EFFECT OF PRICKLY PEAR (*OPUNTIA FICUS-INDICA*) AND ALGARROBO (*PROSOPIS SPP.*) POD SYRUP COATINGS ON THE SENSORY AND CHEMICAL STABILITY IN ROASTED PEANUT PRODUCTS

MARTA G. MESTRALLET[1], VALERIA NEPOTE[2], PATRICIA R. QUIROGA[1] and NELSON R. GROSSO[1,3]

[1]*Quimica Biologica*
Facultad de Ciencias Agropecuarias (UNC)
IMBIV-CONICET
CC 509, 5016 Cordoba, Argentina

[2]*ICTA*
Facultad de Ciencias Exactas
Físicas y Naturales (UNC)
IMBIV-CONICET
Cordoba, Argentina

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ABSTRACT

The purpose of this work was to determine the oxidative stability of roasted peanuts coated with prickly pear and algarrobo pod syrups. General composition, total phenolic compounds and radical scavenging activity were determined on prickly pear and algarrobo pod syrups. Chemical (peroxide value) and descriptive analyses were performed on samples of roasted peanuts, roasted peanuts with prickly pear syrup and roasted peanuts with algarrobo pod syrup stored at 23C for 112 days to determine protective effect of the syrup coating on the product stability. Prickly pear syrup showed higher moisture, protein, ash, lipid, phenolic compound content and lower carbohydrate content than algarrobo pod syrup. Prickly pear syrup also showed higher antioxidant activity (diphenyl picryl hydrazyl inhibition). Peroxide value, oxidized and cardboard intensity flavors increased and roasted peanutty intensity attribute decreased across the storage time for all studied products. Therefore, the addition of syrup coating provided protection against lipid oxidation. Peroxide value reached 10 meqO$_2$/kg after 8.5 days in roasted peanuts, 20.7 days in roasted peanuts coated with prickly pear syrup and 29.5

[3] Corresponding author. TEL: +54-351-4334116; FAX: +54-351-4334116; EMAIL: nrgrosso@agro.uncor.edu

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days in roasted peanuts coated with algarrobo pod syrup at 23C. In consequence, algarrobo pod syrup had the highest protective effect in the roasted peanut product stored at room temperature.

PRACTICAL APPLICATIONS

The results of this work show advantages for using coatings that improve the stability of peanut products by making it more resistant to lipid oxidation and the development of rancid flavor. In this case, the edible coatings are elaborated using prickly pear and algarrobo pod syrups. These syrups could be applied on other similar food products with high lipid content to increase their shelf life and improve their stability, thus preventing loss of their sensory and nutritional quality.

INTRODUCTION

Argentinean peanuts contain approximately 50–55% oil, 25–28% protein, 19–21% carbohydrates and 2.3–2.5% ash. Due to this composition, peanuts are rich in energy. A large proportion of peanut production in the world is destined to domestic food such as peanut butter, salted peanut products, confections and roasted peanuts. The rest of the peanut production is utilized as edible oil source of high quality. Peanut-containing foods have high consumer acceptance because of their unique roasted peanut (RP) flavor. 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).

Peanut products are susceptible to develop rancid and off-flavors through lipid oxidation due to their fatty acid composition: 30–35% and 45–50% of the oil being linoleic and oleic acids, respectively (St. Angelo 1996). Lipid oxidation occurs during storage of peanut products and contributes to the development of undesirable flavors in foods wherein peanuts are an ingredient. The oxidation reactions lead indirectly to the formation of numerous aliphatic aldehydes, ketones and alcohols (Bett and Boylston 1992; Frankel 2005). Simultaneously, off-flavors like oxidized, cardboard and painty increase in such peanut products (Gills and Resurreccion 2000; Grosso and Resurreccion 2002; Nepote *et al.* 2004, 2006a,b).

Edible coatings in peanut products may prevent moisture loss and oxygen diffusion, coating can be also be used as a vehicle of additives such as antioxidants and flavoring agents that improve consumer acceptance (Grosso and Resurreccion 2002). In previous works, honey was used in the coating showing a positive effect regarding consumer acceptance and product stability (Mestrallet *et al.* 2004; Nepote *et al.* 2004).

The prickly pear, *Opuntia ficus-indica*, is originally from Mexico and the Caribbean. It is of importance in arid regions of Argentina because of its adaptability potential to different environmental conditions without cultivation care. Researchers have found antioxidant properties in extracts from prickly pears (Butera *et al.* 2002). Betalain pigments (betanin and indicaxanthin) contribute to the antioxidant activity due to its reducing properties.

The algarrobo tree, *Prosopis spp.*, is found in America, Africa and West Asia. The *Prosopis spp.* is considered an important human and animal food source in arid and semiarid regions in the world (Felker and Bandurski 1979). Antioxidant activity was found in leaves and pods of the Chilean *Prosopis* species (Astudillo *et al.* 2000). The activity was related with the total phenolic content consisting mainly in catechin components.

The objective of this work was to determine the oxidative stability of RPs coated with prickly pear and algarrobo pod syrups along the storage time.

MATERIALS AND METHODS

Materials

Sound and mature seeds of blanched peanuts (*Arachis hypogaea* L.) type Runner, size 38/42 kernels per oz (2004 crop) were provided by the company, Lorenzati, Ruetsch y Cia from Ticino, Cordoba province, Argentina. Before processing, peanuts were inspected; damaged and bruised kernels were manually removed.

Syrup Elaboration

Syrups (in Spanish, in this case called "Arropes") were elaborated from fruits of *Opuntia ficus-indica* (prickly pear) and *Prosopis spp*. (algarrobo) obtained from Quillino, Córdoba, Argentina. Selected and clean fruits weighing 500 g were added with 125 g sugar and 200 mL water and boiled for 1 h. These cooked fruits were cooled and ground. After that, this preparation was filtered and the solid residues were discarded. Finally, the liquid portion was boiled for another hour (Demaio *et al.* 2002). Three batches of prickly pear and "algarrobo" pod syrups were prepared. Each batch was considered a replication in the study.

Proximate Composition of Syrups

Syrup samples weighing 5 g were examined for moisture, lipid, protein, ash and carbohydrate contents (AOAC 1980). Moisture was determined by weight difference of the syrup samples. Lipids were extracted from dried samples for 12 h with petroleum ether (boiling range 30–60C) in a Soxhlet apparatus and the lipid percentage was determined by weight difference. The ash content was performed by incineration in a muffle furnace at 525C. The nitrogen content was estimated according to the Kjeldahl method and converted to protein percentage by using the general conversion factor 6.25 (AOAC 1980). Carbohydrate content was estimated by difference of the other components using the formula

$$\text{Carbohydrate content }(\%) = 100 - (\text{moisture} + \text{protein} + \text{oil} + \text{ash})$$

Total Phenolic Compounds of the Syrups

The phenolic compounds of the syrups were determined spectrophotometrically using the Folin-Ciocalteu method according to Waterman and Mole (1994). Phenolics were extracted from syrups with methanol. Solid content of the extracts was determined by weight difference after methanol evaporation. Diluted extracts, 0.1 mL (10 times with methanol), was transferred into a 10 mL volumetric flask. Then, deionized water, a Folin-Ciocalteu reagent (Anedra, San Fernando, Buenos Aires, Argentina) and Na_2CO_3 solution (20 g in 100 mL of water) were added. After 1 h, absorbance was measured with a spectrophotometer (Perkin Elmer Lambda 25 UV/Vis Espectrometer, Bucks, U.K.) at 760 nm. The concentration of total phenolic compounds in extracts was determined by comparison with the absorbance of gallic acid 1-hydrate (Panreac, Montplet & Esteban SA, Barcelona, Spain). All tests were run in triplicate and averaged. Total phenolic content was expressed in mg gallic acid per 100 g dry syrup.

Radical-Scavenging Activity of the Syrups

The radical-scavenging activity of the syrups was determined using diphenyl picryl hydrazyl (DPPH) radical (Aldrich, Milwakee, WI) according to Schmeda-Hirschmann *et al.* (1999). Methanolic extracts from syrups, 50 and 100 µL (as explained above), were added to a 1.5 mL methanolic solution of DPPH radical (20 µg/mL). The absorbance of the resulting solution was measured at 517 nm with a spectrophotometer (Perkin Elmer Lambda 25 UV/Vis Espectrometer, Bucks, U.K.). All tests were run in triplicate and averaged. The radical-scavenging activity was calculated using the formula

$$\%\ \text{DPPH inhibition} = [1 - (\text{A} - \text{B}/\text{C})] \times 100$$

where A is the absorbance of DPPH and sample; B is the absorbance of sample and C is the absorbance of DPPH.

Product Elaboration

RP. Blanched peanuts were roasted at 140C in an oven (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 *et al.* 1988).

RPs Coated with Prickly Pear Syrup. This product was prepared with 85% RP and 5% prickly pear syrup (RP-P). This product was dried-solid mix. A dried-solid mix was prepared with 70% powdered sucrose, 20% impalpable salt and 10% corn starch. RP was placed into the stainless steel coating pan rotating at 28 rpm. Then the syrup was applied on the RP. Finally, dried-solid mix was poured into the coating pan to separate the kernels.

RPs Coated with Algarrobo Pod Syrup. This product was prepared using the same procedure described for RPs coated with prickly pear syrup (RP-P): 85% RP, 5% algarrobo pod syrup (RP-A). This product was 10% dried-solid mix (w/w/w).

Storage Conditions and Sampling

After preparation of RP, RP-P and RPs and RP-A, samples were packaged in 27 × 28 cm plastic bags (Ziploc, Johnson & Son, Buenos Aires, Argentina). The samples were stored at 23C (room temperature). Samples of each product were removed from storage for evaluation by descriptive and chemical analyses. Samples were evaluated every 28 days during 112 days. Samples were also evaluated on day "zero."

Sensory Descriptive Analysis

Panel. A total of 12 trained panelists (nine female and three male) participated for descriptive analysis of peanut product (RP, RP-P and RP-A) samples obtained from a storage experiment. Panelists were selected according to the following criteria: natural dentition, no food allergies, nonsmokers, between the ages of 18–64, consume roasted peanuts and/or peanut products at least once a month, available for all sessions, 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. The group had previous experience in evaluating peanut samples in storage studies (Nepote *et al.* 2006a,b).

Training. All 12 panelists were trained and calibrated in four training sessions during 4 days. Each training session lasted 2 h. Descriptive analysis procedures as described by Meilgaard *et al.* (1991) and Grosso and Resurreccion (2002) were used during the training and evaluation sections. Panelists evaluated samples using a "hybrid" descriptive analysis method consisting of the Quantitative Descriptive Analysis (Tragon Corp., Redwood City, CA) and the Spectrum™ Analysis Methods (Sensory Spectrum, Inc., Chatham, NJ). A 150 mm unstructured line scale was used (Plemmons and Resurreccion 1998). The attributes' definitions were based on a peanut lexicon (Johnsen *et al.* 1988). A list of attribute definitions and a sheet with warm-up and reference intensity ratings for each attribute (Table 1) were developed during the training sections. The panel was considered calibrated by obtaining an average panel rating with a standard deviation within 10 points (Grosso and Resurreccion 2002).

Sample Evaluation. 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 three-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 randomized block design. The data were registered on paper ballots.

Chemical Analysis

Peroxide Value. Peroxide value (PV) was evaluated following the AOAC (1980) using 5 g of oil from each peanut sample. The PV was expressed as milliequivalents of active oxygen per kilogram of oil ($meqO_2/kg$). The oil was obtained by cold pressing 100 g kernels of the product using a 20-ton press (HE-DU, Hermes I. Dupraz SRL, Cordoba, Argentina).

Statistical Analysis

The study was carried out in three replications. The data were analyzed using the InfoStat software, version 1.1 (Facultad de Ciencias Agropecuarias, Universidad Nacional de Cordoba). Means and standard deviations were calculated. Analysis of variance and the Duncan test were used to detect significant differences ($\alpha = 0.05$) in sensory attribute rating and chemical analysis measurements. The 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 if the independent variable (time) had an effect on the sensory attributes and PV.

TABLE 1.
DEFINITIONS OF ATTRIBUTES, STANDARD REFERENCE AND WARM UP INTENSITY RATINGS USED IN THE DESCRIPTIVE ANALYSIS OF ROASTED PEANUTS AND ROASTED PEANUTS COATED WITH PRICKLY PEAR AND ALGARROBO POD SYRUPS

Attribute*	Definition	Reference	Reference intensity†	Warm up intensity†,‡
Appearance				
1. Brown color	The intensity or the strength of brown color from light to dark brown.	Cardboard (lightness value, $L = 47 \pm 1$).	46	38
2. Roughness	The appearance associated with uneven surface.	Corn flakes (Granix, Buenos Aires, Argentina).	93	36
Aromatics				
3. Roasted peanutty	The aromatic associated with medium roasted peanuts.	Dry roasted peanuts (JL SA, Ticino, Córdoba, Argentina).	69	57
4. Oxidized	The aromatic associated with rancid fats and oils.	Rancid peanuts.	82	6
5. Cardboard	The aromatic associated with wet cardboard.	Moist cardboard.	66	12
6. Raw/Beany	The aromatic associated with raw peanuts having green bean character.	Raw blanched peanuts, type Runner, size 40/50 (JL SA, Ticino, Córdoba, Argentina).	75	17
Tastes				
7. Sweetness	Taste on the tongue associated with sucrose solutions.	2.0% sucrose solution.	20	17
		5.0% sucrose solution.	50	
		10% sucrose solution.	100	
		15% sucrose solution.	150	
8. Salty	Taste on the tongue associated with sodium chloride solutions.	0.2% NaCl solution.	25	12
		0.35% NaCl solution.	50	
		0.5% NaCl solution.	85	
9. Sour	Taste on the tongue associated with acid agents such as citric acid solutions.	0.05% caffeine solution.	20	7
		0.08% caffeine solution.	50	
		0.15% caffeine solution.	100	
10. Bitter	Taste on the tongue associated with bitter solutions such as caffeine.	0.05% citric acid solution.	20	9
		0.08% citric acid solution.	50	
		0.15% citric acid solution.	100	
Texture				
11. Hardness	Force needed to compress a food between molar teeth.	Almonds (Grandiet, Cordoba, Argentina).	69	47
12. Crunchiness	Force needed and amount of sound generated from chewing a sample with molar teeth.	Corn flakes (Granix, Buenos Aires, Argentina).	110	62
13. Tooth pack	The amount of sample left in or on teeth after chewing.	Raw blanched peanuts, type Runner, size 40/50 (JL SA, Ticino, Córdoba, Argentina).	90	55

* Attributes listed in order as perceived by panelists.
† Intensity ratings are based on 150 mm unstructured line scales.
‡ Medium (lightness value, $L = 50 \pm 1$) roasted peanuts (blanched, size 40/50, type Runner).

RESULTS AND DISCUSSION

Proximate Composition, Phenolic Compounds and Radical Scavenging Activity of Syrups

Proximate composition, total phenolic content and % DPPH inhibition for prickly pear and algarrobo pod syrups are presented in Table 2. The results indicate that prickly pear syrup had higher moisture, proteins, ashes and lipids, and less carbohydrate content than algarrobo pod syrup.

Demaio *et al.* (2002) found proximate contents of 0.8% protein, 0.7% lipids, 0.19% pectin, 0.1% fiber, 6% carbohydrates and 90% water in prickly pear. Butera *et al.* (2002) reported antioxidant properties in extracts from prickly pear fruits. In both works, low amounts of polyphenols were found in the pulp, 237 ng/100 g, suggesting that betalain pigments (betanin and indicaxanthin) contribute to the antioxidant activity with contents of these pigments between 7.7–9.5 mg/100 g edible pulp.

TABLE 2.
PROXIMATE COMPOSITION, TOTAL PHENOLIC CONTENT AND DPPH INHIBITION PERCENTAGE ANALYZED IN PRICKLY PEAR AND ALGARROBO POD SYRUPS

	Syrups††	
	Prickly pear	Algarrobo pod
Proximate composition		
Moisture*	32.81 ± 0.81b	22.95 ± 0.14a
Nitrogen†	0.19 ± 0.02b	0.14 ± 0.01a
Proteins ($n \times 6.25$)†	1.21 ± 0.10b	0.86 ± 0.08a
Ashes†	3.43 ± 0.27b	2.96 ± 0.29a
Lipids†	0.32 ± 0.03b	0.10 ± 0.01a
Carbohydrates†	62.23 ± 0.14a	73.13 ± 0.25b
Total phenolic content‡	272.35 ± 2.93b	118.16 ± 1.63a
% DPPH Inhibition§	29.62 ± 3.10b	16.50 ± 1.51a
% DPPH Inhibition of phenolic compounds¶	97.78 ± 9.22b	85.27 ± 8.61a

* g/100 g syrup sample.
† g/100 g on dry base of the syrup.
‡ Expressed as mg gallic acid/100 g dry syrup.
§ Final concentration of dry extract from the syrup in methanol: 1 mg/mL.
¶ Final concentration of phenolics from the syrup in methanol: 10 μg/mL.
†† Mean followed by the same letter within each row are not significantly different at $\alpha = 0.05$.

Astudillo *et al.* (2000) studied proximate composition, phenolic content and % DPPH inhibition in pods and leaves of Chilean algarrobo (*Prosopis*) species. They found values between 7.3–12.4% moisture, 8.4–12.5% proteins, 0.7–1.3% lipids, 2.6–4.3% ashes, 19.4–31.4% fiber, 56.8–64.5% nitrogen-free extract and 1.0–7.9% phenolic compounds in Chilean algarrobo pods. They also found % DPPH inhibition between 25–29% for the extract at a final concentration of 100 μg/mL. They suggested that this antioxidant activity was related to polyphenols.

The results in this study suggest that the preparation process of prickly pear syrup increased the carbohydrate content and decreased the moisture in comparison with the fruit composition reported in the previous works mentioned. Phenolics also increased in this syrup as a consequence of the moisture decrease. The algarrobo pod syrup also showed higher carbohydrate content and lower moisture percentage. In this syrup, phenolics and % DPPH inhibition were lower than in prickly pear syrup.

Storage Stability of Peanut Products

Descriptive Analysis. The intensity ratings of sensory attributes from the descriptive analysis at day 0 of the peanut samples (RP, RP-P and RP-A) are presented in Table 3. The attributes that showed significant differences ($\alpha = 0.05$) among samples were brown color, roughness, raw/beany, sweet, salty, sour and bitter flavors. Roasted peanuts coated with syrups showed higher intensity ratings of brown color, roughness, sweetness and saltiness sensory attributes and lower intensity rating of the raw/beany flavor than roasted peanuts. RP-A had higher intensity ratings of brown color, roughness and bitterness attributes, and lower intensity ratings of sweetness and saltiness attributes than in RP-P.

The roasted peanutty attribute used to characterize peanut flavor in peanut products was about 49.5 (scale 0–150) in all peanut products analyzed in this study (RP, RP-P and RP-A). In previous works, roasted peanuts coated with honey had a roasted peanutty flavor intensity of 48 (Mestrallet *et al.* 2004; Nepote *et al.* 2004). Grosso and Resurreccion (2002) found that the roasted peanutty flavor intensity was 67 and 63 in roasted peanuts and cracker coated peanuts, respectively.

The changes in the intensities of the sensory attributes during storage at 23C in the RP, RP-P and RP-A samples are presented in Fig. 1. The sensory attributes that changed during the storage time were roasted peanutty flavor and those attributes related to the lipid oxidation like oxidized and cardboard sensory attributes. The other attributes did not show significant variations ($\alpha = 0.05$) during storage.

TABLE 3.
MEANS OF SENSORY ATTRIBUTE INTENSITIES FROM DESCRIPTIVE ANALYSIS IN FRESH PRODUCT (STORAGE TIME = 0): RP, RP-P AND RP-A

Sensory attributes	RP*	RP-P*	RP-A*
Appearance			
1. Brown color	16.33 ± 2.40a	24.5 ± 2.50b	29.95 ± 3.34c
2. Roughness	30.59 ± 4.46a	47.79 ± 4.89b	70.09 ± 10.08c
Aromatics			
3. Roasted peanutty	49.06 ± 6.92a	50.04 ± 6.85a	49.42 ± 5.40a
4. Oxidized	3.67 ± 0.44a	3.64 ± 0.57a	4.63 ± 0.62a
5. Cardboard	6.13 ± 0.69a	5.53 ± 0.70a	7.05 ± 1.03a
6. Raw peanutty	11.79 ± 1.57b	4.83 ± 0.61a	4.06 ± 0.66a
Tastes			
7. Sweetness	11.71 ± 1.95a	29.62 ± 3.31c	25.53 ± 3.46b
8. Salty	9.24 ± 1.28a	14.53 ± 1.77b	9.32 ± 1.26a
9. Sour	3.65 ± 0.56a	5.37 ± 0.80b	4.53 ± 0.64ab
10. Bitter	5.86 ± 0.91a	5.67 ± 0.84a	10.21 ± 1.04b
Texture			
11. Hardness	47.13 ± 4.54a	45.79 ± 5.49a	45.58 ± 5.70a
12. Crunchiness	55.74 ± 6.01a	53.92 ± 7.12a	54.56 ± 6.40a
13. Tooth pack	50.59 ± 8.19a	49.08 ± 7.71a	50.12 ± 7.23a

* Mean followed by the same letter within each row are not significantly different at $\alpha = 0.05$.
RP, roasted peanuts; RP-P, roasted peanuts coated with prickly pear syrup; RP-A, roasted peanuts coated with algarrobo pod syrup.

An increase of the cardboard and oxidize flavor intensity ratings was observed in the samples during the storage. On the contrary, the roasted peanutty flavor intensity decreased with storage time in the products. In other works, an increase of the intensity ratings of cardboard and oxidize flavors and a decrease of roasted peanutty flavor was also observed in different peanut products during storage (Bett and Boylston 1992; St. Angelo 1996; Grosso and Resurreccion 2002; Nepote *et al.* 2006a,b).

The intensities of oxidized flavor were from 3.0 (day 0) to 20.2 (day 112) in RP, from 3.1 (day 0) to 11.9 (day 112) in RP-P and from 3.8 (day 0) to 12.5 (day 112) in RP-A. The increase of the intensity rating in this attribute was lower in coated roasted peanuts (RP-P and RP-A) than in RP. The intensity rating of cardboard flavor was higher in RP than in RP-P and RP-A. Significant differences between RP and the other products in oxidized and cardboard flavor intensities were observed after day 28.

In the present work, the intensity ratings of roasted peanutty flavor in the all samples decreased during the storage time as was observed in other works of stored roasted peanuts (Warner *et al.* 1996; Brannan *et al.* 1999; Grosso and Resurreccion 2002). The roasted peanutty flavor can be attributed to the presence of pyrazines (Buckholz and Daun 1981; Crippen *et al.* 1992). Bett

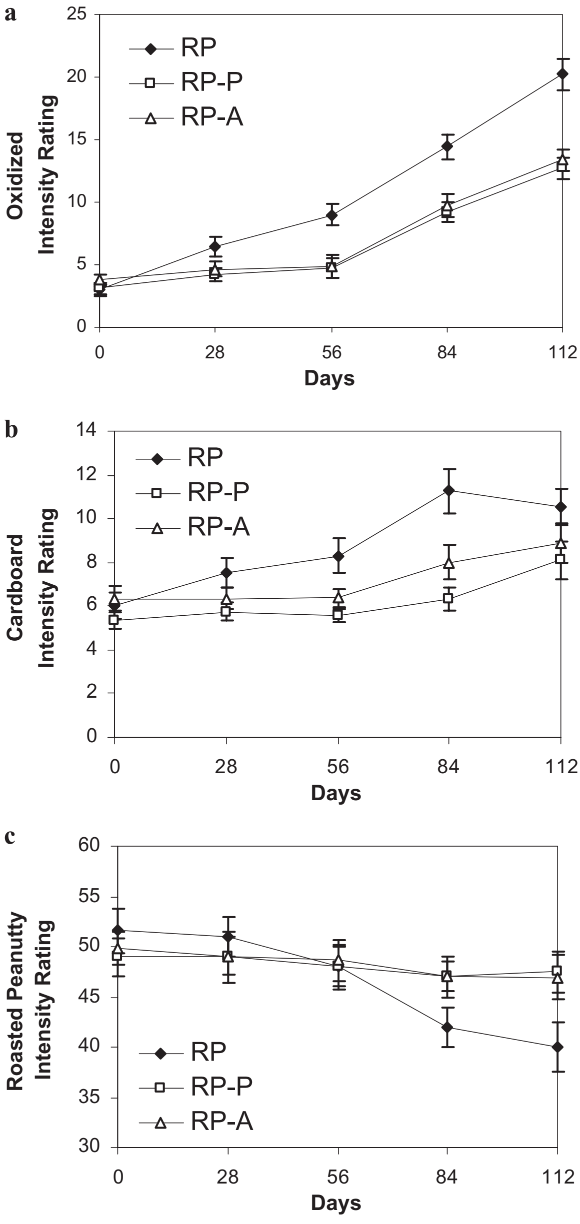

FIG. 1. INTENSITY RATINGS OF SENSORY ATTRIBUTES
(a) Oxidized, (b) cardboard and (c) roasted peanutty in roasted peanuts (RP), roasted peanuts coated with prickly pear syrup (RP-P) and roasted peanuts coated with algarrobo pod syrup (RP-A) during storage at 23C.

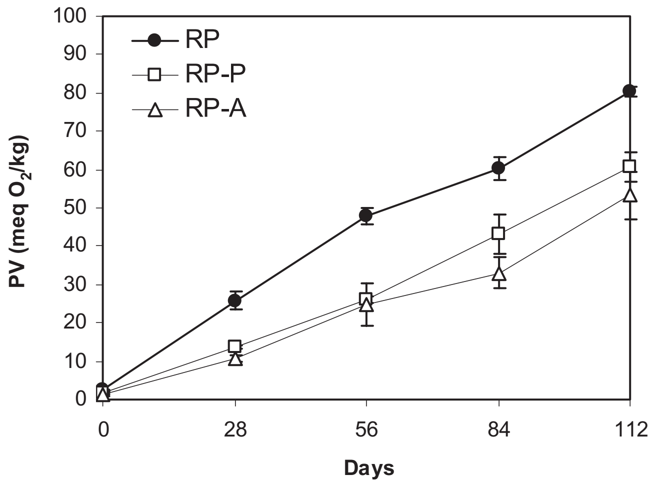

FIG. 2. PEROXIDE VALUES (PV) IN ROASTED PEANUTS (RP), ROASTED PEANUTS COATED WITH PRICKLY PEAR SYRUP (RP-P) AND ROASTED PEANUTS COATED WITH ALGARROBO POD SYRUP (RP-A) DURING STORAGE AT 23C

and Boylston (1992) found that roasted peanutty flavor intensity and alkylpyrazines decreased in stored roasted peanuts. In this work, the intensities of this attribute changed from 51.6 (day 0) to 39.2 (day 126) in RP, from 49.0 to 47.5 in RP-P and from 49.8 to 46.9 in RP-A in samples stored. RP showed higher decreasing tendency, and after day 56, RP had lower intensities of roasted peanutty attribute (significant differences, $\alpha = 0.05$) than in the other coated peanut products.

Chemical Analysis. The changes in PV during storage of the RP, RP-P and RP-A samples are shown in Fig. 2. PV increased during storage in all peanut products. RP had higher PV and showed significant differences ($\alpha = 0.05$) after day 28 with respect to the samples coated with syrup (RP-P and RP-A). RP-P and RP-A did not have significant difference in PV between them. The PVs (meq O_2/kg) were from 2.39 (day 0) to 80.28 (day 112) in RP, from 1.79 (day 0) to 60.71 (day 112) in RP-P and from 1.40 (day 0) to 53.21 (day 112) in RP-A.

Correlation and Regression Analysis. The variables of interest in this study were PV, oxidized, cardboard and roasted peanutty flavors because they changed with storage time. Correlation coefficients are presented in Table 4. Positive correlations higher than 0.77 were observed among the following variables: PV, oxidized and cardboard sensory attributes. All these variables

TABLE 4.
CORRELATION COEFFICIENTS FROM THE VARIABLES: PV AND SENSORY ATTRIBUTES IN RP, RP-P AND RP-A

Related variables	Pearson's correlation coefficients		
	RP	RP-P	RP-A
PV and oxidized	0.91	0.77	0.95
PV and cardboard	0.90	0.79	0.91
PV and roasted peanutty	–0.84	–0.79	–0.86
Oxidized and cardboard	0.99	0.99	0.98
Oxidized and roasted peanutty	–0.94	–0.97	–0.94
Cardboard and roasted peanutty	–0.94	–0.97	–0.97

PV, peroxide value; RP, roasted peanuts; RP-P, roasted peanuts coated with prickly pear syrup; RP-A, roasted peanuts coated with algarrobo pod syrup.

increased during storage time in the three roasted peanut products (RP, RP-P and RP-A). Negative correlations were observed between roasted peanutty flavor and the other mentioned variables (PV, oxidized and cardboard flavors) in the three studied peanut products. These negative correlations indicated that the roasted peanutty flavor decreased when the PVs and the oxidized and cardboard flavor intensity ratings increased during storage.

Prediction equations at 23C for the PV and the sensory attributes from each peanut product (RP, RP-P and RP-A) are presented in Table 5. In general, the dependent variables PV and oxidized, cardboard and roasted peanutty flavors showed $R^2 > 0.70$ in RP, RP-P and RP-A, indicating these variables are good predictors. Therefore, the regression equation from PVs could be used to predict the effect of storage time at this temperature (23C) on these peanut products. The oxidized flavor that is related to off-flavors was first detected by the sensory panel at day 28 in RP and day 84 in RP-A and RP-P, when PVs were 27, 30 and 39 meqO_2/kg, respectively (Figs. 1 and 2). These results indicate that the sensory panel could detect oxidized flavor when the PV was higher than 25 meqO_2/kg in these peanut products.

Bett and Boylston (1992) detected that cardboard flavor intensity had a linear increase across the storage time in RPs while roasted peanutty flavor intensity decreased as storage time increased. Muego-Gnanasekharan and Resurrección (1992) detected that oxidized and cardboard flavor intensities exhibited a linear increase during storage time in peanut paste. Warner *et al.* (1996) observed that oxidized intensity ratings increased and roasted peanutty flavor intensity ratings decreased during storage in ground roasted peanuts but a regression equation was not presented in their work. Grosso and Resurreccion (2002) found that when the oxidized flavor rating of 36.2 is obtained for

TABLE 5.
REGRESSION COEFFICIENTS AND ADJUSTED R^2 FROM THE VARIABLES: PV AND SENSORY ATTRIBUTES IN RP, RP-P AND RP-A

Sample	Dependent variable	Regression coefficients*			
		β_0	β_1	β_{11}	R^2
RP	PV	2.93	0.8478	–0.0015	0.9904
	Oxidized	3.30	0.0517	0.0009	0.9855
	Cardboard	5.93	0.0637	–0.0002	0.9557
	Roasted peanutty	52.07	–0.0472	–0.0007	0.9312
RP-P	PV	1.88	0.3617	0.0015	0.9996
	Oxidized	3.16	0.0051	0.0007	0.9579
	Cardboard	5.55	–0.0163	0.0003	0.8935
	Roasted peanutty	49.25	–0.0266	0.0001	0.8028
RP-A	PV	2.88	0.1768	0.0022	0.9298
	Oxidized	3.81	–0.0067	0.0008	0.9314
	Cardboard	6.29	–0.0087	0.0003	0.8975
	Roasted peanutty	49.82	–0.0218	–0.0001	0.9622

* Regression coefficients for the general regression equation: $Y = \beta_0 + \beta_1 X + \beta_{11} X^2$. Where Y = dependent variable (PV and sensory attributes) and X = independent variable (storage days).
PV, peroxide value; RP, roasted peanuts; RP-P, roasted peanuts coated with prickly pear syrup; RP-A, roasted peanuts coated with algarrobo pod syrup.

roasted peanuts, the overall acceptance rating is predicted to be 5 on the 9-point hedonic scale. This value means "neither like nor dislike" and it is considered the end point of consumer acceptance of the product. In this work, according to the oxidized attribute prediction at 23C (Table 5), an intensity rating of 36.2 required 165 days in RP, 219 days in RP-P and 209 days in RP-A. These results indicate that roasted peanuts with syrup coating required more time to reach the end point of consumer acceptance owing to the development of rancid flavors. The syrup coating could be providing protection against lipid oxidation to peanut products and also covering the oxidized flavors.

The Argentinean Food Code allows for up to 10 meq O_2/kg PV in peanut oil (CAA 1996). There is no legislation for other peanut products in Argentina. For that reason, 10 meq O_2/kg is considered an adequate limit for shelf life in peanut products. Using the prediction equation, PVs higher than 10 meq O_2/kg were reached after 8.5 days in RP, 20.7 days in RP-P and 29.5 days in RP-A. The roasted peanuts coated with prickly pear syrup and the roasted peanuts coated with algarrobo pod syrup had about twice longer shelf life than roasted peanuts. Shen *et al.* (2001) reported a direct relationship between PV and oxidized flavor measured as off-flavor in vegetable oils. Oxidized intensity ratings and PVs are good predictors to determine shelf life in these peanut products. The large discrepancy in the shelf life between PVs and oxidized intensity ratings was due to the criteria used to decide the cut-off point. In the case of the oxidized flavor, the cut-off point for shelf life in peanut products was fixed at 36.2 intensity, rating in a 0–150 mm unstructured scale when its overall acceptance was 5 (neither like nor dislike) on a 9-point hedonic scale (Grosso and Resurreccion 2002). The acceptability in a peanut product decreases when consumers detect off-flavors in it. The secondary oxidation compounds are responsible for the off-flavors. These compounds appear when the oxidation process is advanced (Frankel 2005). For this reason, the cut-off point of the shelf life in peanut products was longer using the oxidized flavor variable in the prediction equations. In the case of PV, the cut-off point was fixed at 10 meq O_2/kg according to the limit allowed by the Argentinean Food Code (CAA 1996) for peanut oil. Peroxides are primary oxidation compounds that appear in the first stage of lipid oxidation (Frankel 2005). For this reason, the cut-off point of the shelf life in peanut products was very short when using the PV variable in the prediction equations. In both cases, the results indicate that the syrup coatings provide protection against lipid oxidation to peanut products. Similar results were observed using another edible coating in honey-roasted peanuts increasing the shelf life of this peanut product (Nepote *et al.* 2006b). The protective effect could be related to these edible coatings (prickly pear and algarrobo pod syrups) because they could be acting as a barrier, thus decreasing oxygen diffusion to the peanut lipids or as a vehicle of natural antioxidants. Phenolics and antioxidant activity such as DPPH inhibition were low in both syrups. However, their protective effect was very significant. According to the results of this work, algarrobo pod syrup showed better protection against peanut lipid oxidation than prickly pear syrup.

CONCLUSION

The results of this work indicate that the use of the coatings of prickly pear and algarrobo pod syrups in roasted peanuts improves the stability of the product by making it more resistant to lipid oxidation and the development of rancid flavors. These syrups could be used in other similar food products with high lipid content to increase their shelf life and improve their stability, thus preventing loss of their sensory and nutritional quality. Besides, this study provides the equation to estimate shelf life of roasted peanuts coated with prickly pear and algarrobo pod syrups from descriptive sensory attribute intensity ratings and PVs.

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