Research Article

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Effect of peanut skin extract on chemical stability and sensory properties of salami during storage

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Abstract

BACKGROUND: Peanut skin extracts (PSEs) have proven antioxidant properties in different food products. The objective of this study was to evaluate the effect of peanut skin extract as natural preserving compounds on chemical stability and sensory properties of salami during storage.

RESULTS: PSE was obtained with ethanol – water and added during the preparation of salami samples. Raw salami samples were cured and stored at 15 °C and 65% relative humidity. Moisture, peroxide value, conjugated dienes, free fatty acids and sensory descriptive attributes were evaluated on the samples. Peroxide values increased during storage in all samples and were 82.9 in control (salami without additives), 18.0 in salami with 0.2 g kg^{-1} PSE (E0.02), 13.0 in salami with 1.0 g kg^{-1} PSE (E0.1), and 0.63 meqO_2 kg^{-1} in salami with butylated hydroxytoluene (BHT) after 42 days of storage. BHT and E0.1 treatments resulted in a lower increase in the intensity of oxidized flavor and a lower decrease in the intensity of salami flavor.

CONCLUSION: Chemical indicators and descriptive results indicated that PSE retards lipid oxidation and preserves sensory properties of salami, prolonging its shelf life.
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Keywords: peanut skin; salami; antioxidant; sensory; stability

INTRODUCTION

According to the Argentinean Food Code, salami is defined as a 'dry sausage prepared on the basis of pork meat or pork meat and beef, with the addition of pork back fat, salt, nitrate/nitrite salts, sugar, spices and wine'.[1]

Sausages are one of the oldest forms of processed meat. Today, thousands of varieties of sausages are made in the world. Dry salami is a traditional cured-meat product in Argentina and is produced according to different methods in different regions of the country.[2]

Raw-cured meat products have an intermediate moisture content. Raw-cured meat products can be stored for long periods of time (up to 2 years) because their manufacturing process involves a combination of preserving factors like salt addition, low pH due to the lactic acid production by lactobacilli, low water activity (a_w) by dehydration, nitrite presence by addition and/or production by microorganisms.[3–5] Traditionally, these products are stored in basements where conditions of temperature and humidity allow suitable preservation. However, conditions of high temperature and illumination may cause oxidative and sensory damage which are perceived as rancidity.[6]

The ripening process begins once the salami is stuffed. Salami products are usually stuffed in casings. Although there are synthetic casings, natural casings are preferred because of their unique characteristics. During the drying process, the product loses water depending on external factors: temperature, ventilation and relative humidity. Ripening rooms use a constant temperature of between 13 and 17 °C for assuring adequate water decrease during the salami drying process. This drying process is necessary for developing an unfavorable environment for the growth of microorganisms. As a consequence, the product maintains microbiological stability without refrigeration. In addition, salt and various spices such as pepper, nutmeg and cloves are usually added to salami before stuffing. These ingredients are commonly used as antiseptics. Industrially, other preservatives are added to accelerate the ripening process, to highlight colors and to prolong shelf life.[2]

Lactobacilli are the most abundant natural microorganisms in stuffed meat. Most of them are homofermentative but some of them are heterofermentative. The latter contribute to the aroma

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and flavor of the sausages because of the formation of volatile acids, alcohols and carbon dioxide. Finally, the red color, which is mainly due to myoglobin, is an important sensory attribute in salami.[7]

Salami products are an important source of both proteins of high biological value and animal fat.[8] The quality of salami depends on the ingredient quality and good manufacturing practices.

This type of product has a high lipid content, making it susceptible to oxidation reactions. These reactions involve the formation of relatively toxic compounds and can cause deterioration of sensory quality.[9] The addition of preservatives in salami products should not be only done in order to control the growth of microorganism, but also to preserve the chemical and sensory properties.

At present, there is renewed interest in the use of naturally occurring antioxidants. Natural antioxidants are presumed to be safe because they occur in nature and in many cases are derived from plant sources. Various natural compounds have been studied as food preservatives.[10–12] Previous studies reported antioxidant activity from peanut skin extracts (PSEs) in food products such as vegetable oils,[13] honey roasted peanuts,[14] cooked and raw beef[15] and beef products.[16] Peanut skins are a waste from blanched processing of peanut kernels. In Argentina, peanut skins are sometimes used to feed cattle; however, their value could be increased if other more valuable uses like natural antioxidant sources could be found for that waste.

The objective of this study was to evaluate the effect of PSE as a natural preserving compound on chemical stability and sensory properties of salami during storage.

EXPERIMENTAL

Materials

Ground beef, ground pork meat, pork back fat, natural bovine casings (approximately 50 mm in diameter) used for salami preparation were purchased in a local market (San Francisco, Córdoba, Argentina). Salt (Celusal, Las Salinas, Tucuman, Argentina), pepper, and nutmeg (Alicante, Rosario, Argentina) were also used for salami preparation. Commercial dry-cured salami (Colonia Tirolesa, Córdoba, Argentina) was used as reference.

Skins from peanuts (*Arachis hypogaea* L.) type Runner (2009 crop) were separated by blanching process and were provided by Lorenzati, Ruescht y Cia of Ticino, Córdoba, Argentina.

Phenolic compound extraction from peanut skins

Phenolic compounds were obtained from defatted peanut skins using a mixture of ethanol–water (70:30, v/v) as extraction solvent according to Nepote *et al.*[11] The extract was filtered through Whatman No. 1 paper and solvent was removed by evaporation under reduce pressure. The concentrated extract was further purified by solvent partitioning using distilled water and ethyl acetate.[10] First, the concentrated extract was dissolved in distilled water. This solution was added to ethyl acetate in a separation funnel. Then, the ethyl acetate and water phases were separated. In the ethyl acetate phase, the solvent was removed under reduce pressure using a rotary evaporator. The obtained extract was stored at −18 °C until used. The final extract had 967.94 mg g^{-1} phenolic compounds expressed as gallic acid equivalent measured according to the Folin–Ciocalteu method.[17]

Salami preparation

Raw salami was prepared by mixing ground beef (403.5 g kg^{-1}), ground pork meat (403.5 g kg^{-1}), diced pork back fat (160.0 g kg^{-1}), salt (28.0 g kg^{-1}), pepper (2.5 g kg^{-1}) and nutmeg (2.5 g kg^{-1}) following a procedure similar to that of Monín.[2] The final mixture was stuffed into a natural bovine casing and tied with cotton string every 18 cm. Four treatments were prepared: salami without additives (C); salami with 0.02 g butylated hydroxytoluene (BHT) 100 g^{-1} product (BHT); salami with 0.02 and 0.1 g peanut skin extract per 100 g product (E0.02 and E0.1, respectively). PSEs and BHT were diluted in 1 mL ethanol and mixed with the salami ingredients before stuffing them.

Storage conditions and sampling

Raw salami samples (C, BHT, E0.02 and E0.1) were stored for ripening and drying in a refrigerated room at 15 °C and 65% relative humidity for 14 days. Then, the salami samples were cured and stored for 28 days under the same conditions; therefore, the whole storage time was 42 days.

Five sampling days (14, 21, 28, 35 and 42 days from storing) were chosen for chemical and sensory analysis. Samples were also chemically analyzed at day zero before storing under refrigerated conditions.

Experimental design

An experimental design of four salami treatments (C, BHT, E0.02 and E0.1), six storage days (0, 14, 21, 28, 35 and 42 days) and three replicates was used. Three different lots of each salami treatment were prepared separately and each lot was considered a repetition. The analyzed variables in this experiment were chemical indicators (moisture, peroxide value (PV), conjugated dienes (CD) and free fatty acids (FFA)) and sensory attributes intensity ratings.

Chemical analysis on salami during storage

Moisture was determined on salami samples according to the oven air-drying AOAC method.[18] Proteins in the samples were analyzed by the Kjeldahl method.[18] Fat was separated from salami samples by Soxhlet extraction with *n*-hexane for 6 h. *n*-Hexane was removed by evaporation under reduce pressure. PV ($meqO_2$ kg^{-1} fat) and FFA (g oleic acid kg^{-1} fat) were determined on salami fat according to AOAC methods.[18] Conjugated dienes, expressed as extinction coefficient *E* (1%, 1 cm, 232 nm), were determined according to COI.[19]

Sensory descriptive analysis on salami during storage

A total of 10 trained panelists (eight female and two male) participated in the descriptive analysis of stored dry-cured salami samples. All panelists had five years of experience in sensory descriptive analysis. The panelists were selected according to the following criteria: (1) people with natural dentition; (2) people without food allergies; (3) nonsmokers; (4) people between the ages of 18 and 64; (5) people who consume salami at least once a month; (6) people available for all sessions; (7) people interested in participating; and (8) people able to verbally communicate the observations regarding the product.[20] For panelist selection, a screening test was performed for descriptive analysis. Before being qualified, all panelists showed a perfect score in a taste sensitivity test and the ability to identify five of seven commonly found food flavors.[21]

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Table 1. Definition of attributes, standard references and warm-up intensity ratings used in descriptive analysis of dry-cured salami samples

Attribute	Definition[a]	References	Reference intensity[b]	Warm-up intensity[b c]
Appearance				
Fat color	Intensity or strength of yellow color from light to dark yellow	Color IC 074 Avorio[d]	35	20
Beef color	Intensity or strength of red color from light to dark red	Color Scania roed ST 969[d]	80	60
Gloss	Amount of reflected light from product	Peanuts with chocolate[e]	58	35
Aromatics				
Salami odor or aroma	Odor associated with dry salami	Commercial salami[f]	110	100
Rancid odor or aroma	Odor associated with rancid fats and oils	Rancid sunflower oil[g]	30	0
Salami flavor	Aromatic associated with dry salami	Commercial salami[f]	115	100
Oxidized flavor	Aromatic associated with rancid fats and oils	Rancid sunflower oil[g]	50	0
Basic tastes				
Salty	Taste on the tongue associated with sodium chloride solution	0.2% NaCl solution 0.35% NaCl solution 0.5% NaCl solution	25 50 85	130
Sour	Taste on the tongue associated with acid agents such as citric acid solution	0.05% citric acid solution 0.08% citric acid solution 0.15% citric acid solution	20 50 100	30
Mouthfeel				
Pungency	Tingling or burning sensation on the tongue	Olive oil[h] Commercial salami[f]	40 55	60
Texture				
Hardness	Force needed to compress food between molar teeth	Almonds[i] Fresh cheese[j]	74 15	35
Tooth packing	Amount of product left on teeth	Raw peanuts Commercial salami[f]	66 22	25
Oily	Amount of oil left on mouth surfaces	Sunflower oil[k] Commercial salami[f]	75 55	60

[a] Attribute definitions based on Meilgaard *et al*. (1991).
[b] Intensity ratings are based on 150 mm unstructured line scale.
[c] Warm-up: commercial dry-cured salami (Colonia Tirolesa, Córdoba, Argentina).
[d] Color codes from RAL color scale.
[e] Peanuts coated with chocolate (ARCOR, Colonia Caroya, Córdoba, Argentina).
[f] Commercial dry-cured salami (Colonia Caroya, Córdoba, Argentina).
[g] Rancid sunflower oil: commercial sunflower oil (Natura, AGD, General Deheza, Argentina) stored for 20 days at 40 °C.
[h] Extra virgin olive oil, Arbequina variety (San Juan, Argentina).
[i] Almonds (Grandiet, Córdoba, Argentina).
[j] Fresh cheese (Port Salud, La Serenisima, Buenos Aires, Argentina).
[k] Commercial sunflower oil (Natura, AGD, General Deheza, Córdoba, Argentina).

All 10 panelists were trained and calibrated in 10 training sessions. Each training session lasted for 2 h. 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) were used for training and evaluation sessions as reported by Grosso and Resurreccion.[22] A 150 mm unstructured line scale was used for sample evaluation.[23] A list of definitions and a sheet with warm-up and reference intensity ratings (Table 1) were developed during the training sections.

All samples were evaluated in partitioned booths at room temperature under white light produced by a Lumilux Plus Eco fluorescent lamp of 58 W 840 cool white (Osram Argentina Compania de Lamparas Electricas SA, Buenos Aires, Argentina) with light intensity of 5200 lumen. Ten grams of salami sample slides were placed into plastic cups with lids coded with 3-digit random numbers. Before beginning the evaluation of the samples, the panelists retested all references and the warm-up sample. The final lists of warm-up and reference intensity ratings and definitions were posted in the booths during the test session. Panelists evaluated six samples and a warm-up sample per session. Samples were tested using a randomized complete block design. The data were registered on paper ballots.

Statistical analysis

The data were analyzed using the InfoStat software, version 2010p (Facultad de Ciencias Agropecuarias, Universidad Nacional de Córdoba). The experiment was replicated tree times. Replicates were used to assess the reliability of the panel.[21] Means and standard deviations were calculated for each chemical variable and sensory attribute. Two-way analysis of variance ($\alpha = 0.05$, factors: 'treatment' and 'time'), and LSD Fisher's multiple range test were performed to find significant differences among means in data from chemical and sensory analysis of salami samples during storage.[24] The evaluation was arranged into blocks according to the panelist. Block-to-block variability was taken into account so as to increase the sensitivity of the study.[21] Principal component analysis (PCA)[25] was performed on the correlation matrix of

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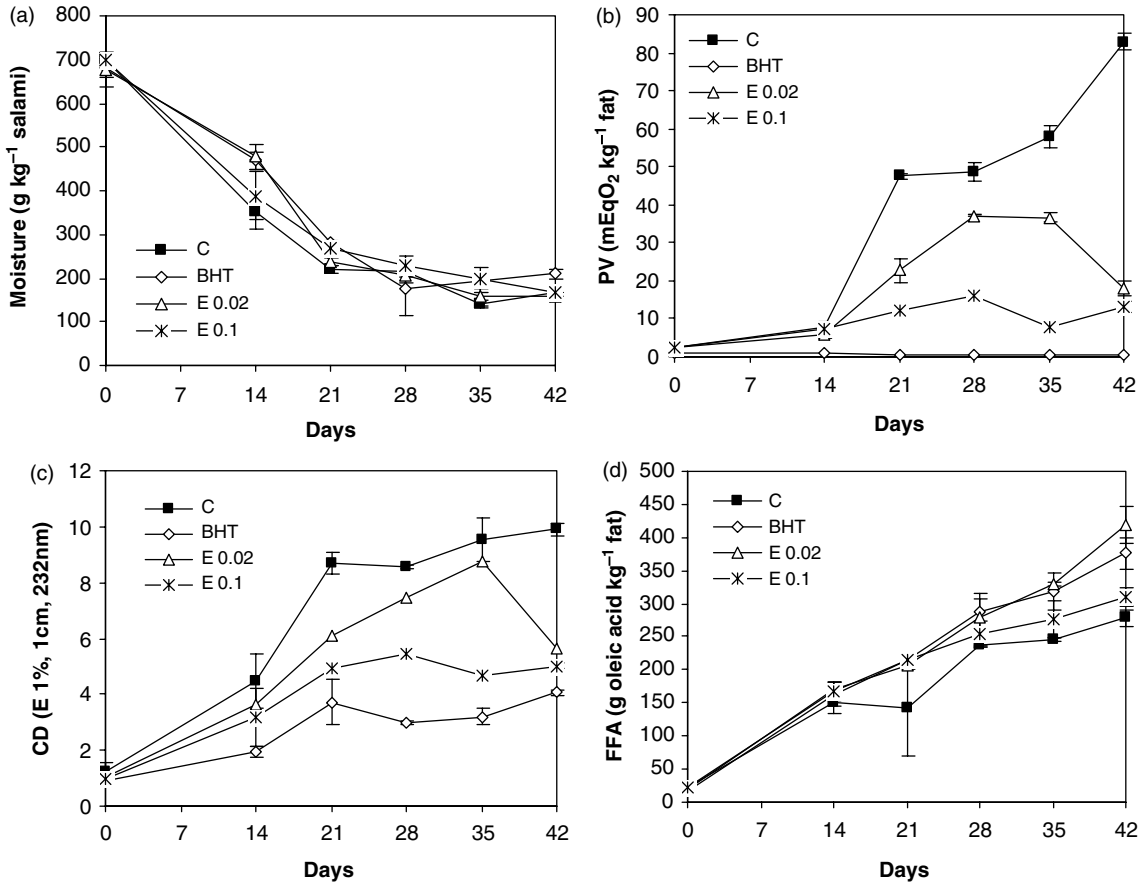

Figure 1. Changes in the chemical variables (a) moisture, (b) peroxide value (PV), (c) conjugated dienes (CD) and (d) free fatty acids (FFA) of salami during storage at 15 °C. Samples: C, salami control; BHT, salami with BHT; E0.02, salami with 0.2 g kg^{-1} PSE; E0.1, salami with 1.0 g kg^{-1} PSE.

the standardized data from chemical and sensory variables. The purpose of the PCA was to explore associations between chemical and sensory variables, and between different salami treatments (C, BHT, E0.02, E0.1).

RESULTS AND DISCUSSION

Chemical analysis

Changes in the chemical variables (moisture, PV, CD and FFA) from salami samples during storage are shown in Fig. 1. Salami samples exhibited significant changes in all chemical variables during storage. Moisture decreased significantly in all samples but no significant differences were found between salami treatments during storage. The first 14 storage days corresponded to the natural drying process. During this drying process, salami moisture and moisture/protein ratio averages decreased drastically from 689.7 to 421.2 g kg^{-1} and from 4.57 to 1.32, respectively. After 42 days of storage, the salami moisture and moisture/protein ratio were 174.7 g kg^{-1} and 0.42, respectively. These values were an average of all salami treatments. In other works,[26] dry-cured salami had a moisture content between 250 and 500 g kg^{-1} and moisture/protein ratio lower than 2.3. De Campos *et al.*[27] found dry matter content (628.5 g kg^{-1}) similar to that found in the present study after 14 days of storage (˜580 g kg^{-1}). The mentioned values can be considered as common for this kind of meat product.

PV and CD are primary lipid oxidation products. Both parameters increased during storage in all samples, with the exception of PV in BHT treatment. PV and CD presented similar behavior during storage in C, E0.02 and E0.1 samples. After 42 days of storage, control samples had the highest PV and CD values, followed by E0.02, E0.1 and BHT. At 35 days of storage, PV and CD from E0.02 treatment reached values near 35 and 9, respectively. After that time, PV and CD decreased markedly. This fact might indicate hydroperoxide decomposition.[9] In consequence, PSE at 0.2 g kg^{-1} (E0.02 treatment) had low antioxidant effectiveness. These results evidence that PSE displays a protective effect against lipid oxidation in salami, and this protective effect was proportional to the extract concentration.

In previous works Nepote *et al.*[14] reported that PSE at a concentration of 0.2 g kg^{-1} had a protective effect against lipid oxidation in honey roasted peanuts. Yu *et al.*[15] reported antioxidant activity of PSE as an antioxidant agent in cooked and raw beef. These authors observed that PSE at concentrations higher than 0.6 g kg^{-1} was as effective as butylated hydroxyanisole (BHA)/BHT at 0.2 g kg^{-1} in inhibiting lipid oxidation. O'Keefe and Wang[16] also found an antioxidant effect of PSE on beef products.

Severini and others [8] reported peroxide and thiobarbituric acid (TBA) values of salami products (traditional and with olive oil) as a function of ripening and storage time (56 days). They found PV and TBA increments until 42 and 15 days of storage, respectively, after which they decreased.

De Campos *et al.*[27] also reported changes in thiobarbituric acid-reactive substance (TBARS) values during 60 days of storage of salami products. They found that this chemical indicator increased in stored salami samples and was affected by the addition of 'yerba mate' extract. Salami samples treated with 'yerba mate' extract

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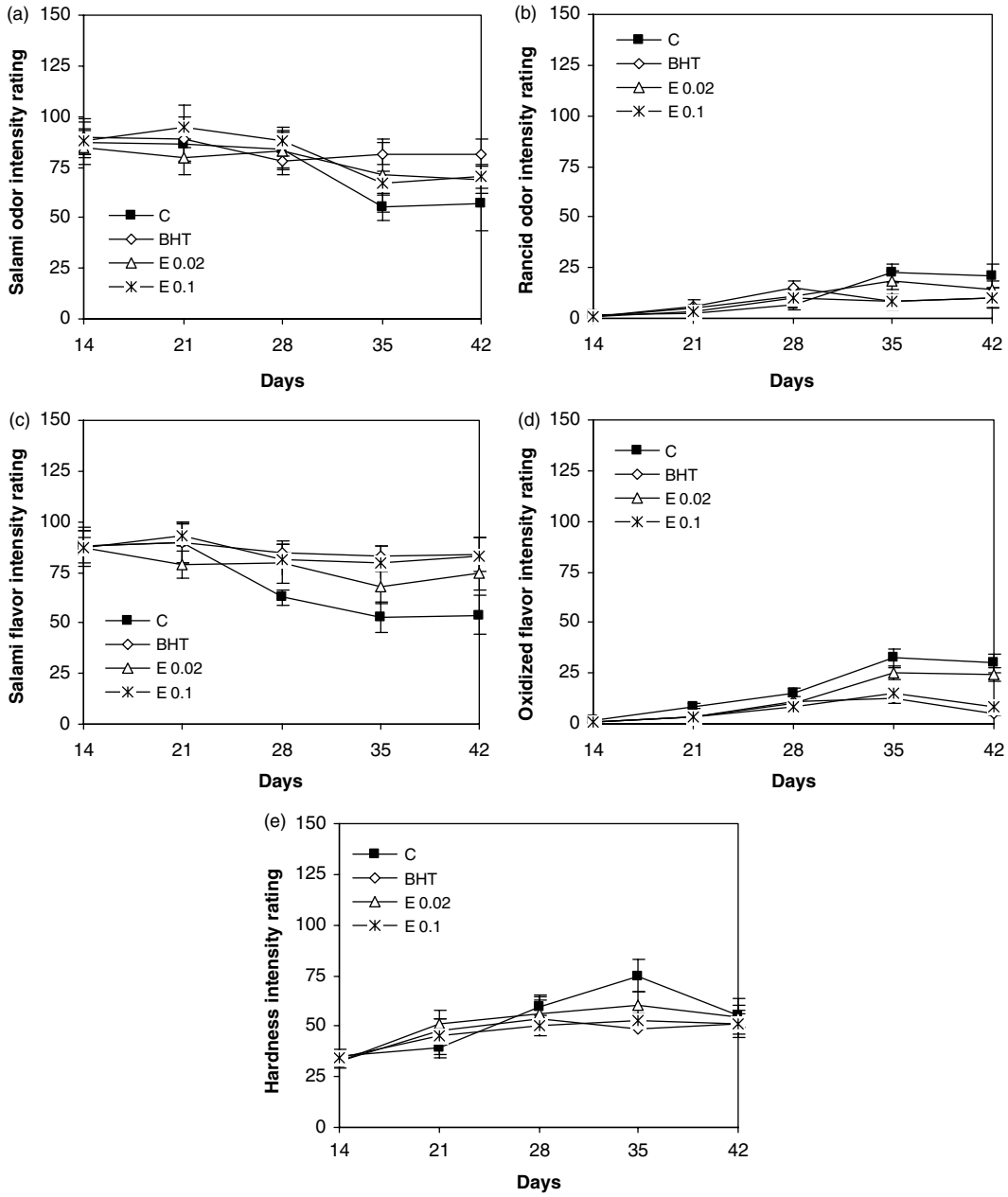

Figure 2. Intensity ratings (scale 0–150 mm) of the sensory attributes of dry-cured salami that significantly changed during storage: (a) salami and (b) rancid odors, (c) salami and (d) oxidized flavors, and (e) hardness. Samples: C, salami control; BHT, salami with BHT; E0.02, salami with 0.2 g kg^{-1} PSE; E0.1, salami with 1.0 g kg^{-1} PSE.

showed significantly lower TBARS values than those without any additive.

FFA values increased during storage in all samples. Raw salami had FFA content between 18 and 22 g oleic acid kg^{-1} fat. After 14 days of ripening, FFA values were between 152 and 169 g oleic acid kg^{-1} fat, and no significant differences were observed among treatments. Significant differences were found between salami treatments at 21 days of storage. After 42 days of storage, salami samples showed the following FFA values: 27.81 in C, 37.62 in BHT, 41.83 in E0.02 and 31.05 g oleic acid kg^{-1} fat in E0.1. Lipolysis reactions, which may occur as a result of enzymatic activity or high-temperature conditions in the presence of water, release fatty acids from triglycerides. [9] The PSE and BHT antioxidant did not protect the salami against this kind of deteriorative reaction.

Sensory descriptive analysis

Attribute intensity ratings from the descriptive analysis of dry-cured salami samples at storage day 14 did not show significant differences among treatments. On average, the attributes that showed the highest intensity (measured on a 0–150 mm line scale) in dry-cured salami were 'salami odor' (87.6), 'salami flavor' (87.5), 'salty' (86.4) and 'beef color' (87.6). Other attributes such as 'oily' (37.1), 'sour' (36.5), 'hardness' (33.8), 'pungency' (29.8), 'gloss' (29.3), 'tooth packing' (27.7) and 'fat color' (25.4) had lower intensity. At day 14, all salami samples had very low intensity ratings for 'rancid odor' (1.1) and 'oxidized flavor' (1.1).

Figure 2 shows intensity ratings of the sensory attributes on dry-cured salami samples that significantly changed (salami and rancid odors, salami and oxidized flavors and hardness) during the

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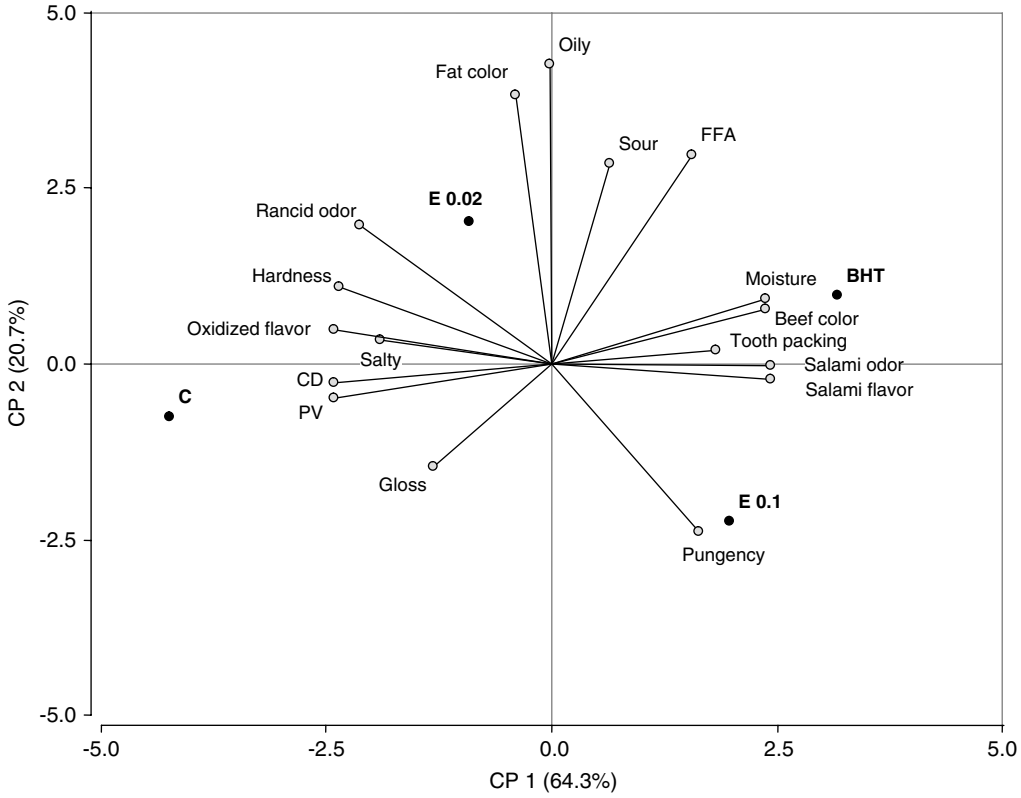

Figure 3. Biplot from the first and second principal components of PCA. Variables: moisture, chemical indicators (PV, CD and FFA) and sensory attributes (salami and rancid odors, salami and oxidized flavors, and hardness) of salami samples (C, salami control; BHT, salami with BHT; E0.02, salami with 0.2 g kg^{-1} PSV; E0.1, salami with 1.0 g kg^{-1} PSE) during storage.

storage period. In general, salami odor and flavor decreased during storage time, while rancid odor and oxidized flavor increased. The increase of rancid odor and oxidized flavor and the decrease of salami odor and flavor were markedly lower in BHT and E0.1 treatments. After 35 days of storage, significant differences in the intensity ratings of these attributes were perceived between the different treatments. Control salami sample had higher intensity ratings of rancid odor and oxidized flavor, and lower salami odor and flavor than the other samples during 42 days of storage. BHT and E0.1 treatments showed lower intensity ratings of rancid odor and oxidized flavor than the other samples.

Hardness attribute increased in all samples. Hardness intensity ratings did not show significant differences among BHT, E0.1 and E0.01 treatments during storage. At day 35, the control sample showed higher intensity rating of hardness than the other samples.

A hybrid descriptive analysis method consisting of the quantitative descriptive analysis (QDA) and the Spectrum™ analysis methods with an unstructured 150 mm line scale[22] was used to evaluate different attributes in the salami samples. Previous studies using this method were not found. However, different authors analyzed sensory attributes on salami products using different sensory methods with trained panelists. Marangoni and Fernandes de Moura[28] defined sensory descriptors in Italian salami after 90 days of storage using a methodology based on the QDA method with an unstructured 10 cm line scale. They reported the highest intensity ratings in 'rancid aroma', 'acid aroma', 'rancid flavor' and 'acid flavor'. Dellaglio *et al.*[29] evaluated 'Felino' salami, a type of Italian dry-cured sausage, with a mean age of 73 days, using a 1–7 scale. This last research reported high intensity ratings of 'rancidity', 'acidity', 'elasticity' and 'age' attributes. Moretti *et al.*[30] studied traditional salami ripened in different conditions using a 0–6 scale. They reported high intensities of 'firmness', 'flavor', 'cohesiveness' and 'color intensity'. Esturk and Ayhan[31] evaluated the texture of sliced salami using a trained panel. They reported an increasing intensity of 'firmness' and 'toughness' of salami samples during storage. In those research studies[28–31] some attributes such as rancid aroma, rancid flavor and firmness were evaluated that were similar to rancid odor, oxidized flavor and hardness, respectively, evaluated in the present study. All of these attributes increased their intensity ratings during storage.

Principal component analysis

The biplot obtained from the first two principal components (PC) is presented in Fig. 3. The first two PCs of the PCA explained 85% of the total variability. This percentage was considered acceptable to draw a correlation among the chemical and sensory variables. The dispersion of the points indicated high variability among samples. Oxidation indicators (PV and CD) were positively associated between them and with oxidized flavor, rancid odor, hardness, saltiness and gloss, and negatively associated with salami odor and flavor, moisture, beef color and tooth packing. Considering the relationships among sensory attributes and oxidation indicators, salami flavor, odor and beef color are positive sensory attributes for the product and they should be preserved during storage.

In addition, the biplot suggests a poor association between the oxidation indicators (PV and CD) and sensory attributes such as fat color, sourness, oiliness and pungency.

The control and E0.02 treatments, which showed higher values in lipid oxidation-related parameters (PV, CD, oxidized flavor and

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rancid odor), appear on the left side of the plot. Conversely, the treatments BHT and E0.1 appear on the right side of the plot associated with positive sensory attributes.

Similar associations between oxidation indicators and sensory attributes were observed in peanut products. Nepote *et al*.[14,32] reported that PV had a positive correlation with negative sensory attributes such as oxidized and cardboard flavors, and a negative correlation with 'roasted peanutty' and consumer acceptance. Nepote and others[14] also reported lower PVs and intensity ratings of oxidized and cardboard flavors in honey roasted peanuts added with PSE as compared to a sample without additives.

Other works on sensory quality of salami did not report any relationship between chemical and descriptive variables.

CONCLUSIONS

This study contributes new data concerning sensory characterization and oxidative stability of salami from Argentina during storage. The main sensory attributes described by panelists in dry-cured salami were 'salami flavor', 'salami odor', 'salty', and 'beef color'. In addition, relationships between chemical indicators such as PV, CD, moisture and descriptive attributes such as salami odor and flavor, rancid odor, oxidized flavor and hardness are reported.

Chemical indicators and descriptive sensory attributes indicated that the peanut skin extract at 0.1 ppm (E0.1 treatment) had a protective effect, prolonging salami shelf life.

Salami is a meat product highly consumed in Argentina and around the world because of both its high nutritional value and sensory characteristics. However, the short shelf life of this product may be a problem for its conservation. Findings obtained in this work show that PSE may be used for preparing salami with a longer shelf life and good sensory profile.

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