Effect of Roasting Oil Composition on the Stability of Roasted High-Oleic Peanuts

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ABSTRACT: Off-flavor due to lipid degradation is an important factor in the shelf life of peanut products. The use of recently developed peanuts with high-oleic acid/linoleic acid (O/L) ratio has the potential to significantly extend the shelf life of roasted peanuts. To determine the full potential for shelf-life improvement of oil-roasted high-O/L peanuts, a study was conducted to examine the effects of roasting high-O/L peanuts (O/L = 30) in high-O/L (O/L = 23.2) or conventional (O/L = 1.5) peanut oil. Peanuts were roasted at 177°C to Hunter L values of 49 ± 1. Roasted peanuts were stored at 30°C for 20 wk. Samples were taken at regular intervals to determine PV, oxidative stability index (OSI), moisture content, and water activity. The O/L ratio of high-O/L roasted peanuts was 27.9 vs. 13.6 for the conventional oil-roasted peanuts. After 20 wk of storage, PV of conventional oil-roasted peanuts was 10.8 compared to 5.3 for the high-O/L-roasted peanuts. OSI values were 88.5 and 52.4 immediately after roasting for the high-O/L-roasted vs. conventional oil-roasted peanuts. OSI for both decreased, but differences remained similar throughout the storage period. Shelf life of high-O/L peanuts decreased when roasted in conventional O/L-peanut oil vs. high-O/L peanut oil.

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KEY WORDS: High-oleic peanut oil, oil-roasted, oleic/linoleic ratio, peanut oil, peanuts, shelf life, stability.

Nearly 2 million tons of peanuts (*Arachis hypogaea* L.) are grown in the United States each year, making the entire peanut industry a multibillion-dollar-per-year business. A major industry concern for roasted peanuts and peanut products is lipid oxidation and the production of associated off-flavors.

Lipid oxidation is potentially a significant problem as peanuts contain 50% oil. Approximately 95% of this oil is in the form of TAG (1). The eight major FA constituting the TAG in peanut oil are palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2), arachidic (20:0), eicosenoic (20:1), behenic (22:0), and lignoceric (24:0) (2).

Oleic and linoleic acids have a significant impact on the shelf-life potential of peanuts because they make up *ca.* 80% of the FA in peanut oil (3,4). Studies have shown that the oleic acid to linoleic acid (O/L) ratio is highly correlated with the shelf life of roasted peanuts, where higher O/L ratios are more stable (5). The O/L ratio of conventional peanuts is 1.5 with a range between 0.9 and 2.5. O/L ratios vary somewhat by cultivar, production area, and market grade (6,7). Warmer climates generally produce slightly higher O/L ratios within varieties of peanuts (8,9).

Research at the University of Florida examined *ca.* 500 peanut lines for FA distribution and identified two lines with O/L ratios of near 35 (10). O'Keefe *et al.* (11) compared the oxidative stability of high-O/L peanut oil to conventional peanut oil. Comparisons were made using extracted, neutralized, and bleached oil from isogenic peanut lines varying only in FA composition. Oil from the high-O/L line contained 76.3% oleic and 4.7% linoleic acids compared to 56.6% oleic and 24.2% linoleic acids in the conventional peanut oil. Oxidative stability was found to be 3.4 to 14.5 times greater for high-O/L peanut oil depending on the method of measurement.

The shelf life of roasted high-O/L peanuts is greater than that of conventional roasted peanuts (11). However, the question of how high-O/L peanuts should be incorporated into the existing oil-roasting industry has been left unanswered. The purpose of this study was to determine the full shelf-life potential of oil-roasted high-O/L peanuts.

EXPERIMENTAL PROCEDURES

Shelled medium-grade size, high-O/L peanuts (O/L ratio 30.0) were obtained from Golden Peanut Co. (Atlanta, GA) and held in cold storage prior to use. Seed coats were loosened by heating in a forced-air oven for 45 min according to the following protocol: 15 min at 43°C, 15 min at 66°C, and 15 min at 88°C. Peanuts were then cooled to room temperature with forced air, blanched, and split with high-pressure air as the peanuts were rotated in a perforated cylindrical metal basket. Peanuts were sorted on a grading screen to separate splits and whole seeds. Remaining whole peanuts were subjected to the high-pressure air treatment a second time and were discarded if they were not split. Blanched split seeds were held in cold storage prior to roasting. Peanuts were split for uniformity and to exclude the retention of oil in the lumen of the seed after roasting.

Split high-O/L peanuts were roasted in a Star oil fryer (Model 403; St. Louis, MO) in high-O/L peanut oil and conventional peanut oil. High-O/L oil was extracted, bleached, and deodorized from peanuts obtained from Dr. Dan Gorbet (University of Florida, North Florida Research and Education Center, Marianna, FL), and Chef's Best (Twelve Baskets Sales

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& Marketing, Mableton, GA) conventional peanut oil was purchased commercially. Peanuts were roasted at 177°C for 3.5 to 6 min to obtain a Hunter L value of 49 ± 1 as determined by a HunterLab colorimeter (Model D25-PC2; Reston, VA). Two 5200-g samples of peanuts were roasted in both high-O/L and conventional oil. Roasted peanuts were removed from the fryer and placed in a single layer on paper towels, and oil was blotted from the hot peanuts with paper towels as they cooled to room temperature. Each sample was randomly distributed into four 1-gal glass jars and stored in incubators at 30°C. Once each week, the jars were opened and peanuts were stirred. Samples were taken at 0, 2, 4, 6, 8, 10, 12, 16, and 20 wk and frozen at –20°C for later analysis.

Subsamples of 110 g were removed from the frozen samples and equilibrated to room temperature before being ground in a Braun KSM-2 coffee grinder (Frankfurt, Germany) to produce a homogeneous sample. Moisture analyses were performed on ground peanut samples (n = 4) using a Despatch LXD series forced-draft oven (Minneapolis, MN) at 130°C for 6 h (12). A Decagon AquaLab CX-1 water activity (a_w) meter (Pullman, WA) was used to measure a_w of ground peanut samples (in duplicate). The remaining ground sample (*ca.* 90 g) was wrapped in cheesecloth and hydraulically pressed at 20,000 psi for 12 min (Carver Laboratory Press; Fred S. Carver, Inc., Wabash, IN) to express oil for further analysis. Expressed oil was collected and analyzed for PV (n = 2) (AOAC method 411.16) (13) and oxidative stability index (OSI) (Omnion, Inc., Rockland, MA) (n = 3) (14). Raw and 0-wk samples (frozen immediately after roasting) were analyzed for total oil content (n = 2) by Soxhlet extraction as described by Kuck and St. Angelo (15).

Expressed oil from raw and 0-wk samples was prepared for FA composition analysis as described by Sanders (16). A Hewlett-Packard (Palo Alto, CA) gas chromatograph model 5890 equipped with an FID was used for FA analysis. A 30 m × 0.25 mm, 0.25 µm film thickness DB-23 (J&W Scientific, Folsom, CA) column was used. The initial temperature was set at 50°C for 1.5 min and programmed to increase at a rate of 8°C/min to 180°C before holding for 5 min at 180°C. The injector temperature was 230°C, and the detector temperature was 300°C. A 0.5 µL injection was made at a split ratio of 100 to 1. Helium was used as the carrier gas with a flow rate of 0.7 mL/min. FAME were identified by comparison of retention times with Nu-Chek-Prep (Elysian, MN) standard GCL-21A. O/L ratios were calculated based on the area percentages of each FAME. Chromatographic data were collected and stored on an IBM computer using Dionex AI-450 chromatography software (Sunnyvale, CA). All statistics were calculated using general linear models in SAS for Windows version 6.12 (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

Raw high-O/L peanuts contained 51.5% oil with an O/L ratio of 30. Moisture content and a_w of high-oleic peanuts before roasting were 5.6% and 0.545, respectively. PV of oil from raw high-oleic peanuts was 0.2 meq/kg, and OSI was 67.7 h. PV of conventional and high-oleic roasting oil was 1.0 and 0.6 meq/kg, respectively. OSI for the oils was 9.2 and 45.8 h, respectively. Conventional peanut oil and high-O/L oil had O/L ratios of 1.5 and 23.2, respectively. The O/L ratio of the oil pressed from the high-O/L peanuts after roasting was 27.9 for high-O/L oil-roasted samples and 13.6 for conventional oil-roasted samples. The O/L ratios of all samples were significantly different at $\alpha = 0.05$.

As a result of roasting, total oil increased by 2.1 to 3.0% in peanuts roasted in conventional and high-oleic peanut oil. Moisture content and a_w of peanuts roasted in conventional oil were 1.59% and 0.25, respectively, compared to 1.04% and 0.18 for high-O/L oil roasted peanuts (Table 1). Moisture content data were significantly different at $\alpha = 0.05$. The slight difference in moisture levels may be explained by the variation of roasting time between the two roasting oils.

Blumenthal (17) suggested that as oil degrades, more surfactants are formed, causing increased contact between oil and the food product being processed. This results in an increased rate of heat transfer to the surface of the food and increased oil uptake by the food. Increased rate of heat transfer would cause a more rapid frying of the peanut to the desired color and thus result in removal of less resident moisture from the peanut. Conventional oil-roasting times were shorter than high-O/L ratio oil-roasting times, and oil uptake was also greater (3.0 vs. 2.1%) in conventional oil-roasting. The conventional oil had been used to establish the roast time vs. color protocol, whereas the high-O/L oil was unused prior to sample roasting. Roasting times ranged 3.5–4.5 min in conventional oil and 5–6 min in high-O/L oil. High-O/L oil-roasted samples roasted longer and subsequently lost slightly more water during the process. However, moisture content and a_w (Table 1) appeared to equilibrate over storage time.

PV of high-O/L peanuts roasted in both conventional and high-O/L peanut oil remained at 0.2 meq/kg immediately after roasting. PV for conventional oil-roasted peanuts increased more rapidly than high-O/L oil roasted peanuts (Fig. 1). The

TABLE 1
Moisture Content (%mc) and Water Activity (a_w) of High-O/L Peanuts Roasted in Conventional and High-O/L Oil Stored for 20 wk

Storage time (wk)	Conventional O/L		High O/L	
	% mc	a_w	% mc	a_w
0	1.59	0.25	1.04	0.18
2	1.64	0.25	1.04	0.19
4	1.73	0.24	1.31	0.18
6	1.66	0.26	1.24	0.22
8	1.58	0.31	1.26	0.31
10	2.05	0.32	1.79	0.32
12	2.04	0.33	1.82	0.33
16	1.93	0.33	1.73	0.31
20	1.93	0.29	1.94	0.31

[a]%mc of raw high-O/L peanuts = 5.60. O/L, ratio of oleic acid to linoleic acid.
[b]Water activity (a_w) of raw high-O/L peanuts = 0.54.

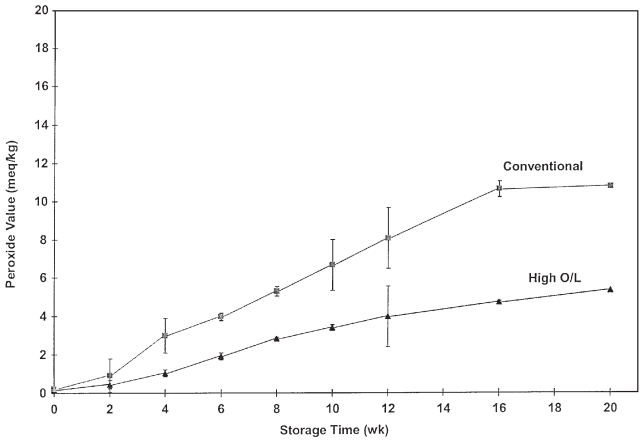

FIG. 1. Peroxide values of peanuts with high ratios of oleic acid/linoleic acid (O/L) roasted in high-O/L peanut oil and conventional peanut oil during 20 wk of storage at 30°C. Vertical error bars represent the standard deviation of four measurements.

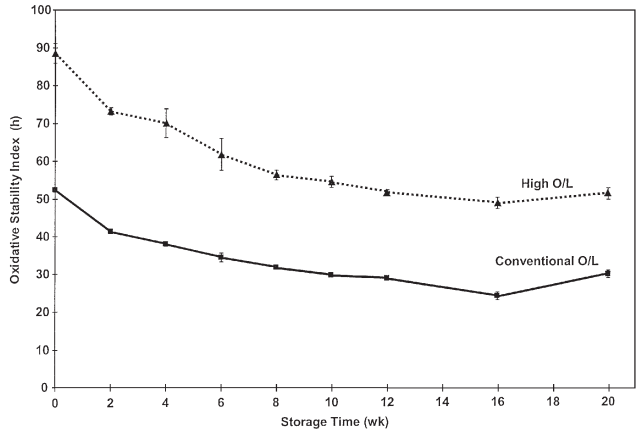

FIG. 2. Oxidative stability index (OSI) of high-O/L peanuts roasted in high-O/L peanut oil and conventional peanut oil during 20 wk of storage at 30°C. Vertical error bars represent the standard deviation of six measurements. For abbreviation see Figure 1.

PV of conventional oil-roasted samples was nearly twice that of high-O/L oil-roasted samples throughout the 20 wk of storage. The more rapid oxidation of the conventional oil probably accounts for the difference in PV, or, because oxidation is autocatalytic, free radical formation from conventional oil may also have resulted in accelerated oxidation of the high-oleic oil within the roasted peanuts.

O/L ratio changed from 30.0 in raw high-O/L peanuts to 13.6 after conventional oil-roasting. OSI decreased from 67.7 h for raw high-O/L peanuts to 52.4 h (Fig. 2) when roasted in conventional peanut oil (OSI = 9.2). This reduction in oxidative stability was possibly related to the decrease in O/L ratio due to uptake of conventional oil into the peanuts during the roasting process. OSI of high-O/L peanuts increased from 67.7 to 88.5 h (Fig. 2) when roasted in high-O/L peanut oil (OSI = 45.8). However, the O/L ratio decreased after roasting from 30.0 to 27.9. The increase in OSI may be related to the formation of antioxidant compounds during the roasting process. Many compounds formed during the Maillard browning reaction, which takes place in peanut roasting, exhibit antioxidant properties (18). Similar antioxidants were probably formed in the conventional oil-roasting, but the decrease in O/L ratio more than compensated for the positive effects of any antioxidant compounds formed.

OSI decreased at similar rates in both samples during storage (Fig. 2) with high-O/L oil-roasted samples remaining at least 21 h higher than conventional oil-roasted samples. After 20 wk of storage, high-O/L-roasted samples had an OSI similar to that of the conventional O/L oil-roasted peanuts immediately after roasting. High-O/L peanuts roasted in high-O/L oil had a longer shelf life than those peanuts roasted in conventional peanut oil. The data suggest that processors utilizing high-O/L peanuts should strongly consider use of high-O/L roasting oil to achieve the full shelf-life potential.

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