Original article

# Oxidative stability in fried-salted peanuts elaborated with high-oleic and regular peanuts from Argentina

**Valeria Nepote, Marta G. Mestrallet & Nelson R. Grosso***

Quimica Biologica, Facultad de Ciencias Agropecuarias (UNC), IMBIV-CONICET, CC 509, 5000 Cordoba, Argentina

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**Summary** The purpose of this work was to determine the chemical and sensory stability of fried-salted peanuts prepared with a high-oleic cultivar, Granoleico (GO-FP) in comparison with a regular cultivar, Tegua (T-FP) of peanut from Argentina. General and fatty acids composition were determined in high-oleic peanuts, cultivar 'Granoleico' (GO) and regular peanuts, cultivar 'Tegua' (T). Consumer test of fresh products, oxidative stability chemical indicators (peroxide and *p*-anisidine values, and conjugated dienes) and descriptive analyses during storage were performed on fried-salted peanuts prepared with GO and T. GO showed a higher Oleic/Linoleic (O/L) ratio (17.1 in raw GO and 10.1 in GO-FP) than T (1.4 in raw T and 1.3 in T-FP). GO-FP did not differ in consumer acceptance in comparison with T-FP. Chemical indicators in GO-FP had a lower increase than T-FP across the storage time. Peroxide value reached 20 meq$O_2$ kg$^{-1}$ after 125 days in GO-FP and after 19 days in T-FP. Sensory attributes did not show significant differences between GO-FP and T-FP along the storage. Fried-salted peanuts prepared with kernels of high-oleic peanuts had better oxidative stability.

**Keywords** fried-salted peanut, high-oleic, oxidative stability, sensory analysis.

## Introduction

Peanuts contain high percentages of oil (50–55%) and protein (25–28%) and low percentages of carbohydrates and ash (Grosso & 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 enjoy widespread popularity because of their unique roasted peanut flavour. The rest of the peanut production is utilised as edible oil source of high quality. Peanuts are continually applied for preparation of new and improved food products; thus, a more complete knowledge of their composition and flavour properties is desirable (Ahmed & Young, 1982).

In general, peanuts contain approximately 50–55% oil with 30–35% and 45–50% of the oil being linoleic and oleic acids, respectively, which become susceptible to development of rancid and off-flavours through lipid oxidation (St. Angelo, 1996). Researchers have described peanut lines from USA with 80% oleic acid and 2–3% linoleic acid, which had improved oil oxidative stability (Braddock *et al*., 1995; Mugendi *et al*., 1998; Pattee *et al*., 2002).

Lipid oxidation occurs during the storage of peanut products and contributes to the development of undesirable flavours. The oxidation reactions lead indirectly to the formation of numerous aliphatic aldehydes, ketones and alcohols (Bett & Boylston, 1992). Simultaneously, off-flavours like oxidised, cardboard and painty increase in such peanut products (Gills & Resurreccion, 2000; Grosso & Resurreccion, 2002).

Many factors influence the shelf-life of peanuts products. These include variety, maturity at harvest, market grade and seed size, processing methods and storage conditions (temperature, time, light and exposure to oxygen). The use of high-oleic peanuts rather than normal peanuts would increase shelf-life and improve the oxidative stability of peanut products, thus preventing loss of sensory and nutritional quality.

The objective of this work was to determine the consumer acceptance, and the chemical and sensory stability of fried-salted peanuts prepared with a high-oleic acid cultivar in comparison with a regular cultivar of peanut from Argentina.

*Correspondent: Fax: +54 351 4334116/7;
e-mail: nrgrosso@agro.uncor.edu

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## Materials and methods

### Materials

Sound and mature seeds of peanuts (*Arachis hypogaea* L.) type Runner 'Granoleico' (GO) and 'Tegua' (T), size 38/42 kernels per oz (2003 crop), were provided by the company Semillero del Carmen, General Cabrera, Cordoba, Argentina. Before processing, peanuts were inspected; damaged and bruised kernels were manually removed.

### Product elaboration

Fried-salted peanuts prepared with Granoleico cultivar (GO-FP) and Tegua cultivar (T-FP). Peanuts were fried at 170 °C in sunflower oil during 4 min. Peanuts were heated to a medium roast or an average Hunter Colour Lightness (L) value of 50 ± 1.0 (Johnsen *et al.*, 1988). Fried peanuts were salted with fine granules of analytical grade sodium chloride (Laboratorios Cicarelli, San Lorenzo, Santa Fe, Argentina)

In the final products, the moisture content was 2.0% according to previous unpublished results evaluated following AOAC methods (AOAC, 1980).

### Determination of oil, ash, protein and carbohydrate contents

Three samples (5 g) from each peanut cultivar were examined for oil, protein and ash. The seeds were selected at random. Seeds were milled and oil was extracted for 16 h with petroleum ether (boiling range 30–60 °C) in a Soxhlet apparatus. The extracted oils were dried over anhydrous sodium sulphate, and the solvent was removed under the reduced pressure in a rotary film evaporator. Oil percentage was determined by weight difference. Ash and nitrogen contents were determined according to the AOAC (1980) method. Ash was performed by incineration in a muffle furnace at 525 °C. The nitrogen content was estimated according to the Kjeldahl method and converted to protein percentage by using the conversion factor 5.46 (AOAC, 1980). Carbohydrate content was estimated by difference of the other components using the following formula: carbohydrate content = 100% – (% protein + % oil + % ash).

### Fatty acid composition

Fatty acid methyl esters were prepared on oils from raw peanuts (GO and T), sunflower (used to fry peanuts) and fried-salted peanuts (GO-FP and T-FP) by transmethylation with a solution of 3% of sulphuric acid in methanol, as previously described (Jellum & Worthington, 1966; Grosso *et al.*, 2000). The fatty acid methyl esters of total lipids were analyzed on a Hewlett Packard HP-6890 gas–liquid chromatograph (Palo Alto, CA, USA) equipped with a flame ionisation detector (FID HP-3398). An HP-INNO-Wax capillary column (30 m × 0.32 mm × 0.5 nm, with polar polyethylene glycol, USA) was used. Column temperature was programmed from 200 (held for 1 min) to 230 °C (20 °C $min^{-1}$). Injector temperature was 260 °C. The carrier (nitrogen) had a flow rate 3.8 mL $min^{-1}$. The separated fatty acid methyl esters were identified by comparing their retention times with those of authentic samples, which were purchased from Sigma Chemical Co. (St Louis, MO, USA) Quantitative fatty acids analysis was performed using heptadecanoic acid methyl ester (Sigma Chemical Co.) as an internal standard (Hashim *et al.*, 1993).

### Storage conditions and samplings

After preparation of GO-FP and T-FP, samples were packaged in 27 × 28 cm plastic bags (Ziploc; Johnson & Son, Buenos Aires, Argentina). The samples were stored at 23 °C (room temperature) and 60 ± 10% relative humidity. Samples of each product were removed from storage for evaluation: chemical and descriptive analyses. Sampling days were: 0, 28, 56, 84, 112 and 142 days.

### Chemical analysis

*Peroxide value (PV)*

It was evaluated following the AOAC method 28.022 (AOAC, 1980) using 5 g of oil of each sample. It consisted in 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 miliequivalents of active oxygen per kilogram of oil (meq$O_2$ $kg^{-1}$) and calculated with the formula: PV (meq$O_2$ $kg^{-1}$) = (volume in mL of $Na_2S_2O_3$) × (0.1 N) × (1000)/(g oil). The oil was obtained for two 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 sulphate and the solvent removed under the reduced pressure in a rotary film evaporator.

*p-Anisidine value (AV)*

This method is commonly used as a measurement for lipid oxidation products. The procedure was described by IUPAC (1987a)). A quantity of 0.5–4.0 ± 0.001 g of peanut oil sample was dissolved with 25 mL of n-hexane in a volumetric flask. The absorbance (Ab) of the solution was measured at 350 nm in a spectrophotometer (u.v.-v. Diode Array Spectrophotometer Hewlett Packard HP 8452 A; Hewlett Packard, Palo Alto, CA, USA), using an n-hexane as blank. In a test tube, 5 mL of the fat solution was mixed with 1 mL of *p*-anisidine reagent (0.25 g *p*-anisidine hydrochloride; BDH Laboratory Reagents, Poole, England, each 100 mL solution in glacial acetic acid). An Ab of this solution (As) was measured at 350 nm after exactly 10 min, using a mixture of 5 mL of n-hexane and 1 mL *p*-anisidine reagent as blank. The *p*-AV was given by the formula: $AV = 25 \times (1.2As\text{-}Ab)/m$, where 'As' is Ab of the fat solution after reaction with the *p*-anisidine reagent, 'Ab' the absorbance of the fat solution and '*m*' the mass of the peanut oil in grams.

*Conjugated dienes (CD)*

Weighed oil samples were dissolved in 6 mL of n-hexane, the conjugated diene Ab was measured at 232 nm in a spectrophotometer (u.v.-v. Diode Array Spectrophotometer Hewlett Packard HP 8452 A), using an n-hexane as blank. The results were reported as the sample extinction coefficient E (1%, 1 cm) (IUPAC, 1987b; COI, 2001).

## Sensory methods

*Consumer analysis*

Panelists ($n = 100$) were from Cordoba City (Cordoba, Argentina) and were recruited using the following criteria: ages between eighteen and sixty-five, non-smokers, non-food allergies and eat-roasted peanuts, and/or peanut products at least twice per week. For sample evaluation, 5 g of the peanut samples were placed into plastic cups with lids, coded with three-digit random numbers. Samples consisting of GO-FP and T-FP (three replications of each one) were prepared for each panelist. Samples were presented to panelist at 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 minimise any residual effect. A nine-point hedonic scale ranging from 1 = dislike extremely to 9 = like extremely was used to evaluate overall acceptance from the samples (Peryam & Pilgrim, 1957).

*Descriptive analysis*

*Panel*

A total of twelve trained panelists (nine female and two male) participated for descriptive analysis of fried-salted peanuts storage study. All panelists had 4 years of experience evaluating peanut products and were selected on the following criteria: natural dentition, no food allergies, non-smokers, between the ages eighteen and sixty-four, consume fried-salted 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 & Resurreccion, 1998). All panelists had to have a perfect score in a taste sensitivity test and the ability to identify five of seven commonly found food flavours before they qualified as panelists.

*Training*

All twelve panelists were trained and calibrated in four training sessions during 4 days. Each training session lasted 2 h for a total of 8 h. Descriptive analysis test procedures as described by Meilgaard *et al.* (1991) and Grosso & 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, CA, USA) and the Spectrum™ Analysis Methods (Sensory Spectrum, Inc., Chatham, NJ, USA).

On the first 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 & Resurreccion, 1998). After that, all twelve panelists worked together to develop the language to describe perceivable product attributes in fried-salted peanut. Fresh and rancid samples of fried-salted peanut 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 *et al.*, 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, flavour and textural attribute. Each panelist gave an intensity rating of each reference between zero 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 second day of training, panelists reviewed descriptors, definitions and reference standards to describe fried-salted peanut samples. Panelists tasted each reference and provided a rating. The panel was calibrated by obtaining an average panel rating with an SD within ten points. Panelists not rating within $\pm 10$ 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 & Resurreccion, 1998).

On the third day of training, panelists finalised the definitions, descriptors and reference standard intensities to describe the fried-salted peanuts. Then, the list of definitions (Table 1) and warm-up and reference intensity ratings (Table 2) were finalised. After that, panelists

 

**Table 1** Definitions of attributes used by the trained panel to describe fried-salted peanuts

| Attribute* | Definition |
|---|---|
| *Appearance* | |
| 1. Brown colour | The intensity or the strength of brown colour from light to dark brown |
| *Aromatics* | |
| 2. Roasted peanutty | The aromatic associated with medium-roasted peanuts |
| 3. Oxidised | The aromatic associated with rancid fats and oils |
| 4. Cardboard | The aromatic associated with wet cardboard |
| 5. Raw/beany | The aromatic associated with uncooked or raw peanuts |
| *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 |
| 12. Toothpack | The amount of sample left in or on teeth and molar teeth |

*Attributes listed in order as perceived by panelists.

evaluated four fried-salted peanut samples with different degrees of oxidised flavours using the paper ballots in order to calibrate themselves.

On the last day of training, panelists continued evaluating fried-salted peanut samples with different degrees of oxidised flavours to practise and to calibrate themselves within ±10 points of the mean ratings for each attribute of the samples.

*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 twelve 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 randomised block design. The data were registered on the paper ballots.

### Statistical analysis

The data were analyzed using the INFOSTAT software, version 1.1 (Facultad de Ciencias Agropecuarias, Universidad Nacional de Cordoba). Means and SD were calculated. ANOVA was used to detect the significant differences between sampling days in sensory attributes and chemical analysis using Duncan's tests to find significant differences ($\alpha = 0.05$) between means. Pearson's 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 variables (time) had an effect on the sensory attributes, PV, *p*-AV and CD.

## Results and discussion

### Oil, ash, protein, carbohydrate contents and fatty acids composition

Granoleico had 49.0, 28.9, 19.6 and 2.4 percentages (on dry basis) of oil, proteins, carbohydrates and ashes, respectively. The percentages of the same constituents in (T) were of 49.1, 31.6, 17.0 and 2.3, respectively. Both cultivars had similar chemical composition but GO showed a little less content ($\alpha = 0.05$) of proteins and higher content of carbohydrates than T.

The fatty acids percentages of GO and T raw peanuts, refined sunflower oil used to prepare the fried products and fried-salted peanuts (T-FP and GO-FP) are shown in the Table 3. As it was expected in the fatty acid composition, GO had a significantly higher relation Oleic/Linoleic (O/L = 17.1) than T (O/L = 1.4). Other authors (O'Keefe *et al.*, 1993; Andersen *et al.*, 1998) found O/L ratios between sixteen and twenty-eight and one and three for high-oleic and normal peanut lines, respectively. GO exhibited a lower relation saturated/unsaturated fatty acids (0.16) than T (0.22) because of GO showed almost the half of palmitic acid (16:0) than T. The other fatty acids did not differ significantly between the peanut cultivars (ANOVA and Duncan's test, $\alpha = 0.05$). Sunflower oil presented the lowest O/L ratio (0.4). Salted-fried peanuts showed O/L ratios of 10.1 and 1.3 for GO-FP and T-FP, respectively. The elaboration process with sunflower oil implied a decreasing in O/L ratios of the fried-salted peanuts with respect to raw peanuts due absorption produced during the fried process. Bolton & Sanders (2002) found O/L ratios of 27.9 in high-oleic peanuts fried in high-oleic peanut oil and of 13.6 in high-oleic peanuts fried in conventional peanut oil.

### Consumer analysis

Significant differences ($\alpha = 0.05$) from the consumer acceptance among the products (GO-FP and T-FP) were not found. In general, the products had consumer acceptances of about '7 = like moderately' in an hedonic scale of nine points. The overall acceptance means in GO-FP and T-FP were 6.66 ± 1.43 and

**Table 2** Standard reference and warm-up intensity ratings used in descriptive tests for fried-salted peanuts

| Attribute | Reference | Reference intensity* | Warm-up intensity*† |
|---|---|---|---|
| *Appearance* | | | |
| 1. Brown colour | Cardboard | 40 | 27 |
| *Aromatics* | | | |
| 2. Roasted peanutty | Dry-roasted peanuts (JL SA, Ticino, Córdoba, Argentina) | 69 | 69 |
| 3. Oxidised | Rancid peanuts | 53 | 8 |
| 4. Cardboard | Moist cardboard | 52 | 11 |
| 5. Raw/beany | Raw peanuts | 69 | 13 |
| *Tastes* | | | |
| 6. Sweet | 2.0% sucrose solution | 20 | 25 |
| | 5.0% sucrose solution | 50 | |
| | 10% sucrose solution | 100 | |
| | 15% sucrose solution | 150 | |
| 7. Salty | 0.2% NaCl solution | 25 | 19 |
| | 0.35% NaCl solution | 50 | |
| | 0.5% NaCl solution | 85 | |
| 8. Sour | 0.05% citric acid solution | 20 | 9 |
| | 0.08% citric acid solution | 50 | |
| | 0.15% citric acid solution | 100 | |
| 9. Bitter | 0.05% caffeine solution | 20 | 7 |
| | 0.08% caffeine solution | 50 | |
| | 0.15% caffeine solution | 100 | |
| *Texture* | | | |
| 10. Hardness | Almonds (Grandiet, Cordoba, Argentina) | 56 | 41 |
| 11. Crunchiness | Corn flakes (Granix, Buenos Aires, Argentina) | 102 | 60 |
| 12. Toothpack | Raw peanuts | 66 | 43 |

*Intensity ratings are based on 150-mm unstructured line scales.
†Medium (lightness value, $L = 50 \pm 1.0$)-roasted peanuts (Blanched Runner, Ticino, Cordoba, Argentina).

**Table 3** Fatty acid percentages (g/100 g fatty acids) of raw peanuts of Tegua (T) and Granoleico (GO), refined Sunflower oil, Tegua fried-salted peanuts (T-FP) and Granoleico fried-salted peanuts (GO-FP)

| Fatty acids | T | GO | Sunflower oil | T-MF | GO-MF |
|---|---|---|---|---|---|
| Palmitic acid (C16:0)* | 8.9 ± 0.9b | 4.9 ± 0.4a | 5.9 ± 0.5a | 8.8 ± 0.9b | 5.0 ± 0.6a |
| Stearic acid (C18:0)* | 2.5 ± 0.3a | 2.5 ± 0.2a | 3.9 ± 0.4b | 2.6 ± 0.2a | 2.6 ± 0.1a |
| Oleic acid (C18:1)* | 45.8 ± 4.7b | 78.5 ± 7.2c | 25.4 ± 2.6a | 44.8 ± 5.0b | 75.8 ± 8.1c |
| Linoleic acid (C18:2)* | 33.3 ± 3.5b | 4.6 ± 0.4a | 62.5 ± 6.1c | 34.8 ± 3.7b | 7.5 ± 0.7a |
| Arachidic acid (C20:0)* | 1.3 ± 0.1b | 1.3 ± 0.2b | 0.4 ± 0.0a | 1.3 ± 0.1b | 1.3 ± 0.1b |
| Eicosenoic acid (C20:1)* | 1.7 ± 0.2b | 2.5 ± 0.2c | 0.4 ± 0.0a | 1.6 ± 0.1b | 2.4 ± 0.2c |
| Behenic acid (C22:0)* | 3.0 ± 0.3b | 2.7 ± 0.3b | 0.9 ± 0.1a | 2.9 ± 0.2b | 2.6 ± 0.2b |
| Lignoceric acid (C24:0)* | 2.0 ± 0.3b | 2.0 ± 0.1b | 0.0 ± 0.0a | 1.9 ± 0.2b | 1.9 ± 0.1b |
| Relation oleic/linoleic | 1.4 | 17.1 | 0.4 | 1.3 | 10.1 |
| Relation saturated/unsaturated | 0.22 | 0.16 | 0.13 | 0.21 | 0.15 |

*Means followed by the same letter within each row are not significantly different at $\alpha = 0.05$.

6.77 ± 1.38, respectively. The differences in the fatty acid composition between GO and T did not have an effect on the acceptability of the products. Other authors (Grosso & Resurreccion, 2002; Nepote *et al.*, 2004) found overall acceptance on roasted and cracker-coated peanut products between 6.0 and 6.4 indicating that fried-salted peanuts had higher overall acceptance than the roasted peanut.

## Chemical and sensory results from stored fried-salted peanuts

### *Chemical analysis*

The changes in the chemical indicators: peroxide and *p*-AVs and CD during storage of the GO-FP and T-FP samples are shown in Fig. 1. The chemical indicators increased with storage time in both products. Along the

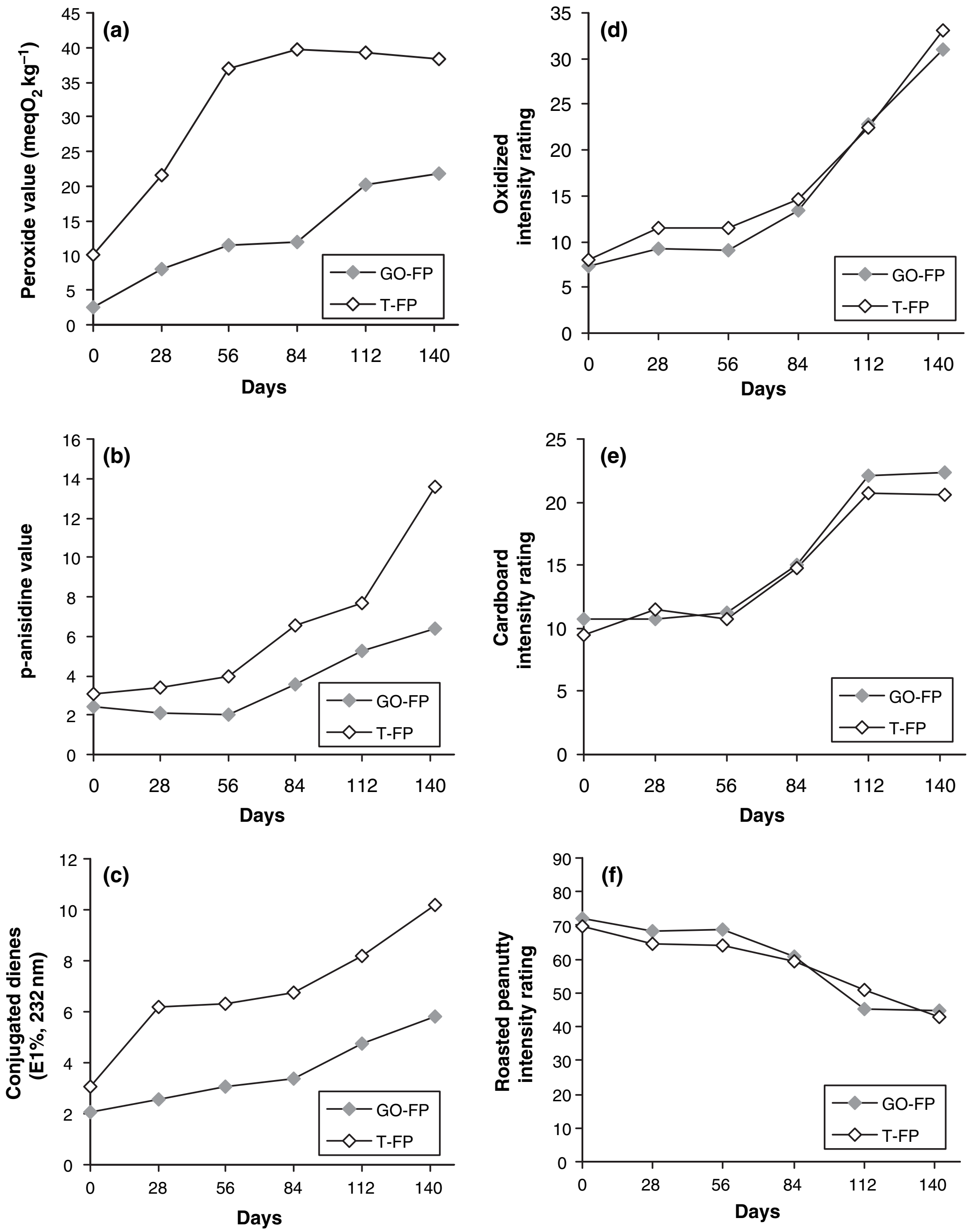


**Figure 1** Results from the chemical analyses: (a) peroxide value (PV), (b) *p*-anisidine value (AV) and (c) conjugated dienes (CD) and intensity rating of sensory attributes: (d) oxidised, (e) cardboard and (f) roasted peanutty in Granoleico (GO-FP) and Tegua (T-FP) fried-salted peanuts during storage at 23 °C.

storage, T-FP had higher peroxide and *p*-AVs, and CD with significant differences ($\alpha = 0.05$) with respect to GO-FP. Peroxide values ($meqO_2\ kg^{-1}$) of GO-FP samples were from 2.4 at days 0–21.8 (maximum PV) at day 142. T-FP sample showed PV from 10.2 at days 0–38.3 at day 142 with a maximum PV of 39.8 at day 84.

*p*-Anisidine values were from 2.4 (day 0) to 6.4 (day 142) in GO-FP and from 3.1 (day 0) to 13.6 (day 142) in T-FP.

Conjugated dienes increased during storage from 2.1 (day 0) to 5.8 (day 142) in GO-FP and from 3.0 (day 0) to 10.2 (day 142) in T-FP.

Other authors found that water activity affects the oxidation process during the storage of peanut products (Baker *et al.*, 2002; Reed *et al.*, 2002). In this work, the water activity during the storage was constant therefore the difference observed in the analyzed oxidation indicators between GO-FP and T-FP was mainly because of the fatty acid composition of the products.

*Descriptive analysis*

Many authors have made descriptive analyses in peanut products such as roasted peanut, peanut-paste, peanut spread (Johnsen *et al.*, 1988; Braddock *et al.*, 1995; Mugendi *et al.*, 1998; Gills & Resurreccion, 2000; Grosso & Resurreccion, 2002; Pattee *et al.*, 2002; Reed *et al.*, 2002; Yeh *et al.*, 2002). However, no descriptive analyses were developed in fried-salted peanut until this moment.

The following attributes, brown colour, roasted peanutty, oxidised, cardboard, raw/beany, sweet, salt, sour, bitter, hardness, crunchiness and toothpack were described by the panel in GO-FP and T-FP. These results are presented in Table 4.

The sensory attributes from the descriptive analysis showed no significant differences ($\alpha = 0.05$) between GO-FP and T-FP at day = 0 indicating that the differences in the chemical composition of the products did not influence the panel scores. The intensity of roasted peanutty attribute used to characterise peanut flavour in peanut products was between seventy and seventy-two (scale 0–150) in both fried-salted peanuts. Grosso & Resurreccion (2002) found that the roasted peanutty intensity was sixty-seven and sixty-three in roasted peanuts and cracker coated peanuts, respectively.

In other works (Bett & Boylston, 1992; St. Angelo, 1996; Grosso & Resurreccion, 2002), an increase of the intensity ratings of cardboard and oxidised and a decrease of roasted peanutty 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 like oxidised and cardboard. The other attributes did not show significant variations ($\alpha = 0.05$) during the storage. The changes of these attributes in GO-FP and T-FP are represented in the Fig. 1. Oxidised and cardboard intensities increased with the storage time. The intensities of oxidised were from 7 on days 0–31 on day 142 in GO-FP and from 8–33 in T-FP. The intensities of cardboard were from 10 on days 0–22 on day 142 in GO-FP, and from nine to twenty-one in T-FP. In spite of their different O/L ratios, T-FP and GO-FP did not show significant differences in an oxidised and cardboard flavour intensities during the storage time. That could be explained because sunflower oil was used in the peanut frying process. This oil had low oxidative stability because of its high level of unsaturated fatty acids such as oleic (25%) and linoleic (63%) acids (Table 3). Similar fatty acid concentrations were reported in other works (Belitz & Grosch, 1999; Hidalgo *et al.*, 2002). During the frying process, sunflower oil is superficially adsorbed in the same way by the fried-peanuts from both cultivars (T and GO) making them similarly susceptible to the development of oxidised flavours. As a consequence, it would be better to use high-oleic frying oils to prepare fried-salted peanuts and to provide better flavour stability to the end products (Warner *et al.*, 1997; Neff *et al.*, 2000; Warner *et al.*, 2001; Bolton & Sanders, 2002).

**Table 4** Means of sensory attribute intensities from descriptive analysis in fresh (storage time = 0) GO and Tegua fried-salted peanuts

| SENSORY ATRIBUTES | GO-FP*† | T-FP*† |
|---|---|---|
| *Appearance* | | |
| 1. Brown colour | 33.29 ± 4.43a | 32.58 ± 4.00a |
| *Aromatics* | | |
| 2. Roasted peanutty | 72.21 ± 9.27a | 69.70 ± 6.54a |
| 3. Oxidised | 7.33 ± 2.75a | 8.04 ± 5.28a |
| 4. Cardboard | 10.75 ± 4.39a | 9.42 ± 4.06a |
| 5. Raw/beany | 8.13 ± 4.03a | 8.75 ± 4.12a |
| *Tastes* | | |
| 6. Sweet | 19.21 ± 3.35a | 19.96 ± 4.18a |
| 7. Salty | 34.00 ± 11.21a | 34.63 ± 11.80a |
| 8. Sour | 9.79 ± 4.23a | 9.58 ± 4.21a |
| 9. Bitter | 8.96 ± 3.47a | 8.33 ± 4.8a |
| *Texture* | | |
| 10. Hardness | 43.13 ± 4.98a | 42.92 ± 4.36a |
| 11. Crunchiness | 60.46 ± 4.05a | 61.33 ± 3.14a |
| 12. Toothpack | 43.83 ± 5.08a | 43.71 ± 4.81a |

*GO-FP = Granoleico fried-salted peanuts and T-FP = Tegua fried-salted peanuts.

†Means followed by the same letter within each row are not significantly different at $\alpha = 0.05$.

Roasted peanutty flavour can be attributed to the presence of pyrazines (Buckholz & Daun, 1981; Crippen *et al.*, 1992). Bett & Boylston (1992) found that the roasted peanutty flavour intensity and alkylpyrazines decreased in stored-roasted peanuts. Warner *et al.* (1996) and Brannan *et al.* (1999) also found that the roasted peanutty flavour decreased in stored-roasted peanuts. In this study, the intensity ratings of roasted peanutty in GO-FP and T-FP decreased during the storage time. The intensities of this attribute changed from 72.2 on days 0–44.9 on day 142 in GO-FP, and from 69.7 to 42.9 in T-FP. This differences were not significant ($\alpha = 0.05$) between the products during the storage time.

## Correlation and Regression analysis

The variables of interest in this study were PV, AV, CD, oxidised, cardboard and roasted peanutty flavours. Correlation coefficients are presented in Table 5. Positive correlations higher than 0.7 were observed among the following variables: PV, AV, CD, oxidised and cardboard flavours. All of these variables increased during the storage time in both products (GO-FP and T-FP). Negative correlations were observed between the roasted peanutty flavour and the other mentioned variables (PV, AV, CD, oxidised and cardboard flavours) in both products. These negative correlations indicated that roasted peanutty flavour decreased when PV, AV, CD, oxidised and cardboard flavours increased during the storage time.

Regression equations of the peroxide and *p*-AVs, CD and trienes and sensory attributes for each product (GO-FP and T-FP) are presented in Table 6.

The dependent variables (PV, AV, CD, oxidised, cardboard and roasted peanutty) showed $R^2 > 0.70$ in both peanuts (GO-FP and T-FP) indicating these variables are good predictors. Therefore, these regression equations could be used to predict the effect of the storage time at 23 °C on these peanut products.

Using the prediction equation, PVs higher than 20 meq$O_2$ kg$^{-1}$ were reached after 125 days in GO-FP and 19 days in T-FP. GO-FP had almost seven times longer shelf-life than T-FP. These results are indicating that GO kernels provide to peanut products higher protection against lipid oxidation. Braddock *et al.* (1995) and Mozingo *et al.* (2004) estimated shelf-life of roasted peanut and roasted and salted in shell peanuts, respectively. They found that the high-oleic peanuts had ten to eleven time longer shelf-life than the normal peanuts. In addition, Mozingo *et al.* (2004) found an

**Table 5** Correlation coefficients among the variables: peroxide (PV), *p*-anisidine values (AV), conjugated dienes (CD) and sensory attributes in GO-FP and T-FP

| | Correlation coefficients* | |
|---|---|---|
| ***RELATED VARIABLES*** | **GO-FP†** | **T-FP†** |
| PV and AV | 0.89 | 0.63 |
| PV and CD | 0.97 | 0.89 |
| PV and oxidised | 0.84 | 0.71 |
| PV and cardboard | 0.90 | 0.67 |
| PV and roasted peanutty | −0.94 | −0.78 |
| AV and CD | 0.95 | 0.78 |
| AV and oxidised | 0.92 | 0.96 |
| AV and cardboard | 0.98 | 0.80 |
| AV and roasted peanutty | −0.98 | −0.94 |
| CD and oxidised | 0.94 | 0.81 |
| CD and cardboard | 0.98 | 0.74 |
| CD and roasted peanutty | −0.98 | −0.88 |
| Oxidised and cardboard | 0.97 | 0.91 |
| Oxidised and roasted peanutty | −0.93 | −0.98 |
| Cardboard and roasted peanutty | −0.98 | −0.94 |

*Pearson's correlation coefficients.
†GO-FP = Granoleico fried-salted peanut; T-FP = Tegua fried-salted peanut.

**Table 6** Regression coefficients and $R^2$ from the prediction equations of PV, *p*-AV, CD and sensory attributes in Granoleico and Tegua fried-salted peanuts

| | | Regression coefficients* | | | |
|---|---|---|---|---|---|
| ***SAMPLE*** | **DEPENDENT VARIABLE** | $\beta_o$ | $\beta_1$ | $\beta_{11}$ | $R^2$ |
| GO-FP† | PV | 2.945766 | 0.144911 | −0.000067 | 0.954595 |
| | AV | 2.222527 | −0.010393 | 0.000293 | 0.957087 |
| | CD | 2.159835 | 0.006642 | 0.000135 | 0.983361 |
| | Oxidised | 9.125894 | −0.124312 | 0.002112 | 0.955838 |
| | Cardboard | 10.775388 | −0.025317 | 0.000903 | 0.996424 |
| | Roasted peanutty | 71.328681 | −0.000485 | −0.001597 | 0.957856 |
| | Sour | 10.32799 | −0.024635 | 0.000712 | 0.93759 |
| | Bitter | 9.503344 | 0.022602 | 0.000332 | 0.858446 |
| T-FP† | PV | 9.539522 | 0.595576 | −0.002806 | 0.971591 |
| | AV | 3.315059 | −0.024234 | 0.000657 | 0.973247 |
| | CD | 3.487714 | 0.07027 | −0.000283 | 0.874341 |
| | Oxidised | 9.342851 | −0.041472 | 0.001465 | 0.974754 |
| | Cardboard | 9.687737 | 0.028365 | 0.000419 | 0.788144 |
| | Roasted peanutty | 68.837458 | −0.067967 | −0.00088 | 0.972291 |
| | Sour | 9.876878 | 0.019771 | 0.000287 | 0.747841 |
| | Bitter | 8.841182 | 0.008342 | 0.000412 | 0.83342 |

*Regression coefficients for the general regression equation: $Y = \beta_o + \beta_1 X + \beta_{11} X^2$, where $Y$ = dependent variable (PV, AV, CD and sensory attributes) and $X$ = independent variable (days of storage).
†GO-FP = Granoleico fried-salted peanuts; T-FP = Tegua fried-salted peanuts.

increment in oxidation because of the addition of salt on roasted in-shell peanuts. According to the result obtained by those authors and the results of this study, fried-salted peanuts would have shorter shelf-life than the roasted peanuts.

## Conclusions

The results of this work indicate that the fried-salted peanuts elaborated with the high-oleic acid peanuts (GO-FP) showed higher stability than those elaborated with normal peanuts (T-FP) making them more resistant to lipid oxidation. Despite the different chemical composition between GO and T, the consumers cannot find differences in the overall acceptance from fried-salted peanuts elaborated using both cultivars. GO peanut could be used to replace normal peanut increasing shelf-life and improving the stability of peanut products, thus preventing loss of their sensory and nutritional quality. Besides, this study provides the equation to estimate shelf-life of fried-salted peanuts from descriptive analysis, peroxide, *p*-AVs and CD.

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