Factors Affecting the Shelf Stability of Sunflower Nuts

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Dehulled, raw, whole sunflower kernels of high-oleic acid (HOA) and high-linoleic acid (HLA) types were shelf-stable at 23 and 37°C for over one year. Dry-roasted HOA kernels were more stable than dry-roasted HLA kernels. Oil-roasted HLA kernels were more stable than dry-roasted ones. Stability of roasting oil and storage temperature had no appreciable effect on shelf stability of kernels.

KEY WORDS: Antioxidant, dry roast, high linoleic acid, high oleic acid, oil roast, peroxide value, shelf stability, sunflower nuts.

Seeds of the sunflower (*Helianthus annuus* L.) are produced for three markets—bird feed, human food and oil (1). The feed and food types are lower in oil content (21–33%) than the oil types (40–50%). As is the case with some other seeds, the linoleic acid content of the oil tends to be higher in those grown in northern latitudes (*e.g.*, Canada, Minnesota) than in those grown farther south (*e.g.*, Texas). The two principal fatty acids in sunflower seeds, oleic (18:1) and linoleic (18:2), normally comprise about 20 and 70%, respectively, of the total fatty acids.

Recently, plant breeders have succeeded in essentially inverting this relationship in both food and in oil types. The new so-called high-oleic acid (HOA) lines, containing up to 80–90% oleic acid, are also environmentally stable, *i.e.*, only minor fluctuations occur in linoleic acid content due to growing location (2,3). Because linoleic acid is about 20 times more susceptible to autoxidation than oleic acid (4), one would expect the high-oleic lines to produce oils and nuts with greater shelf stability than traditional lines. This has been shown to be true in the case of oils (5), but little published information is available on the comparative shelf stability of traditional *vs.* HOA sunflower nuts.

Sunflower seeds are stable to autoxidation in the unshelled state (6). Shelled, roasted sunflower nuts made from the traditional high-linoleic acid (HLA) lines are kept fresh by vacuum-packing them in metal cans or by rapid turnover of flexible film packs in the market. There is a potential for greatly expanded market opportunities for sunflower nuts in such products as breakfast cereals, if it can be shown that the high-oleic types are sufficiently shelf-stable, *i.e.*, lasting for up to one year without specialized packaging, particularly in the roasted state, because roasting imparts a more desirable flavor.

The purpose of this research was to compare the relative shelf stabilities of kernels of a traditional HLA sunflower type and a new HOA type as influenced by dry roasting, oil roasting in either peanut oil or a high-stability oil and oil roasting in the high-stability oil containing a natural antioxidant product.

MATERIALS AND METHODS

Sunflower kernels. HLA and HOA sunflower kernels were obtained from Dahlgren and Co., Inc. (Crookston, MN). Intact seeds were taken from cool storage and decorticated at Dahlgren's facility just prior to shipment to our laboratory. Only unbroken kernels were used in the studies.

Oils. A high-stability oil (Durkex-500) was obtained from the Van den Bergh Food Ingredient Group (Lisle, IL). The manufacturer's specification lists a minimum Active Oxygen Method (AOM) value of 300 h for this product. Peanut oil (Planters) was obtained from the grocery shelf. Although not determined in this study, peanut oils have AOM values that generally do not exceed 30–40 h (7). The fatty acid profiles of these two oils are given in Table 1.

Antioxidant. An oil-soluble natural antioxidant (Sunkatol No. 1) obtained from Taiyo Kagaku Co., Ltd. (Yokkaichi, Japan) is described as a special blend of tea extracts (polyphenolics) (10%), monoglycerides (18%), propyleneglycol ester of fatty acid (9%), partial polyglycerol ester of polycondensed fatty acids of castor oil (36%), ethanol (9%) and 50% mixed tocopherol concentrate (18%). It was added to the treated oils at the supplier's recommended upper limit of 600 ppm, weight basis.

Dry roasting. HLA and HOA sunflower kernels were spread evenly in a thin layer on a cookie sheet and roasted in an oven at 177°C for 5 min.

Oil roasting. HLA and HOA kernels (70 g per batch) were immersed for 1 min in 1.7 L of 177°C Durkex-500 oil or peanut oil in an electric deep-fat fryer (Oster "Li'l Fritter," 1200 W). HOA kernels were subjected to this same treatment in Durkex-500 oil and in peanut oil, each containing 600 ppm by weight of Sunkatol No. 1. The oil was changed after each six batches.

Storage. Raw and roasted HLA and HOA kernels were placed in 8-ounce Mason jars in 70-g portions; the jars were closed with 2-piece screw-type lids and stored at 23 and 37°C. Sufficient quantities of each treatment were stored to enable analysis over a period of at least one year. The lids were opened and reclosed at 1–2 mon intervals to ensure that excess oxygen was present.

Moisture and fat content. Moisture and fat content of the raw HLA and HOA kernels were determined in triplicate by AOAC (8) methods 27.005 and 27.006, respectively.

Oil extraction. At appropriate time intervals kernels were removed from storage, frozen by immersion in liquid nitrogen and ground for about 10 s in an Osterizer 10-speed blender at "frappe" speed. The oil was extracted for 6 h from two subsamples of the ground material from each treatment/storage time by the Soxhlet procedure with petroleum ether (b.p. 30–60°C). Then the two portions of oil were combined, and residual solvent was removed by flushing with nitrogen gas.

Fatty acid composition. The peanut oil used in frying and the oil samples extracted from raw, dry-roasted and oil-roasted HLA and HOA kernels at zero storage time were analyzed in duplicate for fatty acid composition by the gas chromatographic procedure of Einig and Ackman (9). After preparation of the methyl esters, analyses were performed in a Hewlett-Packard instrument (Model 5890; Palo Alto, CA) equipped with a Supelcowax™ 10 column

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TABLE 1

Fatty Acid Compositions of the Fresh Oils in Which High-Linoleic Acid and High-Oleic Acid Sunflower Kernels Were Roasted

Fatty acid	Percent of total fatty acids	
	Durkex-500[a]	Peanut oil
Palmitic	9	7.9
Stearic	5	1.4
Oleic	78	39.1
Linoleic	5	45.0
All others	3	6.6

[a]Data from Durkex-500 specification sheet (Van den Bergh Food Ingredient Group, Lisle, IL).

TABLE 2

Fatty Acid Composition of Raw and Dry-Roasted HLA and HOA Sunflower Kernels[a]

Fatty acid	Percent of total fatty acids			
	Raw		Dry-roasted	
	HLA	HOA	HLA	HOA
Palmitic	3.8	2.8	3.1	2.2
Stearic	2.6	1.7	2.6	1.7
Oleic	14.7	67.9	14.4	68.6
Linoleic	73.0	20.0	71.7	17.7
All others	5.9	7.6	8.2	9.8

[a]HLA, high-linoleic acid; HOA, high-oleic acid.

(0.32 mm i.d. × 30 m long, 0.25 m film thickness; Supelco, Inc., Bellefonte, PA), and a flame-ionization detector (FID) (300°C). The carrier gas was hydrogen. The chromatographic conditions were as follows: injection port temperature, 200°C; FID temperature, 300°C; initial oven temperature, 125°C for 4 min, then increased at 6°C/min to 260°C with a final hold time of 4.5 min. Fatty acids were identified by comparison with retention times of known standards.

Thermogravimetric analysis (TGA). Oil samples extracted at zero storage time from raw HLA and HOA kernels were subjected to TGA in a Mettler TA-3000 Thermal Analysis System (Mettler Instrument Corp., Hightstown, NJ). The system consisted of a hanging pan type electronic balance with a sensitivity of 10^{-3} mg and enclosed in a controlled temperature environment. Each oil sample (20.000–25.000 mg) was placed in a tared microcrucible such that approximately equal surface areas of the oil at 100°C were exposed to a continuous flow (60 cc/min) of oxygen for 600 min. The weight *vs.* time curves were plotted by an IBM PC interfaced to the system. The length of the induction period (IP) was determined as the exposure time coinciding with the intersection of the baseline (horizontal) and a straight line drawn through the major portion of the upward slope of the weight curve.

Peroxide values. Triplicate peroxide value determinations were performed by AOCS Method Cd 8-53 (10) on oil samples extracted at zero storage time and at intervals during storage.

RESULTS AND DISCUSSION

Moisture and fat contents of raw kernels. The raw HLA kernels contained 1.7% moisture and 54.9% fat as com-

TABLE 3

Fatty Acid Composition of HLA and HOA Sunflower Kernels Roasted in Durkex-500 or Peanut Oil with and Without 600 ppm Sunkatol[a]

Fatty acid	Percent of total fatty acids					
	Durkex-500			Peanut oil		
	Oil only		Oil + Sunkatol	Oil only		Oil + Sunkatol
	HLA	HOA	HOA	HLA	HOA	HOA
Palmitic	3.5	3.4	3.3	3.9	3.5	3.6
Stearic	2.7	1.9	1.7	2.5	1.6	1.9
Oleic	18.0	66.3	65.7	18.2	65.0	68.1
Linoleic	66.5	16.5	20.1	69.3	21.7	16.9
All others	9.3	11.9	9.2	6.1	8.2	9.5

[a]Abbreviations as in Table 2. Durkex-500 from Van den Bergh Food Ingredient Group (Lisle, IL); Sunkatol from Taiyo Kagaku Co., Ltd. (Yokkaichi, Japan); peanut oil was Planters Brand.

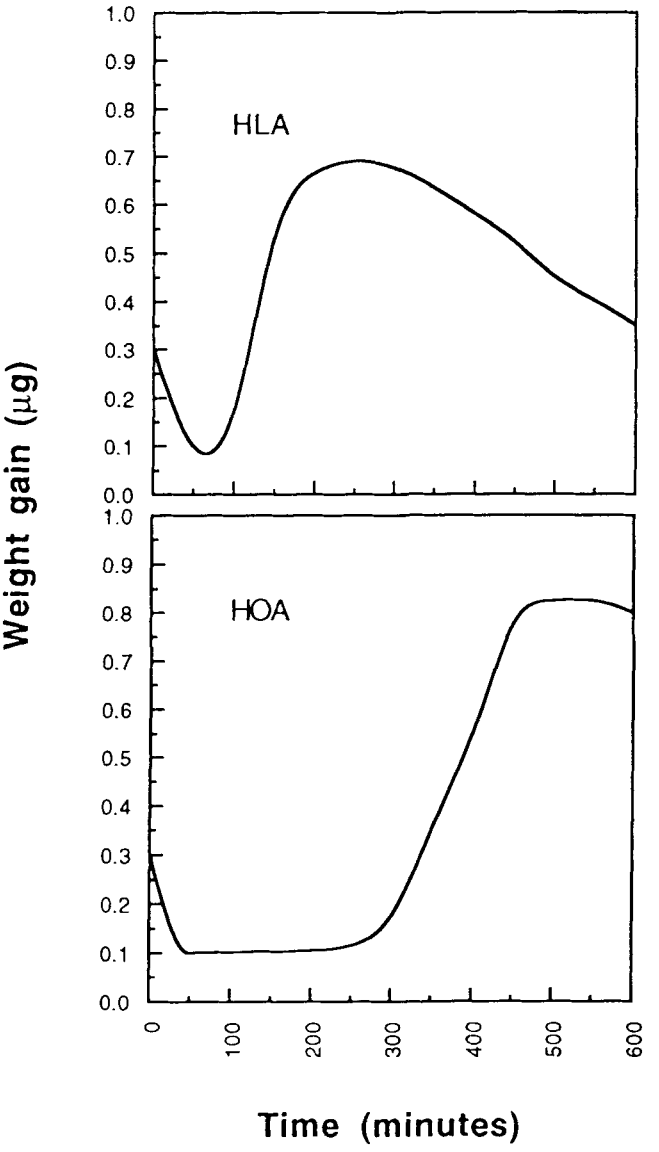

FIG. 1. Thermogravimetric analysis curves for oil extracted from high-linoleic acid (HLA) and high-oleic acid (HOA) sunflower kernels.

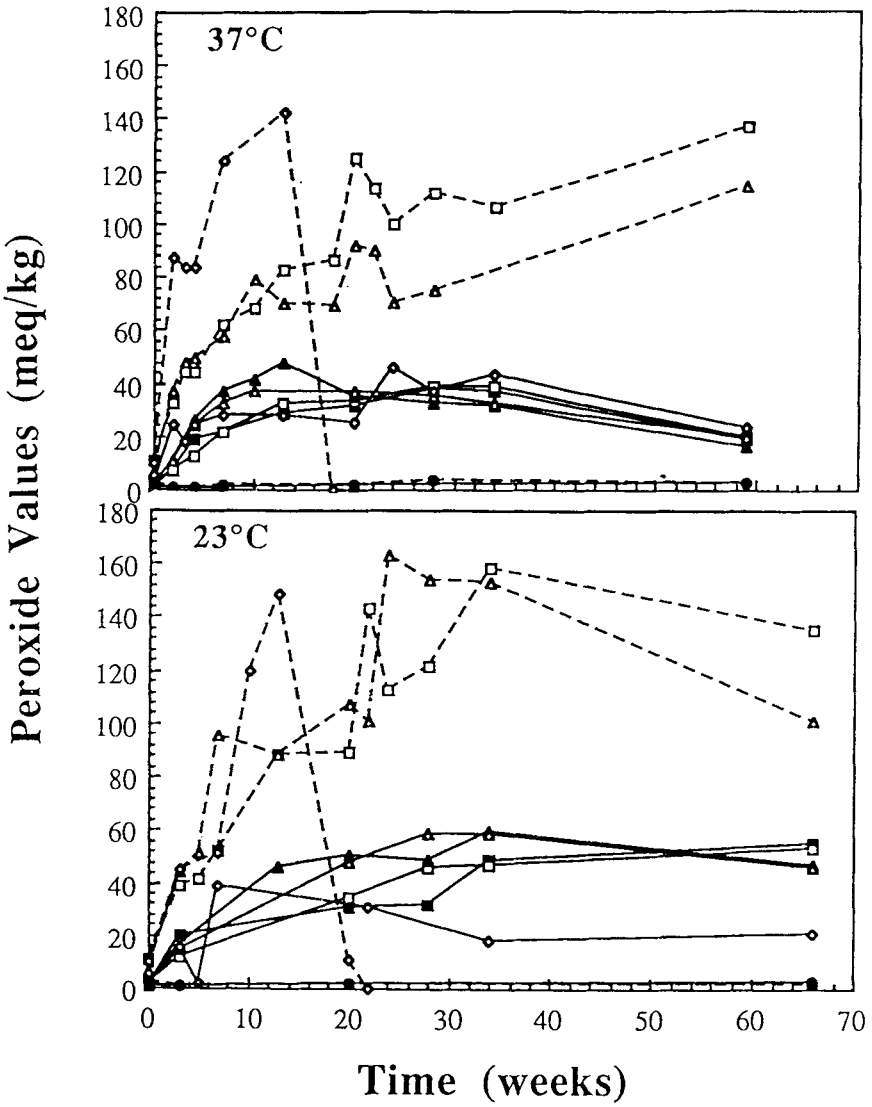

FIG. 2. Plots of peroxide value *vs.* storage time at 23 and 37°C for raw, dry-roasted and oil-roasted sunflower kernels. Dashed lines = HLA; solid lines = HOA. ● = raw, ◆ = dry roast, □ = high-stability oil roast, △ = peanut oil roast, ■ = high-stability oil + Sunkatol, ▲ = peanut oil plus Sunkatol. See Table 3 for abbreviations and information on the oils.

pared to 1.6% moisture and 58.4% fat in the raw HOA kernels.

Fatty acid compositions of roasting oils. The major compositional difference between the two roasting oils (Table 1) is that the peanut oil contained about one-half the level of the relatively stable monounsaturated fatty acid (oleic), but nine times the level of the more unstable diunsaturated fatty acid (linoleic) as compared to the high stability oil. Therefore, one would expect that if the stability of the roasting oil were to be a factor in the shelf life of the roasted nuts, the Durkex-500 oil would be preferred.

Fatty acid compositions of sunflower kernels. The fatty acid compositions of the raw and dry roasted kernels are presented in Table 2. The major difference is in the relative levels of oleic and linoleic acids in the sunflower oil extracted from the two kernel types. The HLA kernels contained about 72–73% linoleic acid and about 14–15% oleic acid. This relationship was essentially reversed in the HOA kernels, which contained about 18–20% linoleic acid and about 68–69% oleic acid.

Table 3 presents data on the fatty acid composition of the oil-roasted kernels. The HLA kernels contained about 66–69% linoleic acid and about 18% oleic acid, whereas HOA kernels contained 16–22% linoleic acid and about 65–68% oleic acid. The fatty acid compositions of the oil-roasted kernels were similar to those of the raw and dry-roasted kernels. Slight differences are probably due to actual compositional differences among sample lots and experimental error inherent in the analytical procedures. It does not appear that oil roasting produced any substantive changes in the fatty acid composition of the kernels.

Thermogravimetric stability of raw kernels. Figure 1 is a comparison of the TGA stabilities of oils extracted from the HLA and HOA raw kernels. The induction period for

oil extracted from HOA kernels (250 min) was about four times that for the HLA kernels (60 min), suggesting that the shelf life would be considerably longer for the former. The initial decrease in weight is due to evaporation of trace amounts of water or other volatile impurities, such as residual petroleum ether, used in extraction. This is followed by a flat curve whose length is proportional to the stability of the oil. The upward slope of the curve is due to the incorporation of oxygen into the oil by the formation of hydroperoxides. Eventually, the hydroperoxides, which are themselves unstable, decompose and the sample weight again decreases.

Shelf life of HLA vs. *HOA kernels.* Figure 2 shows plots of peroxide value *vs.* storage time for the raw kernels, dry-roasted kernels and oil-roasted kernels, with and without added antioxidant. It is evident that raw kernels of both the HLA and HOA types were extremely stable over a period of more than 60 wk at both storage temperatures.

Dry-roasted HLA kernels reached maximum peroxide values in about 10 wk at both storage temperatures. However, the HOA dry-roasted kernels appeared to be about as stable as the HOA oil-roasted kernels at 37°C and perhaps even more so at 23°C. The poor stability of HLA dry-roasted kernels has been observed previously (Dahlgren & Co., Inc., personal communication, 1990). This could be due to disruption of protective membranes or to surface dehydration. It is well established that lipid oxidation proceeds rapidly in dry systems.

Oil-roasted HLA kernels were only slightly more stable than their dry-roasted counterparts. At both storage temperatures, the oil-roasted HOA kernels were considerably more stable than their HLA counterparts, regardless of oil type. There appeared to be little difference in the onset and development of hydroperoxide formation between the two storage temperatures. The apparent greater stability in some cases at the higher temperature may have been due to a more rapid decomposition of hydroperoxides, once they had formed, at the higher temperature.

The effect of roasting oil type on the shelf life of sunflower kernels was of no practical importance. The peroxide value *vs.* time curves for the oil-roasted HLA kernels were roughly parallel, as was also true for the oil-roasted HOA kernels. This is not surprising, because the kernels apparently absorb little, if any, oil. The sunflower oil contained in the kernels themselves would be by far the major contributor to hydroperoxide formation. Therefore, there is no advantage to roasting the kernels in expensive, high-stability oil rather than in peanut oil or any other suitable, fresh oil. By the same token, the use of an antioxidant would also provide no added stability (shelf life), only added cost. In this study, the antioxidant was purposely omitted from the oils for roasting HLA kernels to minimize the number of analyses, but also because our goal was to maximize shelf life by focusing on the hypothetically more stable HOA type.

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