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Universidade Estadual de Londrina  
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Ziegler, Valmor; Dietrich Ferreira, Cristiano; Tuchenhagen Rockembach, Caroline;  
Pereira de Pereira, Cláudio Martin; de Oliveira, Maurício; Cardoso Elias, Moacir  
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# Sensory and chemical properties of peanut grains (*Arachis hypogaea* L) roasted in microwave or oven

## Propriedades sensoriais e químicas de grãos de amendoim (*Arachis hypogaea* L) torrados em micro-ondas ou forno

Valmor Ziegler<sup>1\*</sup>; Cristiano Dietrich Ferreira<sup>1</sup>;  
Caroline Tuchtenhagen Rockembach<sup>1</sup>; Cláudio Martin Pereira de Pereira<sup>2</sup>;  
Maurício de Oliveira<sup>3</sup>; Moacir Cardoso Elias<sup>3</sup>

### Abstract

Peanut grains are an excellent source of proteins and lipids. Before consumption, peanuts are subjected to a roasting process to acquire desirable sensory characteristics, in addition to eliminating microorganisms present. However, this processing step can cause various changes in lipid and protein fraction of grains, which are not totally elucidated in the literature. This study evaluated parameters such as the lipid acidity, peroxide value, primary ( $K_{232}$ ) and secondary ( $K_{270}$ ) products of lipid oxidation, fatty acid profile, reducing sugars, browning index, protein solubility, protein content and intention to purchase of peanut kernels with four colors of testa (striped, rose, red and black), subjected to the roasting process in microwave or oven. After processing, there was a reduction in lipid acidity and unsaturated fatty acids and an increase in saturated fatty acids, peroxide value,  $K_{232}$  and  $K_{270}$  in oil. There was a reduction in protein solubility and reducing sugars, with an increase in browning index. The purchase intention was higher for microwave-roasted red and rose peanut grains, which makes this form of processing interesting due to its convenience and speed.

**Key words:** Oxidative stability. Peanuts. Roasting. Sensory and chemical properties.

### Resumo

Os grãos de amendoim são excelente fonte de proteínas e lipídios. Antes de serem consumidos, os grãos de amendoim são submetidos a um processo de torrefação para adquirir características sensoriais desejáveis, além de eliminar os microrganismos presentes, no entanto, essa etapa de processamento pode causar várias alterações na fração lipídica e proteica dos grãos, as quais não são totalmente elucidadas pela literatura. Esse estudo avaliou parâmetros como a acidez lipídica, o índice de peróxidos, os produtos primários ( $K_{232}$ ) e secundários ( $K_{270}$ ) de oxidação lipídica, o perfil de ácidos graxos, açúcares redutores, índice de escurecimento, solubilidade proteica, teor de proteína e intenção de compra de grãos de amendoim com quatro cores de tegumento (listrado, rosa, vermelho e preto), submetidos ao processo de torrefação em micro-ondas ou forno. Após o processamento, ocorreu uma redução da acidez lipídica e de ácidos graxos poli-insaturados e um aumento de ácidos graxos saturados, índice de peróxidos,  $K_{232}$  e  $K_{270}$  no óleo. Houve uma redução da solubilidade proteica e de açúcares redutores, com aumento

<sup>1</sup> Discentes do Curso de Doutorado, Programa de Pós-Graduação em Ciência e Tecnologia de Alimentos, Universidade Federal de Pelotas, DCTA/FAEM/UFPEL, Pelotas, RS, Brasil. E-mail: vamgler@hotmail.com; cristiano.d.f@hotmail.com; tuch.rock@gmail.com

<sup>2</sup> Prof. Dr., Centro de Ciências Químicas, Farmacêuticas e de Alimentos, UFPEL, Pelotas, RS, Brasil. E-mail: claudiochemistry@gmail.com

<sup>3</sup> Profs. Drs., Programa de Pós-Graduação em Ciência e Tecnologia de Alimentos, DCTA/FAEM/UFPEL, Pelotas, RS, Brasil. E-mail: mauricio@labgraos.com.br; eliasmc@uol.com.br

\* Author for correspondence

no índice de escurecimento. A intenção de compra foi maior nos grãos de amendoim vermelho e rosa torrados em micro-ondas, o que torna essa forma de processamento interessante devido a sua rapidez e conveniência.

**Palavras-chave:** Amendoim. Estabilidade oxidativa. Torrefação. Propriedades químicas e sensoriais.

## Introduction

Peanut (*Arachis hypogaea* L.) is a Fabaceae produced in tropical and subtropical regions and has a high lipid content (50%) and protein content (30%), which makes this grain high in energy (564 kcal 100g<sup>-1</sup>). Peanut grains are consumed in the form of peanut butter, oil, flour, roasted grain and numerous sweet and savory food products (BHATTI et al., 2010; WIN et al., 2011). The roasting process is widely used when processing peanut kernels, as it provides microbiological stability and assists in the development of desirable sensory characteristics. Peanut grain roasting occurs at temperatures of approximately 150 °C for variable periods according to the initial moisture content and dimensions of the grain. The most common methods of preparation use a microwave or conventional oven (CHANG et al., 2013; CÄMMERER; KROH, 2009).

During the roasting process, the lipid fraction is subject to degradation by high temperatures, beginning with the formation of hydroperoxides and peroxides (primary oxidation products –  $K_{232}$ ), which are subsequently broken down into low molecular weight products such as alcohols, ketones and aldehydes (secondary oxidation products –  $K_{270}$ ), which cause changes in color, taste and odor in vegetable oil (PRATT et al., 2011; RODRIGUES et al., 2012). The lipid oxidation products have a direct relationship with cancer development, cell membrane disruption, enzyme inactivation and protein damage. Furthermore, derivatives of lipid peroxides can act as modulators of enzymes or intermediates in biosynthetic processes (PRATT et al., 2011; NIKI, 2009).

The protein fraction of peanut grains consists of approximately 90% globulins, which are classified as arachin (11S) and conarachin (7S) (MOUÉCOUCOU et al., 2004). In addition, a series

of reactions occur between amino acid, reducing sugar and lipid oxidation products forming dark pigments called melanoidins (SU et al., 2011). These pigments directly alter the color, which is an important parameter for marketing roasted peanuts, due to its direct relation to the development of sensory characteristics (SMITH et al., 2014).

In this context, studies related to the peanut grain roasting process have been reported in the literature. Smith et al. (2014) studied the effects of roasting in a microwave, convection oven and a combination of the two methods and verified the formation of major volatile compounds, which are responsible for increasing the acceptability of such grains. Win et al. (2011) studied the effects of different roasting times on the phenolic and antioxidant activity in peanut grains with and without testa, and observed an increase in phenolic compounds and antioxidant activity after 50 min of roasting.

The development of color and flavor during the roasting process is primarily responsible for consumer acceptance of these grains. Thus, the aim of this work was to evaluate the lipid acidity and peroxide index, primary products ( $K_{232}$ ) and secondary products ( $K_{270}$ ) of lipid oxidation, fatty acid profile, protein content, protein solubility, browning index, reducing sugars and purchase intent of peanut grains with four colors of testa, subjected to the roasting process in microwave or oven.

## Materials and Methods

### *Plant material and origin*

The peanut grains (*Arachis hypogaea* L.) used included four testa colorations (striped, rose, red and black) and were obtained from the municipality of São Valério do Sul-RS, Brazil, latitude S 27°47'14",

longitude W 53°56'13" and altitude 421 m. The pods were harvested by hand and dried in the sun until reaching approximately 6% moisture, while immature and damaged specimens were excluded; then, the pods were shelled and the grains stored at 16 °C until processing.

#### *Roasting process and sample preparation*

The roasting process was performed in triplicate; 50-g samples including testa were roasted using two processing methods (oven and microwave). For oven processing (Nova ética, model 400/2ND, São Paulo – SP, Brazil), the samples were roasted at 170 °C with air circulation. Samples were collected every 10 min for homogenization and weighing during the first 60 min of roasting; after 60 min, samples were collected every 5 min. For microwave processing, the samples were roasted in a microwave (Electrolux, model MEF 41, Brazil) at a power of 1600 W and a frequency of 2450 MHz. Samples were collected every 30 seconds for homogenization and weighing. For both processes, the grains were considered roasted when they reached a constant weight. Roasting times obtained in the microwave were 8.0, 8.5, 9.0 and 9.0 min for grains with striped, rose, red and black testa, respectively; in traditional oven treatment, similar values were found for all samples (70 min). After both processes (microwave and oven), the samples were stored at 16 °C for 7 days until performing the analyses described below. Sample preparation consisted of grinding in a laboratory mill (Perten 3100, Perten Instruments, Huddinge, Sweden) to reduce the particles to 35 mesh.

For analysis of lipid acidity, fatty acid profile, peroxides and primary ( $K_{232}$ ) and secondary ( $K_{270}$ ) products of lipid oxidation, the oil was extracted from 150-g samples milled grains, using a Soxhlet apparatus for 8 hours with petroleum ether as an extraction solvent. The solvent was removed on a rotary evaporator under vacuum at 35 °C (Heidolph, Laborota Model 4000, Germany). The oil was

transferred to plastic amber vials and stored at –18 °C until the time of analysis.

#### *Moisture and lipid content*

The moisture content of the peanuts was determined using a drying oven set at 105±3°C with natural air circulation for 24 hours, following the recommendations of the American Society of Agricultural Engineers (ASAE, 2000). The moisture content was expressed as a percentage (%). The lipid content was determined according to method 30-20 of the American Association of Cereal Chemists (AACC, 1995). The fat content was expressed in percentage (%) in basis dry.

#### *Lipid acidity*

Fat acidity was determined following the titration method described in AACC method 02-01A (AACC, 2000). The titratable acidity was expressed as the mass in milligrams of sodium hydroxide required to neutralize the acids in 100 g of extracted oil, using phenolphthalein solution as an indicator.

#### *Peroxide index*

The peroxide index was determined by iodometric titration according to the method described by the American Oil Chemists' Society (AOCS, 2009).

#### *Specific extinction coefficient ( $K_{232}$ and $K_{270}$ )*

In a 10-ml volumetric flask, 0.1 g of oil (clean and filtered) was weighed; the volume was diluted to volume with HPLC-grade isooctane, and the solution was measured using a spectrophotometer (Jenway, 6705 UV/Vis) at 232 and 270 nm. The absorbance were used to determine the specific extinction coefficients ( $K_{232}$  and  $K_{270}$ ) using the method proposed by the American Oil Chemists' Society (AOCS, 2009).

### *Fatty acid profile*

A gas chromatograph (GC-14B, Shimadzu, Kyoto, Japan) with a flame ionization detector (FID) and a DB-225 fused silica capillary column measuring 30 m x 0.25 mm x 0.25  $\mu$ m (50% cyanopropyl methyl and 50% methyl phenyl silicone, J&W Scientific, Folsom, CA, USA) was used. The injector and detector were both maintained at 250 °C. Nitrogen, at a rate of 1.0 ml.min<sup>-1</sup>, was used as the carrier gas.

Oils obtained from whole and milled peanut grains by continuous extraction using AACC method 30-20 (AACC, 2000) were used. Fatty acid derivatization was performed according to the method of Zambiasi et al. (2007); briefly, samples of 45 mg of oil were weighed in test tubes with lids, and 1 ml of petroleum ether and 12 ml of 0.5M HCl in methanol were added. The tubes were vortexed and heated at 65 °C for 1 h. Then, 5 ml of iso-octane and 6 ml of distilled water were added, and the tubes were shaken. The upper layer was partially transferred to a 1.5-ml flask, from which 1.5  $\mu$ L was taken and injected into the gas chromatograph with a 1:50 split ratio. The initial column temperature of 100 °C was maintained for 0.5 min and then brought up to 150 °C at a rate of 8 °C min<sup>-1</sup>. After 0.5 min at 150 °C, the temperature was increased to 180 °C at a rate of 1.5 °C min<sup>-1</sup>. The column was held at 180 °C for 5 min and was then increased to a final temperature of 220 °C at a rate of 2 °C min<sup>-1</sup>. The temperature was maintained for 6 min longer, for a total analysis time of 58 min.

Qualitative analysis was performed by comparison to standard retention time of FAME mix 37 (Sigma-Aldrich) and quantitative analysis was made by area normalization corrected using as internal standard the methyl nonadecanoate (Sigma-Aldrich-C19: 0).

### *Reducing sugars*

The determination of reducing sugars was performed according to the method described

by Miller (1959). The defatted sample (1 g) was weighed in a 50-ml Falcon tube along with 30 ml of distilled water, followed by stirring on a shaking table at 200 rpm for 20 min, and the solution was then centrifuged at 7000 rpm for 10 min at 24 °C (*Eppendorf Centrifuge 5430R*). The supernatant was transferred to Eppendorf vials in 200  $\mu$ L aliquots, to which 200  $\mu$ L of DNS solution (3,5 dinitrosalicylic acid) was added. The resulting solution was placed in a water bath at 100 °C for 5 min, followed by cooling in cold water. Then, 1.6 ml of distilled water was added, and the sample was analyzed at 540 nm in a spectrophotometer. The results were expressed in mg of equivalent glucose.g<sup>-1</sup> of sample, by constructing a glucose standard curve.

### *Browning index*

The progress of the Maillard reaction was verified by determining the browning index, as described by Hwang et al. (2001). The defatted sample (0.4 g) was suspended in buffer containing 50 mM CaCl<sub>2</sub> and 50 mM Tris buffer (pH 7.0); then, measurements were performed in a spectrophotometer at wavelengths of 420 and 550 nm (Jenway, 6705 UV/Vis). The browning index was determined according to the following equation:

$$\text{Browning index} = \text{Absorbance } 420 \text{ nm} - \text{Absorbance } 550 \text{ nm}.$$

### *Crude protein content and protein solubility*

The protein content was determined according to method 46-13 of the American Association of Cereal Chemists (ASAE, 2000). The protein solubility in water was determined according to the method described by Liu et al. (1992) with some modifications. One gram of sample was dispersed in 50 ml of distilled water with constant stirring for 1 h. The slurry was centrifuged (*Eppendorf Centrifuge 5430R*) at 5300 rpm for 20 min, and 2.0 ml of supernatant was collected to determine the protein content. The nitrogen content was determined by the

Kjeldahl method, and the resultant nitrogen value was converted to protein using a factor of 5.46. The protein solubility, expressed as a percentage (%), was calculated as the ratio of soluble protein content to crude protein content.

#### *Purchase intent*

The purchase intent was calculated according with the method described by Minin (2006). The evaluation was performed with 50 untrained panelists, including employees, students and visitors at the Federal University of Pelotas, based on the interest and availability of consumers to participate in the sensory panel. The panelists who participated in the trial were of both sexes (male and female), with ages between 15 and 45 years old. The panelists evaluated how much the visual impression of roasted grains. The panel was structured using samples of peanut grains characterized by four testa colors (striped, rose, red and black), but without the presence of the testa, randomly coded as shown in Figure 1. The samples were coded as follows: 435 (striped roasted in oven), 445 (striped roasted in microwave), 476 (rose roasted in oven), 487 (rose roasted in microwave), 496 (red roasted in oven), 499 (red roasted in microwave), 412 (black roasted in oven), and 425 (black roasted in the microwave). The purchase intent was based on the general appearance of the roasted peanut grains, with scores based in a five-point structured scale: definitely buy (1), would probably buy (2), undecided (3), probably would not buy (4) and definitely would not buy (5).

#### *Statistical analysis*

Analytical determinations for the samples were performed in triplicate, and standard deviations are reported. A comparison of the means was ascertained with Tukey's test to a 5% level of significance using analysis of variance (ANOVA).

**Figure 1.** Purchase intent panel using peanut samples with four testa colors, subjected to the roasting process in a microwave or an oven: 435 (striped roasted in the oven), 445 (striped roasted in the microwave), 476 (rose roasted in the oven), 487 (rose roasted in the microwave), 496 (red roasted in the oven), 499 (roasted red in the microwave), 412 (black roasted in the oven), 425 (black roasted in the microwave).



## **Results and Discussion**

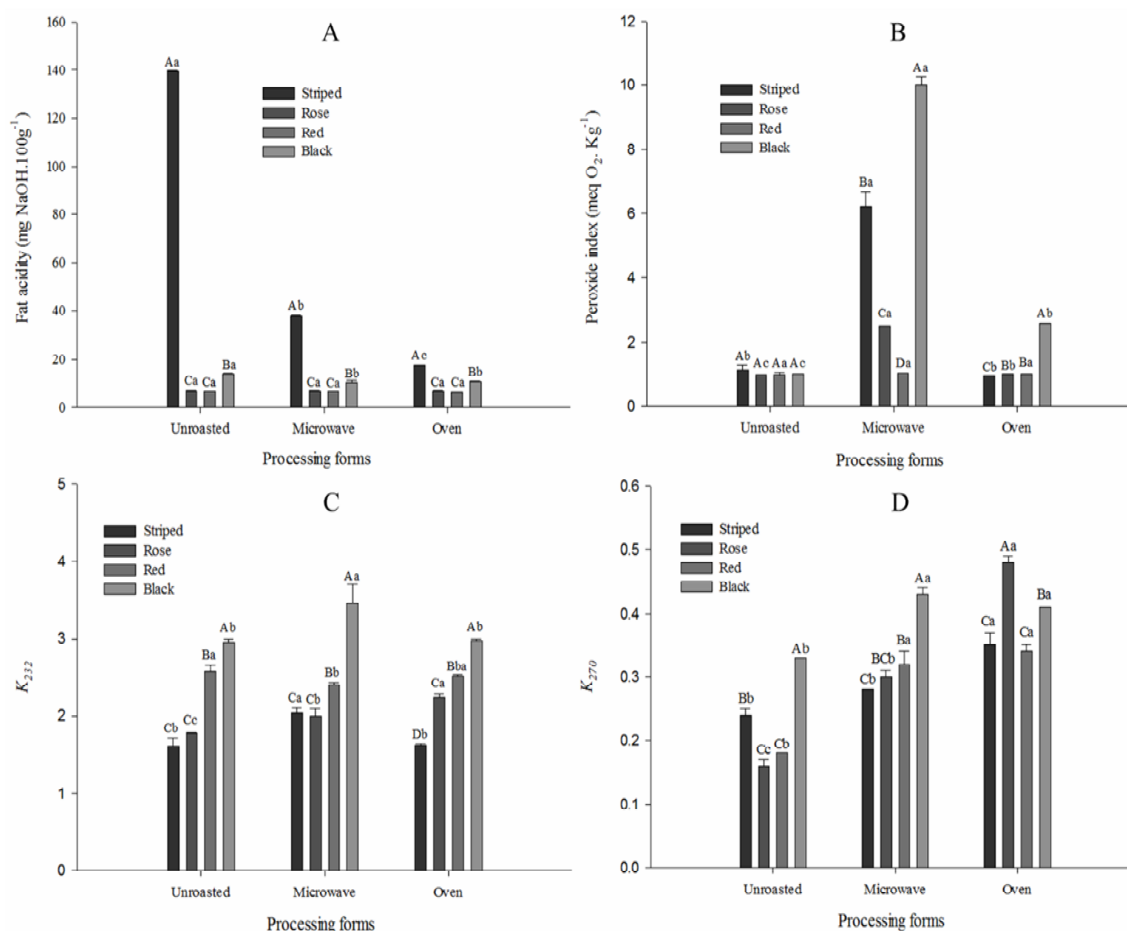
*Lipid content, lipid acidity, peroxide index, primary products ( $K_{232}$ ) and secondary products ( $K_{270}$ ) of lipid oxidation*

The peanut grains presented initial lipid contents of 47.4, 49.8, 45.7 and 45.8%, respectively, for the grains with striped, rose, red and black testa, with values remaining unchanged after microwave and oven processing (data not shown). The grains with striped testa, without processing, showed the highest

( $p < 0.05$ ) lipid acidity index ( $139.5 \text{ mg NaOH } 100\text{g}^{-1}$  of oil) compared to grains with rose, red and black testa, which had indices of 6.7, 6.6 and  $13.9 \text{ mg}$  of  $\text{NaOH } 100\text{g}^{-1}$  of oil, respectively. The higher acidity index in striped grains is most likely due

to an error in the drying step, because they showed 6.9% moisture content, while the black, rose and red grains presented 5.6, 5.1 and 5.4% moisture, respectively; the higher moisture content in the striped grains led to higher hydrolytic activity by lipase (Figure 2A).

**Figure 2.** Lipid acidity, peroxide index, and primary ( $K_{232}$ ) and secondary ( $K_{270}$ ) products of lipid oxidation of oil from peanut grains with striped, rose, red and black testa subjected to the roasting process in a microwave or an oven. Values are presented as a simple arithmetic average of three replicates  $\pm$  standard deviation; numbers followed by the same capital letter indicate the same processing method. Statistically different results were determined using Tukey's test ( $p < 0.05$ ).



The striped, rose and black grains had the highest increases in peroxide index after microwave roasting, with increases of 451.3, 154.1 and 882.3%, respectively, while there was no change for the red-testa grain ( $p < 0.05$ ) (Figure 2B). Cisneros and Paredes (2014) found similar results, with an increase of 617.5% in peroxide index in oil from

Sacha-inchi grains (*Plukenetia volubilis* L.) roasted at a temperature of 83-86 °C for 10 min.

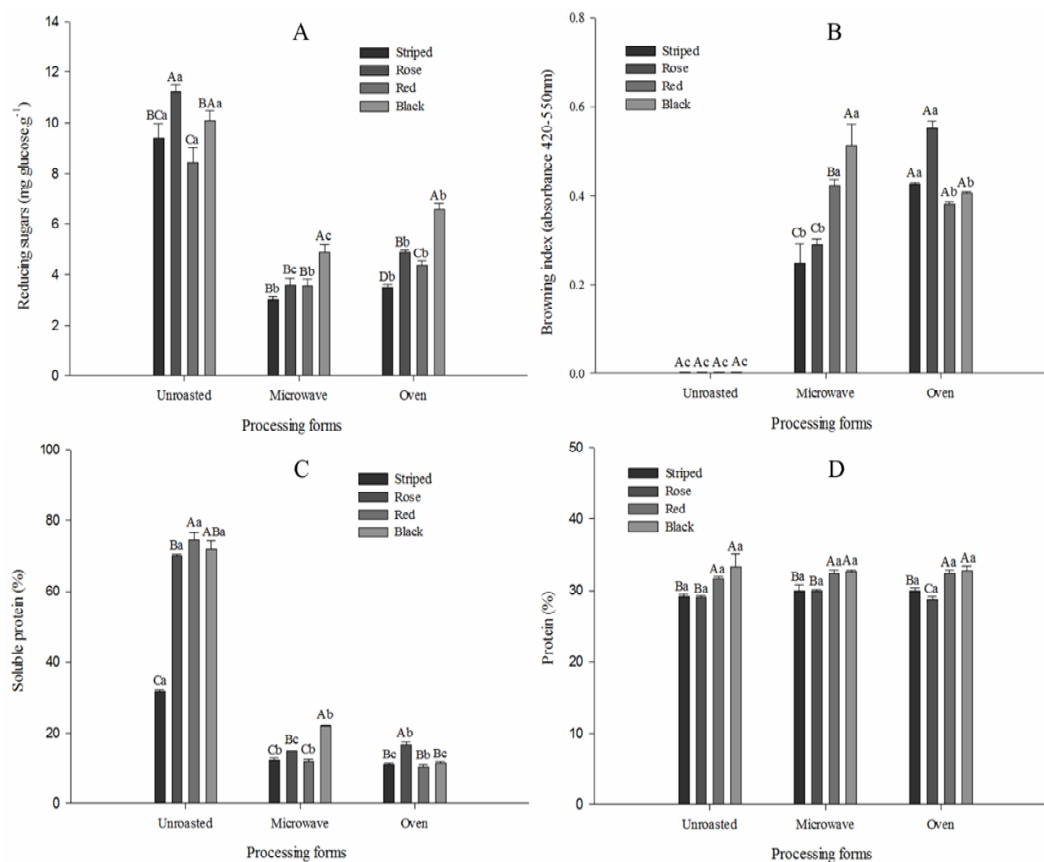
The black-testa grains presented the highest ( $p < 0.05$ ) concentration of  $K_{232}$  (2.95), followed by red-testa grains (2.57), but no significant differences were observed between grains with rose (1.78) and striped (1.61) testa (Figure 2C). In the striped and

black grains, the primary products of lipid oxidation ( $K_{232}$ ) increased after microwave processing, with increases of 26.7 and 17.3%, respectively, while the same two grains remained unaltered after oven processing ( $p < 0.05$ ). In grains with rose testa, this parameter increased by 12.3% ( $K_{232}$ ) with microwave processing and 25.8% with oven processing, while in red-testa grains, the primary products of lipid oxidation ( $K_{232}$ ) decreased by 6.6% ( $K_{232}$ ) in microwave processing and remained unaltered after oven processing ( $p < 0.05$ ). Vaidya and Eun (2013) observed similar behavior, with a 37.5% increase in conjugated dienes in oil obtained from tree nuts roasted at 160 °C for 15 min.

After processing, the greatest reduction in lipid acidity was observed in grains with striped testa,

with values of 73.2 and 87.5%, respectively, for microwave and oven treatment. Grains with black testa also displayed reduced acidity after processing ( $p < 0.05$ ), but no difference was observed between the two processes; the rose and red grains remained unchanged after both microwave and oven roasting. The reduction of lipid acidity during processing in grains with striped and black testa can be attributed to interactions such as the formation of complexes between sugars, free fatty acids and proteins (BECK-GARCÍA et al., 2013), resulting in reduced acid properties in the oil. These interactions are responsible for altering protein conformation, reducing solubility (Figure 3C), modifying the flavor, aroma and color, and changes in grain texture due to protein denaturation and cross-links between peptide chains (TAHA; MOHAMED, 2004).

**Figure 3.** Reducing sugars, browning index, soluble protein and crude protein content of peanut grains with striped, rose, red and black testa subjected to the roasting process in a microwave or an oven. Values are presented as a simple arithmetic average of three replicates  $\pm$  standard deviation; numbers followed by the same capital letter indicate the same processing method. Statistically different results were determined using Tukey's test ( $p < 0.05$ ).



Before roasting, the grains with black testa had the greatest concentration ( $P<0.05$ ) of  $K_{270}$  (0.33), followed by striped grains (0.24), while the rose (0.16) and red (0.18) grains were not different (Figure 2D). The greatest increases were observed in oven-roasted rose (200%) and red (88.9%) grains, followed by microwave-roasted rose (87.5%) and red (77.8%) grains. In grains with striped and black testa, values below 45.8% were observed. Cisneros and Paredes (2014) obtained similar results, with increases of 495.2% in the anisidine content (secondary oxidation products) of oil from sachu inchi grains (*Plukenetia volubilis* L.) roasted at a temperature of 83-86 °C for 10 min.

When the grains are exposed to high temperatures during the microwave and oven roasting processes, damage and cell rupture occur (XU; LI, 2015), which increases the oxygen activity: the high temperatures catalyze a series of oxidative reactions that alters the oil characteristics, as observed in measurements of the peroxide value,  $K_{232}$ ,  $K_{270}$  and fatty acid profile.

#### *Fatty acid profile*

According to the data presented in Table 1, before roasting, the black grains showed the highest ( $p<0.05$ ) concentration of C16 (11.6%), followed by the red (10.6%) and striped (10.4%) grains, which were not significantly different ( $p<0.05$ ), and finally the rose grains (9.4%), with the lowest value ( $p<0.05$ ). The highest concentration ( $p<0.05$ ) of C18:0 was observed in the rose grain (3.7%), followed by the black (2.3%), red (1.5%) and striped (1.0%) grains. C18:1 showed the highest concentration ( $p<0.05$ ) in the rose grain (47.4%), followed by the red (40.8%), striped (38.5%) and black (34.2%) grains. The C18:2 content was not different ( $p<0.05$ ) in the grains with black (47.14%), striped (46.0%) and red (43.7%) testa, but statistically lower concentrations ( $p<0.05$ ) were found in the rose-testa grain (32.2%). The results found in this study are similar to those of Shin et al. (2010), who measured C16:0 (8.8 to 11.5%), C18:0

(2.1 to 2.9%), C18:1 (48.4 to 62.3%) and C18:2 (18.5 to 30.5%) in the characterization of peanut grain oil obtained from 22 cultivars. Differences in the profile of fatty acids in different peanut grains may be the result of factors such as cultivar, cultivation conditions and climate variations in which the plant was exposed during the production of grains in the fields. In general, after microwave and oven roasting, there was a reduction ( $p<0.05$ ) in C18:2 and increase in C18:1 and C18:0, with little change in C16:0, with the exception of oven-roasted rose grain, which showed a reduction in C18:1. The reduction of C18:2 occurs because of a series of oxidative reactions during the grain roasting process: one or more of the double bonds in unsaturated fatty acids are broken, which increases the concentration of C18:0 and C18:1 (MORELLÓ et al., 2004). Rodrigues et al. (2011) found a reduction of C18:0, C18:1 and C18:2 after roasting peanuts grains in an oven at 200 °C for 50 min.

#### *Reducing sugars, browning index, protein solubility and protein content*

Before roasting, the beans presented reducing sugar contents of 9.4, 11.2, 10.4 and 8.4 mg glucose g<sup>-1</sup> sample, respectively, for the grains with striped, rose, red and black testa (Figure 3A). After microwave roasting, these values decreased 68.1 and 57.8% for the grains with striped and red testa, respectively, with no difference ( $p<0.05$ ) between the two processes. For rose-testa grains, the reducing sugars were reduced by 68.0 and 56.4% after microwave and oven processing, respectively. For black-testa grains, the reducing sugar content decreased by 51.5 and 35.0%, respectively, after microwave and oven processing. McDaniel et al. (2012) also observed a decrease in some sugars such as glucose, fructose and stachyose in roasted peanut grains in conjunction with color formation ( $L^* = 53 \pm 1$ ) as measured with a colorimeter (Hunter Colorimeter LAB DP-900 Hunter Associates Lab., Reston, Va., USA), and related the enhancement of dark color with reducing sugars such as glucose, fructose and stachyose.

**Table 1.** Profile of fatty acids (%) on oil from peanut grains with tegument striped, rose, red and black submitted to the roasting process in microwave and oven.

Process	Peanuts			
	Striped	Rose	Red	Black
<i>C16:0</i>				
Unroasted	A 10.44 ± 0.10 b*	A 9.42 ± 0.43 c	A 10.66 ± 0.26 b	A 11.61 ± 0.47 a
Microwave	AB 10.33 ± 0.16 b	A 9.31 ± 0.12 c	B 9.61 ± 0.32 c	A 11.33 ± 0.29 a
Oven	B 10.05 ± 0.04 b	A 9.37 ± 0.11 d	B 9.63 ± 0.13 c	A 11.03 ± 0.06 a
<i>C18:0</i>				
Unroasted	B 1.06 ± 0.17 d	B 3.70 ± 0.24 a	C 1.51 ± 0.02 c	B 2.30 ± 0.15 b
Microwave	A 2.36 ± 0.11 bc	B 3.59 ± 0.14 a	B 2.71 ± 0.19 b	B 2.12 ± 0.17 c
Oven	A 2.48 ± 0.46 c	A 4.84 ± 0.05 a	A 3.23 ± 0.07 b	A 2.81 ± 0.25 bc
<i>C18:1</i>				
Unroasted	B 38.58 ± 1.11 c	B 47.44 ± 0.37 a	C 40.82 ± 0.64 b	B 34.26 ± 1.03 d
Microwave	B 38.01 ± 0.12 c	A 49.85 ± 0.52 a	B 43.48 ± 0.18 b	B 34.44 ± 0.06 d
Oven	A 43.47 ± 1.19 ab	C 42.19 ± 1.45 b	A 44.73 ± 0.42 a	A 39.61 ± 0.25 c
<i>C18:2</i>				
Unroasted	A 46.04 ± 2.20 a	A 32.26 ± 0.45 b	A 43.77 ± 0.23 a	A 47.14 ± 1.90 a
Microwave	B 40.59 ± 0.46 b	B 27.84 ± 0.46 d	B 32.76 ± 0.48 c	A 44.59 ± 1.15 a
Oven	C 35.95 ± 2.00 a	B 27.41 ± 0.27 c	B 30.70 ± 1.35 b	B 36.30 ± 0.49 a

\* For each fatty acid, simple arithmetic average of three replicates ± standard deviation, followed by different uppercase letters in the same column, and lowercase on the same line, differ by Tukey test ( $p < 0.05$ ).

After roasting, the browning index of samples increased ( $p < 0.05$ ). For the black- and red-testa grains, the largest increase ( $p < 0.05$ ) occurred with microwave processing, while for the striped and rose grains, the largest increase ( $p < 0.05$ ) occurred with oven processing (Figure 3B). Smith and Barringer (2014) reported that the development of dark pigments is the primary control parameter in the roasting process and that  $L^*$  values (CIELAB) of approximately 59 are associated with an ideal degree of roasting. The striped, rose, red and black peanut grains showed initial soluble protein values of 31.6, 69.7, 74.4 and 72.0%, respectively (Figure 3C). After both roasting processes, the soluble protein content was reduced ( $p < 0.05$ ) for all samples, with the largest decrease observed in oven-roasted red grains (86.1%). The results of this study are similar to the results obtained by Davis et al. (2010), who observed an 88.0% reduction in the soluble protein content of peanut grains subjected to oven roasting at 166 °C for 77 min. The crude protein contents of peanut grains with striped,

rose, red and black testa were, respectively, 29.1, 29.0, 31.7 and 33.3%, without significant changes ( $p < 0.05$ ) after undergoing roasting in a microwave or oven (Figure 3D).

The results presented in this section are important for understanding the roasting process. The increase in browning index is mainly due to the Maillard reaction, which causes a reduction in protein solubility, in which the interaction between sugars and amino acids, particularly lysine, forms dark pigments called melanoidins (MCDANIEL et al., 2012); this process directly changes the color and flavor of the grains, favoring consumer acceptance of the product.

#### Purchase intent

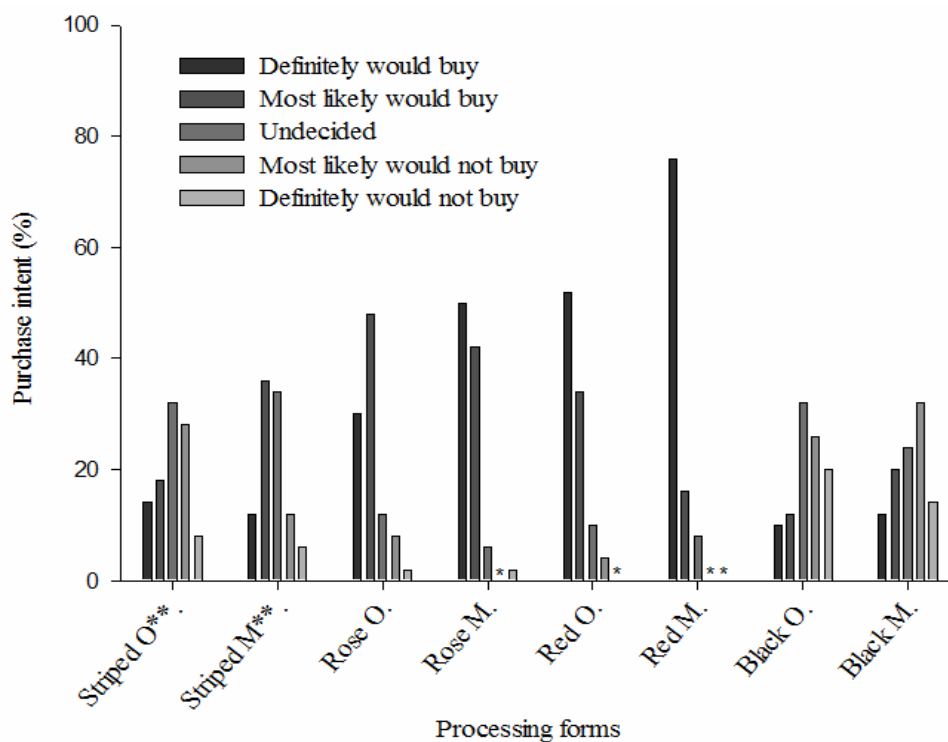
Positive evaluations were considered to include “definitely buy” and “would probably buy”, these positive evaluations were summed to calculate purchase. The highest purchase intent was observed for microwave-roasted red (92%) and rose (92%)

grains, followed by red (86%) and rose (78%) grains roasted in the oven (Figure 4). The black and striped grains, roasted in either a microwave or an oven, showed low purchase intent by the panelists. The purchase intent was selected based on global parameters, so other attributes were also taken into account when choosing. The grains with red and

rose testa presented similar size, color and aroma characteristics. Most likely, the grains with black testa were assigned poor purchase intent due to their smaller dimensions compared with the other samples (Figure 1), while the striped testa grains presented non-uniform coloration (Figure 1), which justifies their purchase intent values.

**Figure 4.** Purchase intent of peanut grains with striped, rose, red and black testa subjected to the roasting process in a microwave or an oven.

Where: \*attribute unidentified; O\*\*= Oven; M\*\* = Microwave



## Conclusion

Peanut grains with striped, rose, red and black testa were affected by microwave- and oven-roasting, which caused changes such as a reduction in lipid acidity and unsaturated fatty acids and an increase in saturated fatty acids, peroxide index,  $K_{232}$  and  $K_{270}$  in oil. There was a reduction in soluble protein and reducing sugars, with an increase in browning index. Regarding the intention to purchase, the red and rose grains had higher purchase intent when processed in a microwave; this processing method

is promising due to its practicality and reduced roasting time when compared with oven treatment.

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