Natural Antioxidant Effect from Peanut Skins in Honey-roasted Peanuts

V. NEPOTE, M.G. MESTRALLET, AND N.R. GROSSO

ABSTRACT: The purpose of this work was to determine the antioxidant effect of extracts obtained from peanut skins on honey roasted peanuts. A consumer test, chemical analysis, and descriptive sensory analysis were performed on samples of honey roasted peanuts without antioxidants (HRP), honey roasted peanuts with natural antioxidant from peanut skins (HRP-NA), and honey roasted peanuts with butylated hydroxytoluene (HRP-BHT). The consumer acceptance test was performed on fresh products at day 0 to determine whether the addition of antioxidant has an effect on the product acceptance by the consumers. The chemical analyses, peroxide and thiobarbituric acid reactive substance (TBARS) values, and the descriptive analysis were performed during 126 d of storage to determine the antioxidant effect of peanut skin extracts on product stability. Peroxide and TBARS values as well as oxidized and cardboard flavors increased, and roasted peanutty flavor decreased across the storage time for all samples. Addition of natural antioxidants from peanut skins did not affect the acceptance of the product but provided protection against lipid oxidation being a little less efficient compared with BHT. Peroxide value reached 10 meq O_2/kg after 19.6 d in HRP, 28.0 d in HRP-NA, and 34.0 d in HRP-BHT.

Keywords: peanut, antioxidant, descriptive analysis, consumer test, peroxide value

Introduction

Peanuts are characterized by high oil and protein content and a low percentage of carbohydrates and ash (Grosso and Guzman 1995). A large proportion of peanut production in the world goes into domestic food use, the end products being peanut butter, salted peanut products, confections, and roasting stock. These peanut-containing foods have widespread popularity because of their unique roasted peanut flavor. The rest of the peanut production is used for an edible source of high-quality oil. Peanuts are continually applied for preparation of new and improved food products; thus, a more complete knowledge of their composition and flavor properties is desirable (Ahmed and Young 1982).

Peanuts contain approximately 50% to 55% oil with 30% to 35% and 45% to 50% of the oil being linoleic and oleic acids, respectively, which becomes susceptible to development of rancid and off-flavors through lipid oxidation (St. Angelo 1996). Lipid oxidation occurs during storage of peanut products and contributes to the development of undesirable flavors in foods in which peanuts are an ingredient. The oxidation reactions lead indirectly to the formation of numerous aliphatic aldehydes, ketones, and alcohols (Bett and Boylston 1992). Simultaneously, off-flavors such as oxidized, cardboard, and painty increase in such peanut products (Gill and Resurreccion 2000; Grosso and Resurreccion 2002).

Edible coatings in peanut products may prevent moisture loss and oxygen diffusion, may be used as a vehicle of additives such as antioxidants and flavoring agents, and improve the consumer acceptance for applying flavoring. The addition of antioxidants to foods is one of the most effective means for retarding fat oxidation. It has become increasing popular as a method for increasingly shelf-life of food products and improving the stability of lipids and lipid-containing foods, thus preventing loss of sensory and nutritional quality. Synthetic antioxidants, such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate (PG), are used in many foods to prevent rancidity. Because of growing concern for the potential health hazards of synthetic antioxidants, several authors are researching the health risk of these antioxidants when used in foods. One example is the work from Ito and others (1982) that reported BHA to be carcinogenic in animal experiments. There is renewed interest in the increased use of naturally occurring antioxidants. Natural antioxidant are presumed to be safe because they occur in nature and in many cases are derived from plant sources. For these reasons, many studies have been carried out to find out potential antioxidant activity compounds from natural sources (St. Angelo 1996).

Several studies on the antioxidant components from peanut hulls have been performed. Duh and others (1992) extracted and identified luteolin as antioxidant component. Yen and others (1993) described the relationship between antioxidant activity of methanol extracts and maturity of peanut hulls and reported that the total phenolic content increased with maturity. Yen and Duh (1994) reported a marked radical-scavenging effect of methanolic extracts of peanut hulls; in 1995, they also found that the Spanish peanut cultivar had higher total phenolic content than other peanut cultivars. Finally, Duh and Yen (1997) reported that antioxidant compounds of methanolic extracts from peanut hulls had antioxidant efficacy in soybean and peanut oils. Nepote and others (2002) have found antioxidant activity in vegetable oil of compounds from peanut skins.

Peanut skins are a waste from blanched processing of peanut kernels. In Argentina, peanut skins are sometimes used to feed cattle; however, their value could be increased if other more valuable uses like natural antioxidant sources could be found for that waste. The objective of this work was to determine the antioxidant effect of extracts obtained from peanut skins on honey roasted peanut products.

MS 20040104 Submitted 2/20/04, Revised 4/8/04, Accepted 4/26/04. *Authors are with the Quimica Biologica, Facultad de Ciencias Agropecuarias (UNC), IMBIV-CONICET, CC 509, 5000 Cordoba, Argentina. Direct inquiries to author Grosso (e-mail nrgrosso@agro.uncor.edu).*

Materials and Methods

Materials

Sound and mature seeds of blanched peanuts (*Arachis hypogaea* L.) type Runner, size 38/42 kernels per oz (2001 crop) were provided by Lorenzati, Ruescht y Cia of Ticino, Cordoba, Argentina. Before processing, peanuts were inspected; damaged and bruised kernels were manually removed.

Product elaboration

Roasted peanuts (RP). Blanched peanuts were roasted in an oven at 140 °C (Memert, model 600, Schwabach, Germany) for 30 min. Peanuts were heated to a medium roast or an average Hunter color Lightness (*L*) value of 50 ± 1.0 (Johnsen and others 1988).

Honey roasted peanuts (HRP). This product was prepared with 85% RP and 5% syrup solution and 10% dried solid mix (w/w/w). A syrup solution was prepared consisting of 50% sucrose, 35% honey, and 15% distilled water (w/w/w). A dried solid mix was prepared consisting of 70% impalpable sucrose, 20% impalpable salt, and 10% corn starch. RP were placed into the stainless-steel coating pan rotating at 28 rpm. Then a syrup solution was applied to the RP. Finally, a dried solid mix was poured into the coating pan to separate the kernels. In the final product, the moisture content was 2.3% according to previous unpublished results evaluated following AOAC methods (AOAC 1980). This moisture content was the same in the 3 products studied in this work.

Honey roasted peanuts with butylated hydroxytoluene (HRP-BHT). The procedure to prepare this product was the same as that used to make to HRP. The antioxidant BHT was applied in a proportion of 0.02% in a syrup solution (w/w).

Honey roasted peanuts with natural antioxidant (HRP-NA). The natural antioxidants were phenolic compounds obtained from defatted peanut skins using ethanol as extraction solvent according to the methodology followed by Nepote and others (2002). They reported that defatted peanut skins had 16.2% ethanolic extract. Therefore, 0.02 g ethanolic extract used to prepare 100 g HRP-NA was obtained from 0.15 g of peanut skins. This amount of peanut skins is lower than the natural skin/kernel ratio. The procedure to prepare this product was the same used to make HRP. The natural antioxidants was added in a proportion of 0.02% in a syrup solution (w/w).

Storage conditions and samplings

After preparation of HRP, HRP-BHT, and HRP-NA, samples were packaged in 27- × 28-cm plastic bags (Ziploc, Johnson & Son, Buenos Aires, Argentina). The samples were stored at 23 °C (room temperature). Samples of each product were removed from storage for chemical and descriptive analyses. Sampling was performed every 21 d over a 126-d period. Samples were also evaluated on day 0.

Chemical analysis

Peroxide value. Peroxide value (PV) was evaluated following the AOAC method 28.022 (AOAC 1980) using 5 g of oil from each HRP sample. It consisted of determining the reaction in darkness of a mixture of oil and chloroform/acetic acid 2:3 (v/v) with saturated potassium iodide solution. The iodine formed was titrated with 0.1 *N* $Na_2S_2O_3$. The PV was expressed as milliequivalents of active oxygen per kilogram of oil (meqO_2/kg) and calculated with the formula: PV (meqO_2/kg) = (volume in mL of $Na_2S_2O_3$) 3 (0.1 N) 3 (1000)/(g oil). The oil was obtained for 2 extractions with 50 mL of n-hexane (Anedra, San Fernando, Buenos Aires, Argentina) from samples (20 g) during 12 h by maceration at room temperature in a dark room. The extracted oils were dried over anhydrous sodium sulfate, and the solvent was removed under reduced pressure in a rotary film evaporator.

Thiobarbituric acid reactive substances (TBARS). The thiobarbituric acid (TBA) test is commonly used as a measurement for lipid oxidation products. The procedure was a colorimetric method described by Heath and Packer (1968). Briefly, each HRP sample (100 mg) was mixed in 2 mL distilled water; 2 mL of 0.5% TBA in 20% trichloroacetic acid was added to mixture and was vortex mixed. The mixture was then incubated at 95 °C for 30 min for color development. The reaction was stopped by putting the reaction tubes in an ice bucket. After that, the samples were centrifuged at 10000 3 *g* for 15 min. The supernatant was removed and the absorbance was read at 532 nm in a spectrophotometer (Spectronic 21, Bausch and Lomb, Rochester, N.Y., U.S.A.). The TBARS values was calculated from extinction coefficient of 155/m*M*/cm (Kosugi and others 1989).

Sensory methods

Consumer analysis. Panelists (*n* = 100) were from Cordoba (Argentina) and were recruited using the following criteria: ages between 18 and 65 years, nonsmokers, no food allergies, and eat roasted peanuts and/or peanut products at least two times per week. For sample evaluation, 5 g of peanut samples were placed into plastic cups with lids, coded with 3-digit random numbers. Samples consisting of HRP, HRP-BHT, and HRP-NA (3 replications each) were prepared for each panelist. Samples were presented to panelist in random order during the test day. Samples were presented with water and paper ballots on a plastic tray. Panelists were instructed to consume the whole sample and rinse their mouths with water between samples to minimize any residual effect. A 9-point hedonic scale ranging from 1 = dislike extremely to 9 = like extremely was used to evaluate overall acceptance from HRP, HRP-BHT, and HRP-NA samples (Peryam and Pilgrim 1957).

Descriptive analysis. A total of 12 trained panelists (9 female and 2 male) participated for descriptive analysis of the honey roasted peanuts storage study. All panelists were selected on the following criteria: natural dentition, no food allergies, nonsmokers, between the ages of 18 and 65 years, consume roasted peanuts and/or peanut products at least once per month, available for all session, interest in participating, and able to verbally communicate regarding the product (Plemmons and Resurreccion 1998). All panelists had to have a perfect score in a taste sensitivity test and the ability to identify 5 of 7 commonly found food flavors before they qualified as panelists.

All 12 panelists were trained and calibrated in 4 training sessions for 4 d. Each training session lasted 2 h for a total of 8 h. Descriptive analysis test procedures as described by Meilgaard and others (1991) and Grosso and Resurreccion (2002) were used to train the panelists. Panelists evaluated samples using a "hybrid" descriptive analysis method consisting of the quantitative descriptive analysis (Tragon Corp., Redwood City, Calif., U.S.A.) and the Spectrum™ Analysis Methods (Sensory Spectrum, Inc., Chatham, N.J., U.S.A.).

On the 1st day of training, panelist were given a review of concepts of sensory analysis. Then they were asked to taste standard solutions of sucrose, sodium chloride, citric acid, and caffeine at varying concentrations and intensities that corresponded to points on a 150-mm unstructured line scale (Plemmons and Resurreccion 1998). After that, all 12 panelists worked together to develop the language to describe perceivable product attributes in HRP. Fresh and rancid samples of HRP were presented to each panelist. Panelists identified appearance, aromatics, taste, and texture attributes that would be used to describe the product samples. A lexicon for peanut samples (Johnsen and others 1988) was used to

provide an initial list of attributes. Panelists decided whether terms were redundant and should be removed or if additional terms should be included in the list of attributes and defined each attribute (Table 1). Panelists also identified references to be used to describe each appearance, flavor, and textural attribute. Each panelist gave an intensity rating of each reference between 0 and 150 for each attribute. The mean intensity rating was calculated and used as attribute in intensity rating for that particular reference (Table 2).

On the 2nd day of training, panelists reviewed descriptors, definitions, and reference standards to describe HRP samples. Panelists tasted each reference and provided a rating. The panel was calibrated by obtaining an average panel rating with a standard deviation within 10 points. Panelists not rating within ±10 points of the mean rating were asked to re-evaluate the sample and adjust their rating until a consensus was reached. After that, medium roasted peanuts were presented as a warm-up sample to be used for each panelist as the initial sample during training and testing sessions (Plemmons and Resurreccion 1998).

On the 3rd day of training, panelists finalized the definitions, descriptors, and reference standard intensities to describe HRP. Then, the list of definitions (Table 1) and warm-up and reference intensity ratings (Table 2) were finalized. After that, panelists evaluated 4 HRP samples with different degrees of oxidized flavors using paper ballots to calibrate themselves.

On the last day of training, panelists continued evaluating HRP samples with different degrees of oxidized flavors to practice and to calibrate themselves within ±10 points of the mean ratings for each attribute of the samples.

All samples were evaluated in partitioned booths under fluorescent light at room temperature. Ten grams of product sample were placed into plastic cups with lids coded with 3-digit random numbers. Panelists evaluated 12 samples per day plus a warm-up sample. The final lists of warm-up and reference intensity ratings and definitions were posted in the booths for all test sessions. Samples were tested using a complete 14 randomized block design. The data were registered on paper ballots.

Statistical analysis

The data were analyzed using the InfoStat software, version 1.1 (Facultad de Ciencias Agropecuarias, Universidad Nacional de Cordoba, Cordoba, Argentina). Means and standard deviations were calculated. Analysis of variance was used to detect significant differences between sampling day in sensory attributes and chemical analysis using LSD tests to find significant differences ($\alpha = 0.05$) between means. Pearson coefficient was used to calculate correlation between dependent variables from chemical and sensory analyses. Second-order polynomial regression equations in the regression analyses were used to determine whether the independent variables (time) had an effect on the sensory attributes and on the peroxide and TBARS values.

Results and Discussion

Consumer analysis

Significant differences ($\alpha = 0.05$) of the acceptance among the products (HRP, HRP-NA, and HRP-BHT) were not found. In general, the products had acceptances of about "6 = like slightly" in an hedonic 9-point scale. The overall acceptance means in HRP, HRP-BHT, and HRP-NA were 5.98 ± 1.67, 6.05 ± 1.77, and 6.04 ± 1.74, respectively. The addition of natural antioxidants from peanut skins (HRP-NA) or artificial antioxidant (HRP-BHT) did not affect the acceptability of the product compared with honey roasted pea-

Table 1—Definitions of attributes used by the trained panel to describe honey roasted peanuts

Attribute[a]	Definition
Appearance	
1-Brown color	The intensity or the strength of brown color from light to dark brown
2-Roughness	The appearance associated with uneven surface
Aromatics	
3-Roasted peanutty	The aromatic associated with medium roasted peanuts
4-Oxidized	The aromatic associated with rancid fats and oils
5-Cardboard	The aromatic associated with wet cardboard
Tastes	
6-Sweet	Taste on the tongue associated with sucrose solutions
7-Salty	Taste on the tongue associated with sodium chloride solutions
8-Sour	Taste on the tongue associated with acid agents such as citric acid solutions
9-Bitter	Taste on the tongue associated with bitter solutions such as caffeine
Texture	
10-Hardness	Force needed to compress a food between molar teeth
11-Crunchiness	Force needed and amount of sound generated from chewing a sample with molar teeth

[a]Attributes listed in order as perceived by panelists

Table 2—Standard reference and warm-up intensity ratings used in descriptive tests for honey roasted peanuts

Attribute	Reference	Reference intensity[a]	Warm-up intensity[a,b]
Appearance			
1-Brown color	Cardboard (lightness value, $L = 47 \pm 1.0$)	61	44
2-Roughness	Corn flakes (Granix, Buenos Aires, Argentina)	61	44
Aromatics			
3-Roasted peanutty	Dry roasted peanuts (JL SA, Ticino, Córdoba, Argentina)	81	59
4-Oxidized	Rancid peanuts	103	5
5-Cardboard	Moist cardboard	53	8
Tastes			
6-Sweet	2.0% sucrose solution	20	16
	5.0% sucrose solution	50	—
	10% sucrose solution	100	—
	15% sucrose solution	150	—
7-Salty	0.2% NaCl solution	25	9
	0.35% NaCl solution	50	—
	0.5% NaCl solution	85	—
8-Bitter	0.05% caffeine solution	20	7
	0.08% caffeine solution	50	—
	0.15% caffeine solution	100	—
9-Sour	0.05% citric acid solution	20	2
	0.08% citric acid solution	50	—
	0.15% citric acid solution	100	—
Texture			
10-Hardness	Almonds (Grandiet, Cordoba, Argentina)	61	52
11-Crunchiness	Corn flakes (Granix, Buenos Aires, Argentina)	100	41

[a]Intensity ratings are based on 150-mm unstructured line scales.
[b]Medium (lightness value, $L = 50 \pm 1.0$) roasted peanuts (blanched runner).

nuts without antioxidants. Grosso and Resurreccion (2002) found similar overall acceptance on cracker coated and roasted peanut products (between 6.12 to 6.37).

Chemical and descriptive analyses

The changes in peroxide and TBARS values during storage of the samples HRP, HRP-NA, and HRP-BHT are shown in Figure 1. The peroxide and TBARS values increased with storage time in all products. During storage, HRP had higher peroxide values and showed significant differences ($\alpha = 0.05$) after day 42 with respect to the samples with antioxidants. HRP-BHT exhibited lower peroxide values during the whole storage time. However, the differences between HRP-BHT and HRP-NA were very little. These differences were significant after day 63.

The TBARS value differences among the samples were not significant through storage. However, HRP showed higher TBARS values. HRP-NA and HRP-BHT did not have significant differences in TBARS values during storage time.

The sensory attributes from the descriptive analysis presented in Table 3 showed no significant differences (at $\alpha = 0.05$) among HRP, HRP-NA, and HRP-BHT at day 0, indicating that the antioxidant inclusion in the product did not influence the panel scores. The roasted peanutty attribute used to characterize peanut flavor in peanut products was 48 (scale 0 to 150) in HRP. Grosso and Resurreccion (2002) found that the roasted peanutty intensity was 67 and 63 in roasted peanuts and cracker coated peanuts, respectively.

In other works (Bett and Boylston 1992; St. Angelo 1996; Grosso and Resurreccion 2002), an increase of the intensity ratings of cardboard and oxidize and a decrease of roasted peanutty attribute in peanut products during the storage time was observed. In this work, the sensory attributes that changed during the storage time were also roasted peanutty and those attributes related to the lipids oxidation such as oxidized and cardboard. The other attributes did not show significant variations ($\alpha = 0.05$) during storage. The changes of the attributes oxidized, cardboard, and roasted peanutty in HRP, HRP-NA, and HRP-BHT during the storage time are represented in the Figure 2. Oxidized and cardboard intensities increased with the storage time. The intensities of oxidized were from 4.4 on day 0 to 13.1 on day 126 in HRP. The rating of this attribute was lower in HRP-NA and HRP-BHT. The intensity rating of cardboard was higher in HRP than in HRP-NA and HRP-BHT. Significant differences between HRP and the other products in oxidized and cardboard intensities were observed at day 21.

The intensity ratings of roasted peanutty in all the samples decreased during the storage time. The intensities of this attribute changed from 48.3 on day 0 to 41.3 on day 126 in HRP, from 48.9 to

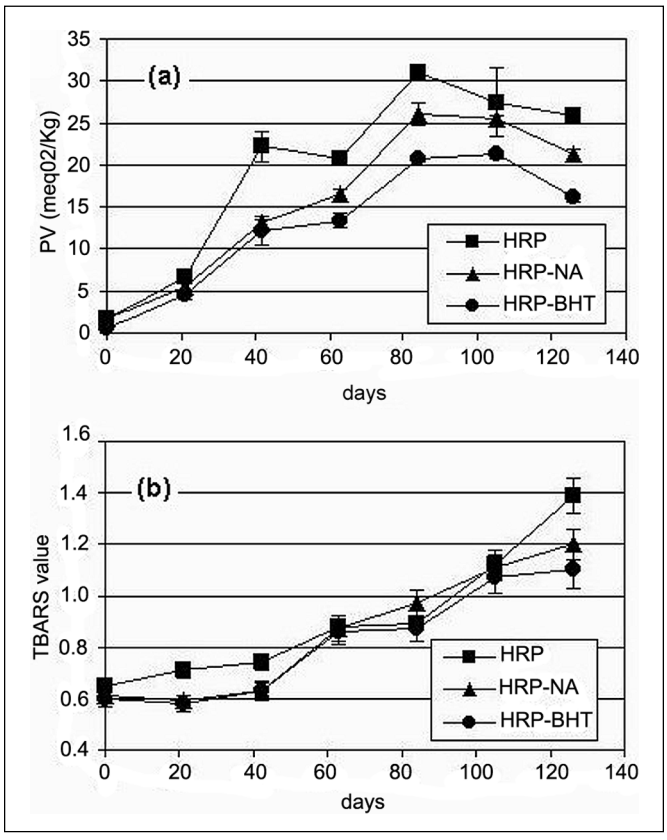

Figure 1—(a) Peroxide (PV) and (b) thiobarbituric acid reactive substance (TBARS) values in honey roasted peanuts (HRP), honey roasted peanut with natural antioxidant (HRP-NA), and honey roasted peanut with BHT (HRP-BHT) during the storage time at 23 °C.

Table 3—Means of sensory attribute intensities from descriptive analysis in fresh (storage time = 0) honey roasted peanuts

Sensory atributes	HRP[a,b]	HRP-NA[a,b]	HRP-BHT[a,b]
Appearance			
1-Brown color	42.31 ± 6.51a	43.63 ± 6.29a	42.64 ± 5.66a
2 Roughness	57.97 ± 9.09a	55.5 ± 8.72 a	56.03 ± 9.45a
Aromatics			
3-Roasted peanutty	48.28 ± 14.07a	48.86 ± 13.47a	48.03 ± 13.13a
4-Oxidized	4.36 ± 4.45a	4.08 ± 4.27a	3.61 ± 3.15a
5-Cardboard	6.31 ± 4.05a	6.28 ± 3.68a	6.06 ± 3.21a
Tastes			
6-Sweet	39.72 ± 26.22a	37.64 ± 19.19a	34.97 ± 13.00a
7-Salty	36.94 ± 19.13a	33.31 ± 15.95a	33.58 ± 13.19a
8-Bitter	6.53 ± 3.21a	6.28 ± 2.67a	5.94 ± 3.16a
9-Sour	3.67 ± 3.66a	3.33 ± 3.16a	3.51 ± 3.33a
Texture			
10-Hardness	48.72 ± 3.85a	48.69 ± 4.08a	48.67 ± 5.1a
11-Crunchiness	38.92 ± 5.34a	40.14 ± 4.73a	39.08 ± 5.95a

[a]HRP = honey roasted peanuts; HRP-BHT = honey roasted peanuts with BHT; HRP-NA = honey roasted peanuts with natural antioxidant
[b]Mean followed by the same letter within each row are not significantly different at $\alpha = 0.05$.

Table 4—Correlation coefficients among the variables: peroxide (PV) and thiobarbituric acid reactive substance (TBARS) values, and sensory attributes in honey roasted peanuts with and without antioxidants

	Correlation coefficients[a]		
Related variables	**HRP[b]**	**HRP-NA[b]**	**HRP-BHT[b]**
PV and TBARS	0.75	0.83	0.92
PV and oxidized	0.92	0.92	0.85
PV and cardboard	0.89	0.93	0.87
PV and roasted peanutty	–0.87	–0.91	–0.95
TBARS and oxidized	0.79	0.75	0.86
TBARS and cardboard	0.81	0.78	0.86
TBARS and roasted peanutty	–0.70	–0.81	–0.88
Oxidized and cardboard	0.98	0.99	0.99
Oxidized and roasted peanutty	–0.91	–0.92	–0.98
Cardboard and roasted peanutty	–0.94	–0.91	–0.98

[a]Pearson correlation coefficients
[b]HRP = honey roasted peanuts; HRP-BHT = honey roasted peanuts with BHT; HRP-NA = honey roasted peanuts with natural antioxidant

Table 5—Regression coefficients and adjusted R^2 from prediction equations of peroxide (PV) and thiobarbituric acid reactive substance (TBARS) values and sensory attributes in honey roasted peanuts with and without antioxidants

Sample	Dependent variable	Regression coefficients[a] β_o	β_1	β_{11}	R^2
HRP[b]	PV	0.036667	0.563019	–0.002811	0.90
	TBARS	0.676190	–0.000663	0.000048	0.92
	Oxidized	4.307540	0.120805	–0.000428	0.73
	Cardboard	6.229206	0.036451	–0.000056	0.76
	Roasted peanutty	48.569524	–0.139932	0.000682	0.62
HRP-NA[b]	PV	–0.427738	0.423971	–0.001852	0.92
	TBARS	0.562619	0.002738	0.000021	0.90
	Oxidized	4.037063	–0.009257	0.000222	0.60
	Cardboard	6.209762	–0.004813	0.000170	0.53
	Roasted peanutty	48.520952	0.010454	–0.000422	0.66
HRP-BHT[b]	PV	–0.872619	0.382007	–0.001836	0.92
	TBARS	0.557619	0.002721	0.000015	0.84
	Oxidized	3.592222	0.013492	0.000030	0.47
	Cardboard	6.069921	–0.003980	0.000157	0.53
	Roasted peanutty	48.064048	–0.028628	–0.000003	0.45

[a]Regression coefficients for the general regression equation: $Y = \beta_o + \beta_1 X + \beta_{11} X^2$, where Y = dependent variable (PV, TBARS, sensory attributes) and X = independent variable (days of storage)
[b]HRP = honey roasted peanuts; HRP-BHT = honey roasted peanuts with BHT; HRP-NA = honey roasted peanuts with natural antioxidant

42.8 in HRP-NA and from 48.0 to 44.9 in HRP-BHT. After day 42, HRP had intensities of roasted peanutty. This difference was significant ($\alpha = 0.05$) compared with the products with antioxidants. The samples with antioxidant (HRP-NA and HRP-BHT) did not show significant differences in the intensities of oxidized, cardboard, and roasted peanutty attributes during storage. Roasted peanutty flavor can be attributed to the presence of pyrazines (Buckholz and Daun 1981; Crippen and others 1992). Bett and Boylston (1992) found that roasted peanutty flavor intensity and alkylpyrazines decreased in stored roasted peanuts. Warner and others (1996) and Brannan and others (1999) also found that roasted peanutty flavor decreased in stored roasted peanuts.

Correlation and regression analysis

The variables of interest in this study were PV, TBARS values, and oxidized, cardboard, and roasted peanutty flavors. Correlation coefficients are presented in Table 4. PV and TBARS data showed correlation with sensory data. Positive correlations higher than 0.70 were observed among the following variables: TBARS, PV, and oxidized and cardboard flavors. All of these variables increased during storage time in the 3 honey roasted peanuts (HRP, HRP-BHT, and HRP-NA). Negative correlations were observed between roasted peanutty flavor and the other mentioned variables (TBARS, PV, and oxidized and cardboard flavors) in the 3 honey roasted peanuts. These negative correlations indicated that roasted peanutty flavor decreased with PV and TBARS values, and oxidized and cardboard flavors increased during storage time.

Prediction equations of the peroxide values, TBARS, and sensory attributes that changed with the storage time for each product (HRP, HRP-NA, and HRP-BHT) are presented in Table 5.

The dependent variables (peroxide and TBARS values) showed $R^2 > 0.70$ in HRP, HRP-NA, and HRP-BHT, indicating these variables are good predictors. Therefore, the regression equation from peroxide and TBARS values could be used to predict the effect of the storage time at 23 °C on these peanut products.

In the Food Code from Argentina, 10 meq O_2/kg is the maximum level of peroxide value allowed for peanut products. According to the prediction equation of peroxide values, peroxide values higher than 10 meqO_2/kg were reached after 19.6 d in HRP, 28.0 d in HRP-NA, and 34.0 d in HRP-BHT. These results indicate that BHT pro-

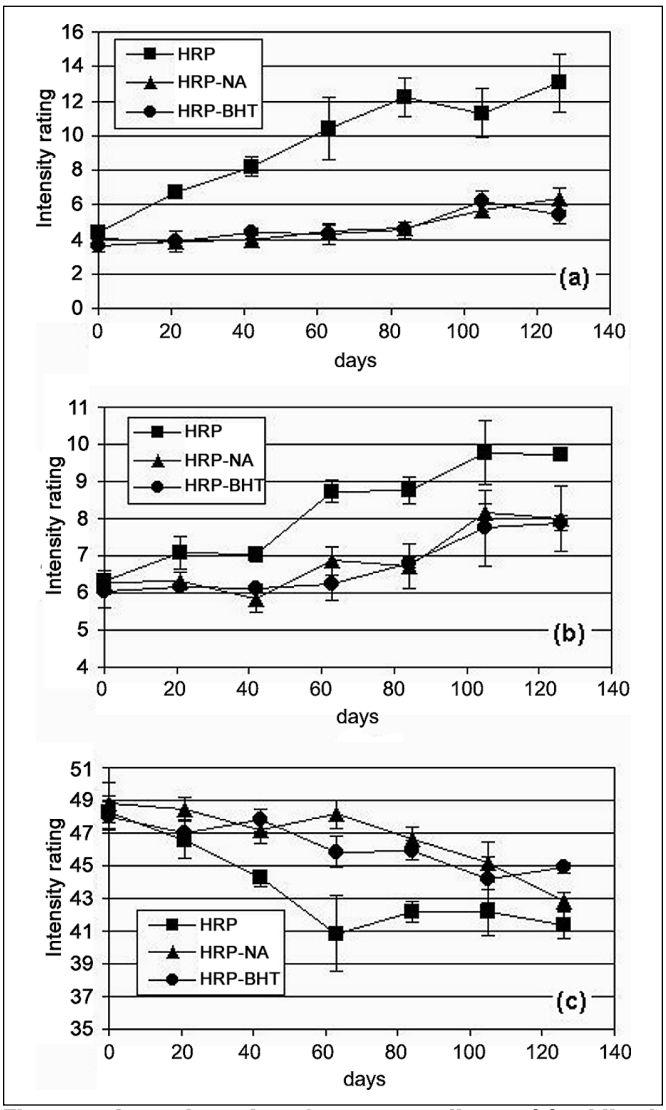

Figure 2—Intensity rating of sensory attributes: (a) oxidized, (b) cardboard, and (c) roasted peanutty in honey roasted peanuts (HRP), honey roasted peanut with natural antioxidant (HRP-NA), and honey roasted peanut with BHT (HRP-BHT) during storage time at 23 °C.

vided the highest protection against lipid peroxidation, but natural antioxidant from peanut skins also provided protection.

The variables, oxidized and cardboard, had $R^2 > 0.70$ for HRP, only. The samples with antioxidants (HRP-NA and HRP-BHT) showed $R^2 < 0.70$ for the attributes oxidized and cardboard flavors. The roasted peanutty attribute had $R^2 < 0.70$ in all peanut products. In the last one, the regression coefficient was low because of the difference in the intensity between the beginning and the end of the storage time in the studied peanut products. Bett and Boylston (1992) detected that cardboard flavor intensity had a linear increase across storage time in roasted peanuts, whereas roasted peanutty flavor intensity decreased as storage time increased. Muego-Gnanasekharan and Resurreccion (1992) detected that oxidized and cardboard flavor intensities exhibited a linear increase during storage time in peanut paste. Warner and others (1996) observed that oxidized flavor intensity increased and roasted peanutty flavor decreased during storage time in ground roasted peanuts, but a regression equation was not presented in their work.

Conclusions

The results of this work indicate that the use of antioxidants in the coating of honey roasted peanuts improves the stability of the product, making it more resistant to lipid oxidation and the development of rancid flavors. The phenolic compounds obtained from peanut skins have antioxidant activity. This natural antioxidant compound from peanut skins could be used in other food products to increase shelf-life and improve the stability of foods containing a high lipid proportion, thus preventing loss of their sensory and nutritional quality. Besides, this study provides the equation to estimate shelf-life of honey roasted peanuts with and without antioxidant from descriptive analysis, peroxide, and TBARS values.

Acknowledgments

This work was supported by Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and Secretaría de Ciencia y Tecnología, Univ. Nacional de Córdoba (SECYT-UNC), Argentina.

References

Ahmed EH, Young CT. 1982. Composition, quality, and flavor of peanuts. In: Pattee HE, Young CT, editors. Peanut science and technology. Yoakum, Tex.: American Peanut Research and Education Society, Inc. p 655–88.
[AOAC] Assn. of Official Analytical Chemists. 1980. Official methods of analysis. Horwitz W, editor. 13th ed. Washington, D.C.: AOAC.
Bett KL, Boylston TD. 1992. Effect of storage on roasted peanut quality. In: St. Angelo AJ, editor. Lipid oxidation in food. ACS Symposium Series 500. Washington, D.C.: American Chemical Society. p 322–43.
Brannan GL, Koehler PE, Ware GO. 1999. Physico-chemical and sensory characteristics of defatted roasted peanuts during storage. Peanut Sci 26:44–53.
Buckholz LL, Daun H. 1981. Instrumental and sensory characteristics of roasted peanut flavor volatiles. In: Teranishi R, Barrera-Benitez H, editors. Quality of selected fruits and vegetables. ACS Symposium Series 170. Washington, D.C.: American Chemical Society. p 163–81.
Crippen KL, Vercellotti JR, Lovegren NV, Sanders TH. 1992. Defining roasted peanut flavor quality. Part. 2. Correlation of GC volatiles and sensory flavor attributes. In: Charalambous G, editor. Food science and human nutrition. Amsterdam: Elsevier Science Publisher BV. p 211–27.
Duh P, Yen G. 1997. Antioxidant efficacy of methanolic extracts of peanut hulls in soybean and peanut oils. JAOCS 74(6):745–8.
Duh P, Yeh D, Yen G. 1992. Extraction and identification of an antioxidative component from peanut hulls. JAOCS 69(8):814–8.
Gills LA, Resurreccion AVA. 2000. Sensory and physical properties of peanut butter treated with palm oil and hydrogenated vegetable oil to prevent oil separation. J. Food Sci 65(1):173–80.
Grosso NR, Guzman CA. 1995. Chemical composition of aboriginal peanut (*A. hypogaea*) seeds from Peru. J Agric Food Chem 43:102–5.
Grosso NR, Resurreccion AVA. 2002. Predicting consumer acceptance ratings of cracker-coated and roasted peanuts from descriptive analysis and hexanal measurements. J Food Sci 67(4):1530–7.
Heath RL, Packer L. 1968. Photoperoxidation in isolated chloroplast. I. Kinetics and stoichiometry of fatty acid peroxidation. Arch Biochem Biophys 125:189–98.
Ito N, Hagiwara A, Shibata M, Ogiso T, Fukushima S. 1982. Induction of squamous cell carcinoma in the forestomack of F334 rats treated with butylated hidroxyanisole. Jpn J Canc Res(Gann) 73:332–4.
Johnsen PB, Civille GV, Vercellotti JR, Sanders TH, Dus CA. 1988. Development of a lexicon for the description of peanut flavor. J Sensory Stud 3:9–17.
Kosugi H, Jojima T, Kikugawa K. 1989. Thiobarbituric acid-reactive substances from peroxidized lipids. Lipids 24:873–81.
Meilgaard M, Civille GV, Carr BT. 1991. Sensory evaluation techniques. 2nd ed. Boca Raton, Fla.: CRC Press Inc. p 135–83.
Muego-Gnanasekharan KF, Resurrección AVA. 1992. Physicochemical and sensory characteristic of peanut paste stored at different temperatures. J Food Sci 57:1385–9.
Nepote V, Grosso NR, Guzman CA. 2002. Extraction of antioxidant components from peanut skins. Grasas Aceites 53(4):391–5.
Peryam DR, Pilgrim FJ. 1957. Hedonic scale method of measuring food preferences. Food Technol 11(9):9–14.
Plemmons LE, Resurreccion AVA. 1998. A warm-up sample improves reliability of responses in descriptive analysis. J. Sensory Stud 13:359–76.
St. Angelo AJ. 1996. Lipid oxidation in food. Crit Rev Food Sci Nutr 36(3):175–224.
Warner KJH, Dimick PS, Ziegler GR, Mumma RO, Hollender R. 1996. Flavor-fade and off flavor in ground roasted peanuts as related to selected pyrazines and aldehydes. J Food Sci. 61:469–472.
Yen G, Duh P. 1994. Scavenging effect of methanolic extracts of peanut hulls on free-radical and active-oxygen species. J Agric Food Chem 42:629–32.
Yen G, Duh P. 1995. Antioxidant activity of methanolic extracts of peanut hulls from various cultivars. JAOCS 72 (9):1065–7.
Yen G, Duh P, Tsai C. 1993. Relationship between antioxidant activity and maturity of peanut hulls. J Agric Food Chem 41:67–70.