Oxidative Deterioration in Vegetable Oils: Health-Food Oils Versus Conventional Oils

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ABSTRACT

Storage stability of health-food and conventional vegetable oils was evaluated by determining oxidative deterioration during accelerated storage at 60°C of unused oils and room-temperature storage of unused and used (once-heated) oils. Oxidative changes were determined by peroxide value (PV), 2-thiobarbituric acid (TBA) test, measurement of weight increase, and sensory evaluation. Vegetable oils included were safflower and corn oils with (conventional oils) or without (health-food oils) added antioxidants. Health-food oils oxidized much faster by all measures than conventional oils, although composition of fatty acids was similar within each oilseed category. In addition, peak values of PV and TBA tests were higher for health-food oils than conventional oils. Differences between health-food and conventional oils increased steadily with the increase in storage time when unused oils were stored at room temperature; for used oils the steady increase was followed by a decrease after approximately 100 days. However, differences were greater with used oils than the unused within 100 days. As to the different oilseeds, safflower oils were more susceptible to oxidation than corn oils, the differences being widened by heating treatment before storage. The TBA test was more sensitive and correlated better with rancid odor development in these vegetable oils at early stages of oxidation, whereas peroxide value determination was generally more reliable for monitoring the oxidative deterioration over longer storage periods, up to certain limits.

In recent years the public has been increasingly interested in so-called health food, organic food, and natural food (5). The term "health food" is frequently used to be inclusive of organic and natural food. It is not unusual now to find separate health-food sections in the supermarket.

The available scientific reports on quality of health foods are limited to a small number of articles dealing with nutrient analysis and evaluation of eating quality (2,3,12). According to these reports, health foods are not better than conventional counterparts in the quality aspect studied. Health foods are, however, generally much more expensive than corresponding conventional foods (2). The growing concern in the public sector about food additives and the rapid growth of the health-food market led us to conduct a study on storage stability of health food versus conventional food. Specifically, the present study was concerned with stability of vegetable oils without preservatives. The investigation has been focused on oxidative deterioration during storage, since autoxidation is the primary cause of the quality deterioration of vegetable oils. Refined, salad and cooking oils were chosen because they can be found both in health-food stores and in the supermarket, whereas crude vegetable oils are sold only in health-food stores. Storage conditions and/or treatments employed were oven storage of unused oils and room temperature storage of unused and once-used (for frying) oils.

MATERIALS AND METHODS

Materials

Corn and safflower oils, processed as salad and cooking oils, were purchased from a local health-food store and a supermarket. All oils were of nationally known brands. The abbreviations to be used for the oils are CO-H (health-food corn oil), SF-H (health-food safflower oil), CO-C (conventional corn oil), and SF-C (conventional safflower oil). The purchase price of each health-food oil was twice as great as that of the conventional counterpart. CO-C contained isopropyl citrate and methyl silicone as additives and SF-C contained BHA, BHT, and citric acid. No additives were included in CO-H and SF-H according to label descriptions.

GLC analysis

Oils were converted to fatty acid methyl esters according to the AOAC (1) method. GLC analysis of methyl esters was done using a Hewlett-Packard Model 5710-A gas chromatograph equipped with a flame ionization detector. A stainless-steel column (6 ft x 1/8 inch) packed with 10% of 75%-cyanopropyl silicone on 100-120 mesh Chromosorb W was used. The trials were isothermal at 170°C and the carrier gas (helium) flow was 20 ml/min. Peak areas were measured with an electronic integrator. Peak identities and quantitative accuracy were determined from known standards for each fatty acid reported.

Chemical analysis

The peroxide value (PV) of oil samples was determined by the AOAC (1) method. The 2-thiobarbituric acid (TBA) test described by Tarladgis et al. (4) was slightly modified; 2 g of oil were emulsified with 0.2 g of Tween 20, and 5 ml of a 0.5% solution of propyl gallate and EDTA...
were added to the distillation mixture (16). TBA reagent was prepared in distilled water instead of an acidic medium (15).

Sensory evaluation

The oil samples stored at 60 °C were evaluated for the intensity of rancid odor with a laboratory panel of 8-12 judges. Those judges who were found to be entirely insensitive to rancid odor during preliminary judging sessions were eliminated from evaluation. A six-point descriptive rating scale ranging from 6 (not detectable) to 1 (very strong) was used for sensory scores. The oils were not warmed for odor evaluation. The mean odor scores of samples were calculated to relate the sensory data with the chemical analysis data.

Oil storage

For oven storage, 11-g aliquots of oils from newly opened bottles were weighed into 100-ml beakers and stored at 60 °C. The oil samples were periodically removed from the oven for chemical analyses and to determine the increase in oil weight. The remainder of each oil sample, after sampling for chemical analyses, was tightly covered and immediately placed in a freezer at -18 °C until the following day for sensory evaluation. The oven storage lasted until the oils were completely polymerized as judged by visual observation of viscosity.

For shelf storage, a 150-ml aliquot of each oil was placed in a 450-ml glass storage bottle (6.5 cm I.D.) with lid and stored in the dark at room temperature (24-26 °C). An amount necessary for chemical analysis was withdrawn from storage bottle at each sampling period.

To determine the stability of once-heated (used) oils, 120 g of flour-water mixture (1:6, wt/vol) were fried for 20 min in 450 ml of oil in an aluminum electric skillet. Oil was first added to the unheated skillet and heated to 191 °C before introducing the flour-water mixture. The fried dough and small dough fragments were removed before the used oil was divided into 30-ml aliquots in 100-ml beakers and stored in the dark with a sheet of paper loosely covering the samples.

RESULTS

Fatty acid composition of oils

Fatty acid profile of each health-food oil was nearly the same as that of the corresponding conventional oil. The fatty acid data (Table 1) of these oils were comparable with those of USDA (4).

Oven storage

The results of PV and TBA-number determinations are illustrated in Fig. 1. Health-food oils oxidized faster than conventional oils. In addition, the peak values of both chemical tests were higher for the health-food oil in each oilseed category. PV and TBA number increased faster with safflower oils (for both health-food and conventional) than with corn oils.

The relative rates with which rancid odor developed with these oils were: SF-H > CO-H, SF-C > CO-C. A high correlation was demonstrated between TBA number and odor score and between TBA number and PV during the earlier period (up to 12 days) of storage, but the correlations decreased upon extending the storage period to 20 days (Table 2). The correlation between PV and odor score was also high, but changed little when the storage period was increased to 20 days. The weaker correlation between TBA number and odor score during the 20 days of storage was attributable to the two TBA value peaks observed with SF-H (see Fig. 1); we also have observed two TBA value peaks with soybean oils which usually contain considerably higher amounts of linolenic acid (unpublished data). The relationship between PV and TBA number was similarly influenced by the emergence of two TBA value peaks. No odor evaluation was made beyond 20 days of storage since all oils were moderately to strongly rancid by this time.

![Figure 1. PV and TBA numbers during oven storage of health-food and conventional oils at 60 °C.](image)

### TABLE 1. Fatty acid composition<sup>a</sup> by GLC analysis

<table>
<thead>
<tr>
<th>Oils</th>
<th>Saturated fatty acids (%)</th>
<th>Unsatuated fatty acids (%)</th>
<th>Total poly-unsaturated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16:0 18:0 20:0 22:0 16:1 18:1 18:2 18:3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health-food oils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safflower</td>
<td>Trace 8.4 2.4 Trace</td>
<td>13.4 75.8 Trace</td>
<td>75.8</td>
</tr>
<tr>
<td>Corn</td>
<td>12.0 1.9 Trace</td>
<td>24.8 60.0 1.2</td>
<td>61.2</td>
</tr>
<tr>
<td>Conventional oils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safflower</td>
<td>7.7 2.5 Trace</td>
<td>13.9 76.0 Trace</td>
<td>76.0</td>
</tr>
<tr>
<td>Corn</td>
<td>12.4 2.1 Trace</td>
<td>24.8 59.5 1.2</td>
<td>60.7</td>
</tr>
</tbody>
</table>

<sup>a</sup>Calculated as percentage of total GLC peak area, as methyl esters.
Oil samples were also weighed at intervals to indirectly determine the amount of oxygen absorbed (9). Although the data are not presented in detail, the patterns of weight increment rate were similar to those of PV increase; the rate of weight gain was faster with health-food oils than conventional oils.

**Room temperature storage**

The results of PV determination showed that health-food oils were more susceptible to oxidation than conventional oils regardless of whether oils were used or unused. The rates of PV increase were: unused oils — SF-H > CO-H > SF-C > CO-C; used oils — SF-H > SF-C > CO-H > CO-C. The differences between health-food and conventional oils increased steadily with the increase in storage time for unused oils. For used oils the difference increased until about 100 days, followed by a decrease (Fig. 2). This indicates that the major part of oxidation occurred with health-food oils within 100 days of storage while conventional oils were still oxidizing after 100 days.

The differences between health-food and conventional oils were greater for used oils than the unused within 100 days. The opposite was observed in storage beyond this period — storing once-heated oils longer than 100 days is an unlikely practice in the use of vegetable oils. The differences between SF-H and CO-H and also between SF-C and CO-C were also widened by the heating treatment. It should also be noted that safflower oil with additives oxidized faster than corn oil without additives when the oils were once heated before storage.

**DISCUSSION**

PV determination is the most widely used chemical method to measure oxidative rancidity of fats and oils, whereas the TBA test is as widely used for meat products. Although the TBA test has not been adopted for the day-to-day quality control and product development in food industry, its usefulness for oil products has been indicated (7,18). The present study has demonstrated that the TBA test is more sensitive and correlates better with rancid odor development in vegetable oils at early stages of oxidation, whereas PV determination is generally more reliable for monitoring the oxidative deterioration over longer storage periods, up to certain limits.

Conventional vegetable oils had greater storage stability than health-food oils as evaluated by all measures. Safflower oils oxidized at a greater rate than corn oils as predictable from the high content of polyunsaturated fatty acid (mostly linoleic acid) in safflower oils. The widened gaps after heating treatment between health-food and conventional oils and also between safflower and corn oils have a practical implication in the use of these oils — whether to be used as salad or cooking oils, particularly for repeated use in frying. Safflower oil has been promoted as an ideal polyunsaturated dietary fat to alleviate problems encountered with consumption of saturated fats in connection with coronary diseases. Precautions should be exercised by dietitians and consumers in handling this vegetable oil.

The result of oxidative deterioration of vegetable oils does not end with development of rancid odor in the oils or in food products prepared with the oils. Loss of potency of the fat-soluble vitamins A, D, and E due to co-oxidation induced by lipid peroxides has been well established. Similarly, co-oxidation results in destruction of the water-soluble vitamins, pyridoxine, pantothenic acid, biotin, and ascorbic acid. Adverse effect of oxidizing lipids on the nutritive and biological values of the water-soluble vitamins, pyridoxine, pantothenic acid, biotin, and ascorbic acid. Adverse effect of oxidizing lipids on the nutritive and biological values of the water-soluble vitamins, pyridoxine, pantothenic acid, biotin, and ascorbic acid. Adverse effect of oxidizing lipids on the nutritive and biological values of the water-soluble vitamins, pyridoxine, pantothenic acid, biotin, and ascorbic acid.

Further, toxicity of oxidized lipids has been discussed (8). Finally, it should be noted that the health-food users’ rationale or reasons for consuming health-foods are directly or indirectly related to the health and nutritional aspects (13). The implication of this study is in contrast with their belief.

**REFERENCES**