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Chemical, sensory, and microbiological stability of stored raw peanuts packaged in polypropylene ventilated bags and high barrier plastic bags

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ABSTRACT

The purpose of this study was to compare the chemical, microbiological, and sensory stability of raw peanuts packaged in high barrier plastic bags (EVOH) under vacuum and in regular polypropylene (PP) ventilated bags during 60 days of storage at 40 °C. The peroxide value showed a higher increase (from 0.38 to 0.95 meqO_2/Kg) in PP samples than in EVOH samples (from 0.38 to 0.63 meqO_2/Kg) during storage. The highest free fatty acids value (0.60g oleic acid/100g peanut oil) was reached by EVOH samples at day 60. The samples packaged in PP pouches showed a significantly higher oleic/linoleic ratio (15.94) and lower iodine value (78.07) with respect to EVOH (13.80 and 80.30, respectively) at the end of storage. A greater decrease of α-tocopherol was observed in PP ventilated bags (from 27.78 to 23.24 mg/100g oil) than in EVOH bags (from 27.78 to 25.10 mg/100g oil). At storage day 60, only molds were detected for both peanut samples but EVOH (2900 CFU/g) showed higher values than PP (2170 CFU/g). An increase of the cardboard flavor and a decrease of roasted peanutty were greater in PP samples. The EVOH bags preserve raw peanuts with better quality in comparison with PP bags.

1. Introduction

The peanut industry's challenge is to preserve chemical, microbiological and sensory quality of peanuts and peanut-containing foods until it reaches the consumer. Lipid oxidation is one of the major causes of peanut deterioration. Oxidative changes affect the overall quality of the end product making it less acceptable or unacceptable for consumers. Those reactions lead to the formation of volatile compounds such as hydrocarbons, alcohols, furans, aldehydes, ketones and acid compounds. Most of these are responsible for off-flavors and certain oxidation compounds are potentially toxic for human health (Akoh & Min, 2002).

Peanut seeds are rich in tocopherols. These are lipid-soluble natural antioxidants that act as free radical scavengers counteracting propagation of the free radical chain so that they protect against lipid oxidation. However, these antioxidants are prone to decomposition, particularly at elevated temperatures and the presence of oxygen molecules resulting in the formation of degradation products, and contributing to sensory or nutritional deterioration (Christopoulos & Tsantili, 2011).

Since oxidative reactions in food lipids are a constant concern for all mentioned above, it is important to know how different factors influence the rate of lipid oxidation to find the best way to keep the oxidative stability in peanuts and by-products during the marketing chain. There are many catalytic factors that can accelerate peanut lipid oxidation in postharvest management. The most important extrinsic factors are storage conditions including temperature, O_2 availability, time, exposure to light and relative humidity (Torres, Barros, Palacios, Chulze, & Battilani, 2014).

An improper handling of storage conditions may also promote the development and colonization of microorganisms. Therefore, in postharvest management, microorganisms continue their multiplication, and if storage conditions are not good, new microorganisms can colonize the product and contribute, along with lipid oxidation, to the emergence of undesirable flavors and mainly affect food safety (Torres et al., 2014).

Food processors attempt to reduce or prevent oxidation and colonization of microorganisms through the application of special

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measures to control storage conditions such as the removal of oxygen, addition of antioxidants, use of gas barrier packaging materials, nitrogen-filled headspaces, vacuum packaging and barriers to light (Talcott, 2005). Today, polypropylene (PP) ventilated big bags are the most universally used packaging to transport and store large tons of seeds, particularly peanuts, for long periods of time due to their proven convenience and low cost. However, the effects of this kind of packaging material on lipid oxidation, microbiological contamination and sensory attributes of raw peanuts during certain conditions of storage in comparison to others packaging materials such as ethylene vinyl-alcohol (EVOH) films are unknown. EVOH films are copolymers of ethylene and vinyl alcohol, which have many desirable properties such as their resistance to oils and weather effects, excellent barrier properties with low oxygen and water permeability, ability to prevent insect infestation and contamination with undesirables odors of the surrounding environment (McKeen, 2012).

The purpose of this study was to compare the chemical, microbiological and sensory stability of raw peanuts produced in Argentina, packaged in high barrier plastic bags (EVOH) under vacuum with respect to raw peanuts packaged in regular polypropylene (PP) ventilated bags during storage.

2. Materials and methods

2.1. Materials

Sound and mature seeds of raw peanuts type Runner (cv. Granoleico), size 38/42 kernels per ounce (2013 crop), were provided by the company Lorenzati, Ruetsch & Cia (Ticino, Prov. Córdoba, Argentina).

2.2. Methods

2.2.1. Storage conditions and sampling

Peanut samples (2 kg) were placed in bags (25 cm × 35 cm × 3.6 cm = 3150 cm^3) of two different packaging materials: a) polypropylene (PP) ventilated pouches (Córdoba Envases, Córdoba, Argentina) having 75 μm total thickness and b) high barrier plastic pouches made of ethylene vinyl-alcohol (EVOH) having 175 μm total thickness with an oxygen transmission rate of 1–5 cm^3/m^2/bar/24hs (DISE S.A., Cordoba, Argentina) packaged under vacuum condition (- 760 mmHg) using an industrial packaging machine. In both cases, there was no headspace in the bags because the material used for PP ventilated pouches was holey and the EVOH bags were packed under vacuum. The packaged kernels were placed randomly on shelves and stored in a dark room at 40 °C (accelerated storage conditions) and 60 ± 10% relative humidity for 60 days. The ambient temperature and relative humidity were recorded using a data logger. The samples were removed from storage on day 0, 20, 40, and 60 for analysis.

2.2.2. Peanut kernel moisture content

The moisture was determined by the method 27.500 (AOAC, 2010).

2.2.3. Lipid oxidation indicators

Peanut oil was obtained by cold pressing from the peanut samples using a 20-ton press (HE-DU, Hermes I. Dupraz S.R.L., Córdoba, Argentina). The following indicators were determined on peanut oil samples: peroxide value (PV) expressed as milliequivalents of active oxygen per kilogram of oil, meqO_2/kg (AOAC, 2010); conjugated dienes (CD) and trienes (CT) reported as extinction coefficient E 1%, 1 cm (COI, 2001); and free fatty acids (FFA) expressed as g oleic acid/100 g peanut oil (AOAC, 2010).

2.2.4. Fatty acid composition

The fatty acid methyl esters were analyzed on a Perkin Elmer Clarus 600 gas–liquid chromatograph (Waltham, Massachusetts, USA). A SAC™-5 capillary column (30m × 0.25 mm i.d., 0.25 μm film thickness; C#24156, Supelco) was used. Separation, identification and quantification of the fatty acid methyl esters were performed according to Asensio, Grosso, and Juliani (2015). Iodine value (IV) was calculated from the fatty acid composition using the formula:

$$IV = (\%\,C18:1 \times 0.8601) + (\%\,C18:2 \times 1.7321) + (\%\,C20:1 \times 0.7854)$$

2.2.5. Tocopherol analysis

Tocopherols' concentrations (α, β, γ and δ) in peanut oils were analyzed by HPLC according to Silva, Martinez, Casini, and Grosso (2010) using a Zorbax RX-SIL column (5 μm particle size, 4.6 × 250 mm, Agilent Technologies, Palo Alto, CA, USA). A solution of 0.5% v/v isopropanol in hexane was used as the mobile phase and tocopherols were detected at 298 nm. Identification and quantification of peaks were done by comparing their retention time with those of standards purchased from Sigma–Aldrich (St Louis, MO, USA).

2.2.6. Volatile analysis (VA)

The extraction of volatile compounds of peanut samples was done by solid phase microextraction (HS-SPME) fiber and analyzed by gas chromatography/mass spectrometry (GC/MS) according to Quiroga, Asensio, and Nepote (2014). The SPME fiber used was divinylbenzene/carboxen/polydimethylsiloxane (DVB/CAR/PDMS) (Supelco, Bellefonte, PA, USA). Raw peanut seeds (2 g) were ground and placed in a vial at 70 °C for 20 min. The fiber was exposed to the vial headspace for 10 min and then injected into a GC–MS Perkin Elmer Clarus 600 coupled with a mass detector. An ELITE 5MS (30 m × 0.25 mm i.d., 0.25 μm film thickness; Perkin Elmer) was used. The column temperature was programmed from 50 °C (10 min hold) to 280 °C (5 min hold) at a rate of 4 °C/min. Ionization was performed by electron impact at 70 eV. Identification of volatile compounds was performed in full scan mode (m/z 40–550) via a combination of the NIST mass spectral library and gas chromatographic retention times of standard compounds. When standards were not available, volatile compounds were tentatively identified using GC/MS spectra only.

2.2.7. Microbiological count

Counts of aerobic mesophilic bacteria were determined by culturing samples in TSA (Triptone Soya Agar, Britania Lab). Quantitative enumeration was done using the surface-spread method. Ten grams of each milled peanut sample were blended and homogenized in 90 mL peptone water (0.1 g/100 mL) in sterile sample bags. Plates were incubated for 24 h at 37 °C. The results were expressed as colony forming units per g of peanut kernels (CFU/g) (FDA-BAM Online, 2001).

Counting of total yeasts and molds was determined as stated above except that SDA (Sabouraud Dextrose Agar, BritaniaLab) was used as culture medium by pour-plated method. Plates used for counting were those containing 10–100 colony forming units (CFU). All plates were incubated at 25 °C for 5 days (ISO method 7954, 1987).

2.2.8. Sensory descriptive analysis

Peanut samples were roasted at 155 °C for 20 min in an air circulation oven (Garmont, Alta Gracia, Argentina) and blanched