.2±1.8a	5.6±2.1b	4.9±2.1c	5.7±2.1b
2.5% Palm Oil	5.9±2.0b	6.9±0.7b	6.3±1.9a	5.6±2.1b	5.3±2.0b	5.9±2.1b
1.5% Hydrogenated vegetable oils[9]	6.5±1.6a	7.6±0.8a	6.6±1.6a	6.2±1.8a	6.3±1.5a	6.7±1.5a

[1] Ratings are based on a 9- point hedonic scale. 1=dislike extremely, 5=neither like or dislike and 9=like extremely. 50 consumers rated ten samples, five treatments and one processing replication

[2] Percent added on a weight by weight basis

[3] Palm Oil Research Institute of Malaysia, Kuala Lumpur, Malaysia

[4] Fix-X, Procter & Gamble, Cincinnati, OH

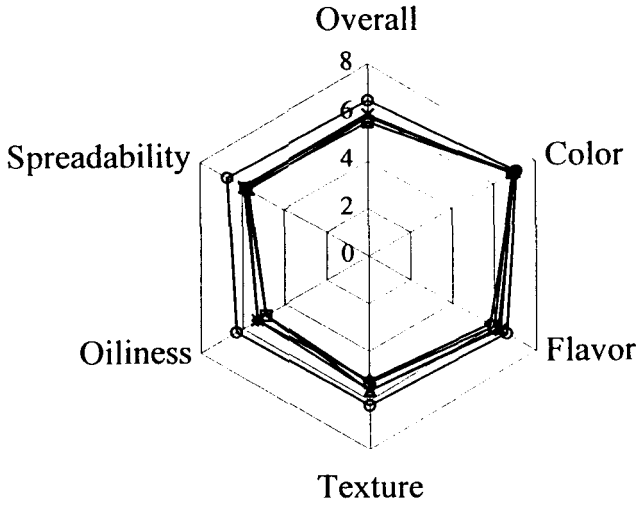

FIG. 2. MEAN CONSUMER RATINGS OF SENSORY ATTRIBUTES OF UNSTABILIZED AND STABILIZED PEANUT BUTTER

Where diamonds represent unstabilized, squares represent 1.5% palm oil, triangles represent 2.0.% palm oil, crosses represent 2.5% palm oil, and circles represent peanut butter stabilized with hydrogenated vegetable oils. Ratings are based on a 9-point hedonic scale. Fifty consumers rated ten samples, five treatments and one processing replication.

and oiliness. Consumer liking of oiliness had a negative linear relation with descriptive terms brown color, stickiness, oiliness, and spreadability. Consumer ratings for spreadability had a negative linear relation with descriptive terms oiliness and spreadability. Parameter estimates for all descriptive terms had negative values, indicating a negative relationship between intensity of attributes and consumer liking. As the intensity of brown color increases (Table 7), consumer overall acceptance and ratings of color and oiliness decreases. As the intensity of stickiness increases, the consumer liking of the oiliness of the peanut butter decreases. The consumer liking of color, oiliness and spreadability decreases with increasing intensity of oiliness. Consumer overall acceptance of the peanut butter and liking of oiliness and spreadability also decreases with increasing intensity of spreadability. A strong linear relationship occurs as the coefficient of determination (R^2) approaches 1. None of the relations mentioned previously, with the exception of one, had coefficients of determinations close

TABLE 7.
PARAMETER ESTIMATES USED IN THE PREDICTION OF CONSUMER ATTRIBUTE RATINGS FROM DESCRIPTIVE ATTRIBUTE INTENSITY RATINGS[1]

	Consumer Attribute Ratings[3]			
Descriptive Attributes[2]	Overall	Color	Oiliness	Spreadability
Intercept	198.79	74.58	18.98	--
Brown Color	-7.100	-2.52	-0.26	--
Brown Color*Brown Color	0.065	0.023	--	--
R^2	0.58	0.61	0.51	--
Intercept	--	--	170.55	--
Stickiness	--	--	-4.46	--
Stickiness*Stickiness	--	--	0.030	--
R^2	--	--	0.53	--
Intercept	--	19.40	78.27	56.37
Oiliness	--	-0.77	-4.50	-3.11
Oiliness*Oiliness	--	0.012	0.069	0.047
R^2	--	0.60	0.67	0.59
Intercept	9.33	--	10.50	31.57
Spreadability	-0.027	--	-0.040	-0.39
Spreadability*Spreadability	--	--	--	0.0015
R^2	0.55	--	0.63	0.85

[1]Consumer terms are listed vertically and descriptive terms are listed horizontally
[2]Ratings are based on a 150 mm scale with anchors at 12.5 mm and 137.5 mm for slight and strong.
[3]Ratings are based on a 9- point hedonic scale. 1=dislike extremely, 5=neither like or dislike and 9=like extremely.

to 1. The coefficient of determination expressing the relationship of descriptive term spreadability with consumer term spreadability was high (R^2=O.85) as expected. However, as mentioned previously, this linear relationship was negative. An increase in the intensity of spreadability, would indicate an increase in the ease in which the peanut butter spreads on a cracker. This could also indicate a soft peanut butter. Therefore, the consumers like a more firmer peanut butter. This was also apparent in the consumer ratings of spreadability (Table 6) of the peanut butter. Consumers liked the spreadability of HVO significantly more than the peanut butter stabilized with PO and UPB. The peanut butter stabilized with PO and UPB had a softer texture than HVO.

Out of sixteen descriptive attributes, only four, brown color, stickiness, oiliness, and spreadability related well with consumer terms overall, color, oiliness and spreadability. There were no linear relations between consumer terms' texture and flavor and any of the descriptive attribute terms.

More descriptive terms were expected to relate with the consumer attribute ratings because the terms used for consumers were taken from the list of descriptors developed by the descriptive panel. For example, consumer ratings for the attribute texture was expected to relate with descriptive textural terms graininess, hardness, adhesiveness gumminess, mouthcoating and mouthdryness and consumer attribute flavor was expected to relate with descriptive terms raw, roasted, oxidized, sweet, salty and bitter, however no relationship was seen.

Although consumer panelists consumed peanut butter at least once a month, they did not necessarily consume nor like natural peanut butter, peanut butter with no stabilizer or softer textured peanut butter. This could be one of the reasons for lack of relationships and for the negative parameter estimate values.

CONCLUSIONS

Differences in sensory profiles of the peanut butter stabilized with PO, UPB and HVO, existed. These differences were only seen in the attributes of brown color, raw flavor, hardness, gumminess and spreadability. Differences in consumer acceptance ratings for all attributes existed. In general, HVO was preferred to those peanut butters stabilized with PO and UPB. Only descriptive attributes spreadability correlated highly with consumer attribute spreadability.

ACKNOWLEDGMENTS

This study was part of Lebecca A. Gills masters thesis and was supported in part by grants from the U.S. Agency for International Development, Peanut Collaborative Research Support Program (Grant number LAG-4048-G-OO-6013-00). Recommendations do not represent an official position or policy of USAID.

REFERENCES

AACC. 1983a. Moisture-modified vacuum-oven method. In *Approved Methods of the American Association of Cereal Chemist*, 8th Ed., Secs. 44-40, American Association of Cereal Chemists, Inc., St. Paul, Minnesota.

AACC. 1983b. Crude fat in wheat and soy flour, feeds and cooked feeds. In *Approved Methods of the American Association of Cereal Chemists*, 8th Ed., Secs. 30-25, American Association of Cereal Chemists, Inc., St. Paul, Minnesota.

ASTM. 1981. Guidelines for the selection and training of sensory panel members. ASTM. Special Technical Publication 748. American Society for Testing and Materials, Philadelphia, Pennsylvania.

BRANDT, M.A., SKINNER, E.Z. and COLEMAN, J.A. 1963. Texture profile method. J. Food Sci. *28*, 404–409.

CIVILLE, G.V. and SZCZESNIAK, A.S. 1973. Guidelines to training a texture profile panel. J. Texture Studies *4*, 204–223.

EINSTEIN, M.A. 1991. Descriptive techniques and their hybridization. In *Sensory Science Theory and Application in Foods*, Ch. 11, (H.T. Lawless and B.P. Klein, eds.) pp. 317–338, Marcel Dekker, New York.

GILLS, L.A. 1998. Texture of Unstabilized Peanut Butter and Peanut Butter Stabilized with Palm Oil. M.S. Thesis, University of Georgia, Athens.

HINDS, M.J., CHINNAN, M.S. and BEUCHAT, L.R. 1994. Unhydrogenated palm oil as a stabilizer for peanut butter. J. Food Sci. *59*, 816–820, 832.

JOHNSEN, P.B., CIVILLE, G.V., VERCELLOTTO, J.R., SANDERS, T.H. and DUS, C.A. 1988. Development of a lexicon for the description of peanut flavor. J. Sensory Studies *3*, 9–17.

MEILGAARD, M., CIVILLE, G.V. and CARR, B.T. 1991. *Sensory Evaluation Techniques,* 2nd ed. CRC Press, Boca Raton, FL.

MUEGO, K.F., RESURRECCION, A.V.A. and HUNG, Y.-C. 1990. Characterization of the textural properties of spreadable peanut based products. J. Texture Studies *21*, 61–73.

MUEGO-GNANASEKHARAN, K.F. and RESURRECCION, A.V.A. 1992. Physicochemical and sensory characteristics of peanut paste stored at different temperatures. J. Food Sci. *57*, 1385–1389.

MUNOZ, A.M. and CHAMBERS, E., IV. 1993. Relating sensory measurements of consumer acceptance of meat products. Food Technol. *47*(11), 128–131, 134.

O'MAHONY, M. 1986. *Sensory Evaluation of Food*, Marcel Dekker, New York.

PLEMMONS, L. 1997. Sensory Evaluation Methods to Improve Validity, Reliability, and Interpretation of Panelist Responses. M.S. thesis, University of Georgia, Athens, GA.

RESURRECCION, A.V.A. 1988. Comparison of flavor quality of peanut based pastes and peanut butter by sensory methods. J. Food Sci. *53*, 1827–1830.

RESURRECCION, A.V.A. 1988. *Consumer Sensory Testing for Product Development*, Aspen Publishers, Gaithersburg, Maryland.

SAS Institute, Inc. 1987. *SAS/STAT Guide for Personal Computers,* 6th Ed. SAS Institute, Inc., Cary, NC.

STONE, H. and SIDEL, J.L. 1993. *Sensory Evaluation Practices*, Academic Press, San Diego, CA.

SZCZESNIAK, A.S., BRANDT, M.A. and FRIEDMAN M.H. 1963. Development of standard rating scales for mechanical parameters of texture and correlation between objective and sensory methods of texture evaluation. J. Food Sci. *28*, 397–403.

WEISS, T.J. 1970. *Food Oils and Their Uses*, AVI Publishing Co., Westport, Conn.

WILLETT, W.C., STAMPFER, M.J., MANSON, J.E., COLDITZ, G.A., SPEIZER, F.E., ROSNER, B.A., SAMPSON, L.A. and HENNEKENS, C.H. 1993. Intake of trans fatty acids and risk of coronary heart disease among women. The Lancet *341*, 581–585.

WOODROOF, J.G. 1983. Peanut butter. In *Peanuts: Production, Processing, Production,* 3rd Ed., Ch. 9, pp. 181–227, AVI Publishing Co., Westport, Conn.