Food Chemistry **31** (1989) 215–224

Oxidative Stability of Sesame Oil Prepared from Sesame Seed with Different Roasting Temperatures

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(Received 13 January 1988; revised version received and accepted 22 April 1988)

ABSTRACT

Sesame oils were prepared from sesame seed with different roasting temperatures (A, 180°C; B, 190°C; C, 200°C and D, 210°C) before pressing and then stored at various conditions for the evaluation of their oxidative stability in comparison with refined soybean oil. No apparent differences were found in peroxide formation between sesame oils stored in the dark at room temperature. However, peroxide, and conjugable oxidation products of sesame oil (A) and soybean oil increased rapidly on exposure to fluorescent light or stored at 60°C. Amounts of volatiles in sesame oils exposed to fluorescent light or stored at 60°C increased markedly, especially pentane and hexanal, but were lower than in soybean oil. Sesame oil (C) had higher oxidative stability and flavour scores than other samples when exposed to fluorescent light.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest oil seed crops known to mankind. Its oil has a mild taste and is high in unsaturated fatty acids (*c.* 85%) (Sonntag, 1981). The sesame oil prepared from roasted seed has a special flavour and long shelf-life (Manley *et al.*, 1974; Kikugawa *et al.*, 1983) and is more prevalent in the Far East.

Sesame oil is known to be the most resistant to oxidative rancidity among the several vegetable oils. Fukuda *et al.* (1986) reported that the major

Food Chemistry 0308-8146/89/$03·50

antioxidants of sesame oil are sesamol and γ-tocopherol. The authors also indicated that sesamol is higher in roasted seed oil than unroasted seed oil. It was found that certain processing treatments resulted in the formation of free sesamol from its bound form (sesamolin). On the other hand, crude sesame oil contained high amounts of chlorophyll. Chlorophyll was reported as a prooxidant in oils when exposed to fluorescent light (Usuki *et al.*, 1984); however, it showed antioxidative activity in the autoxidation of oils when stored in the dark (Endo *et al.*, 1985). Thus, the oxidative stability of sesame oil would be influenced by antioxidative components, especially in crude sesame oil. However, data concerning the effect of processing conditions on the change of antioxidative components and oxidative stability of sesame oil have scarcely been reported.

Yen *et al.* (1986) reported the optimum processing conditions for sesame oil and indicated that the quality of sesame oil was affected by the roasting temperature. The purpose of this study was to investigate the oxidative stability of sesame oil prepared from sesame seed with different roasting temperatures and to compare the sesame oil with refined soybean oil under various oxidative conditions.

MATERIALS AND METHODS

Materials

The sesame seed used in this study, which was imported from Thailand, was purchased from a local oil manufacturer in Taichung. The refined soybean oil was obtained from Taisun Oil Co. with the following characteristics: acid value, 0·04; iodine value, 128; saponification value, 195.

Methods

Preparation of sesame oil

Washed and dried sesame seed was roasted at 180°C, 190°C, 200°C and 210°C ($\pm$5°C) for 30 min with an automatic roasting machine, ground to pass through a 12 mesh sieve, steamed with boiling water for 7 min and finally pressed (300 kg/cm^2) to obtain sesame oil.

Storage studies

Samples of sesame oil from different roasting temperatures and soybean oil, 10 ml each, were placed in a series of transparent glass bottles having a 5 cm

cross section and a volume of 20 ml each. The bottles remained loosely capped, enabling direct contact between oil surface and atmospheric air. The oil samples were exposed to three oxidative conditions: absolute darkness at room temperature (25 ± 1°C), an opaque laboratory oven at 60°C, and exposure to a 40 W fluorescent lamp for 24 h per day (with 1 m distance) at room temperature (25 ± 1°C).

Peroxides measurement

Peroxides of oils were determined by the ferric thiocyanate method as described by Ueda *et al.* (1986).

Conjugated oxidation products

The oil samples were diluted in iso-octane to a final concentration of 2 mg/10 ml. Conjugated dienes and trienes in oil samples were determined spectrophotometrically (Shimadzu double beam spectrophotometer, Model-220) at 232 and 268 nm, respectively (Yoon *et al.*, 1985).

Gas chromatographic volatile profiles

The direct GC method developed by Dupuy *et al.* (1976) was used for the analysis of volatiles from the oxidized sesame oil and soybean oil with a modification. The analysis was performed on a Shimadzu Model GC-6AM gas chromatograph equipped with a 274·3 × 0·3 cm stainless steel column packed with Porapak P 80/100 mesh (Supelco Co., PA). The oil was injected directly into the heat inlet of the GC through a linear tube packed with glass wool. The flame ionization detector (FID) and injector ports were maintained at 220°C. Column oven was maintained at 40°C during the initial hold period of 40 min, then programmed to 180°C at 4°C per min and held at 180°C for 35 min. The flow rate of nitrogen carrier gas was 60 ml/min; hydrogen, 30 ml/min; air, 300 ml/min. The pentane and hexanal peaks were identified by comparison of retention times with authentic compounds. Total volatiles, pentane and hexanal were used to evaluate the relationship between flavour score and volatiles in oils.

Sensory evaluation

Samples were submitted to an experienced panel consisting of 15 persons. The panellists were asked to rate the odour and flavour scores of the sample on a 10-point hedonic scale in which 10 = 'like extremely', and 1 = 'dislike extremely'. Analysis of variance was performed on the data set to determine whether there were significant differences by treatment in odour or flavour. Differences of treatment means at the 5% probability level were evaluated by LSD tests (Steel & Torrie, 1960).

RESULTS AND DISCUSSION

In the present study, the sesame oils prepared with different roasting temperatures, 180°C, 190°C, 200°C and 210°C, were designated as samples A, B, C and D, respectively. The results showing the oxidative stability of sesame oils and refined soybean oil are presented in Figs 1–4 and Table 1. The values that appear in these figures and table are the averages of three determinations except the sensory evaluation.

Oxidative evaluation during storage

Hydroperoxide is the primary product of lipid oxidation; therefore, the determination of peroxide value can be used as an oxidative index for the early stage of lipid oxidation. It generally can be stated that low quality oil will have a shorter induction period. In this study, the ferric thiocyanate method was used for measuring the change of hydroperoxide in oil samples during storage under various conditions; the results are given in Fig. 1.

The increase of hydroperoxide in refined soybean oil was faster than other sesame oils stored in the dark at room temperature. However, there was no apparent difference in peroxide formation among sesame oils stored in this condition for 10 weeks. Sesame oil (D) showed better stability than other samples at the end of this storage condition; this might be due to sample D containing a high level of sesamol, which formed from sesamolin in sesame oil with the high roasting temperature treatment.

The hydroperoxide, in refined soybean oil on exposure to fluorescent light, increased more markedly than when stored in the dark at room temperature. The sesame oils showed similar tendencies in hydroperoxide formation except the sample A when exposed to fluorescent light. With this storage condition, sample C gave the best oxidative stability among the oil samples.

Oil stability is usually determined under accelerated conditions (60°C or more) because ambient conditions demand an excessively long period. The peroxide value (absorbance at 500 nm) of refined soybean oil was over 1 absorbance unit when stored in the dark at 60°C for 6 weeks; however, all the sesame oils gave peroxide values below 0·5 units. This might result because the soybean oil had a higher linolenic acid and lower antioxidant content than sesame oil. In sesame oil, the formation of hydroperoxide in oil samples stored at 60°C was lower than those exposed to fluorescent light except for the sample A. This may be due to the degradation of sesamolin to sesamol by increasing storage temperature which can prevent the oxidation of sesame oil. In addition, Fig. 1 also illustrates that the content of hydroperoxide in refined soybean oil increased with storage time; however, the induction period of oxidation of sesame oil was longer than refined soybean oil until 6 weeks of storage, then the hydroperoxide increased.

TABLE 1

Development of Volatile Content and Flavour Score in Sesame Oils and Soybean Oil during Storage under Various Conditions.

Oil sample	*Storage time (weeks)*	*At RT* in dark*				*At 60°C in dark*				*Exposed to fluorescent light at RT**			
		GC Peak Area ($\times 10^3$)			*Flavour score*	*GC Peak Area ($\times 10^3$)*			*Flavour score*	*GC Peak Area ($\times 10^3$)*			*Flavour score*
		Pentane	*Hexanal*	*Total volatiles*		*Pentane*	*Hexanal*	*Total volatiles*		*Pentane*	*Hexanal*	*Total volatiles*	
Sesame oils													
A**	0	24·0	13·8	101·7	***	24·0	13·8	101·7		24·0	13·8	102	
	4	43·3	25·2	121·2		142	128	857		210	98·4	607	
	8	60·0	70·7	289·5	4·31[b]	417	216	952	3·08[c]	228	122	852	4·15[c]
B**	0	16·8	14·3	76·5	***	16·8	14·3	76·5		16·8	14·3	76·5	
	4	37·0	20·6	117·6		42·7	48·1	206		63·3	55·8	194	
	8	42·4	26·4	190	5·23[ab]	49·4	93·9	306	5·00[b]	87·0	81·5	559	4·77[c]
C**	0	2·2	2·0	14·8	***	2·2	2·0	14·8		2·2	2·0	14·8	
	4	18·1	6·2	41·3		13·3	12·4	57·3		23·5	14·1	76·6	
	8	19·7	18·6	85·0	6·38[a]	19·7	12·5	64·5	6·46[a]	25·2	17·6	467	6·23[a]
D**	0	2·5	2·9	24·1	***	2·5	2·9	24·1		2·5	2·9	24·1	
	4	13·8	17·4	73·4		15·6	19·4	90·0		35·9	26·9	142	
	8	22·2	17·6	121	6·08[a]	47·4	43·1	198	5·85[a]	65·8	52·8	526	5·54[b]
Soybean oil	0	33·3	13·5	95·8	***	33·3	13·5	95·8		33·3	13·5	95·8	
	4	40·4	14·2	108		723	203	2 493		373	57·2	662	
	8	61·6	82·6	430	2·31[c]	1 882	583	4 786	1·46[d]	687	64·0	1 051	1·92[d]

* Room temperature.

** Sesame oil samples A, B, C and D were prepared with roasting temperatures 180, 190, 200, 210°C, respectively.

*** Means in the same column with different superscripts are significantly different ($p < 0·05$).

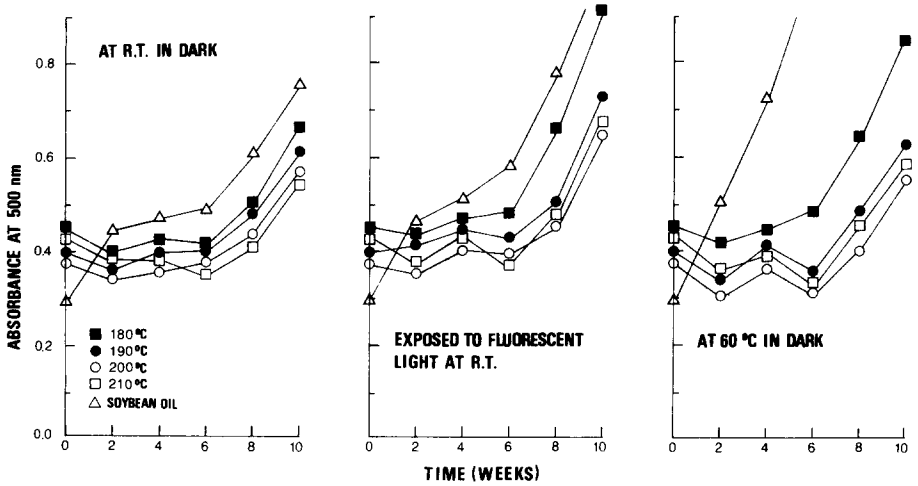

Fig. 1. Development of POV (at 500 nm) in sesame oils (prepared with different roasting temperatures) and soybean oil during storage under various conditions.

The determination of conjugated dienes (absorbance at 232 nm) and trienes (absorbance at 268 nm) which are measures of primary and secondary oxidation, respectively, was carried out so that more evidence about the state of lipid oxidation could be obtained. Figure 2 shows the changes of conjugated dienes and trienes in oil samples during storage under various conditions. The results indicate that the trends for changes in conjugated dienes paralleled the trends observed for changes in peroxide value as shown in Fig. 1. Meanwhile, the changes in conjugated trienes were

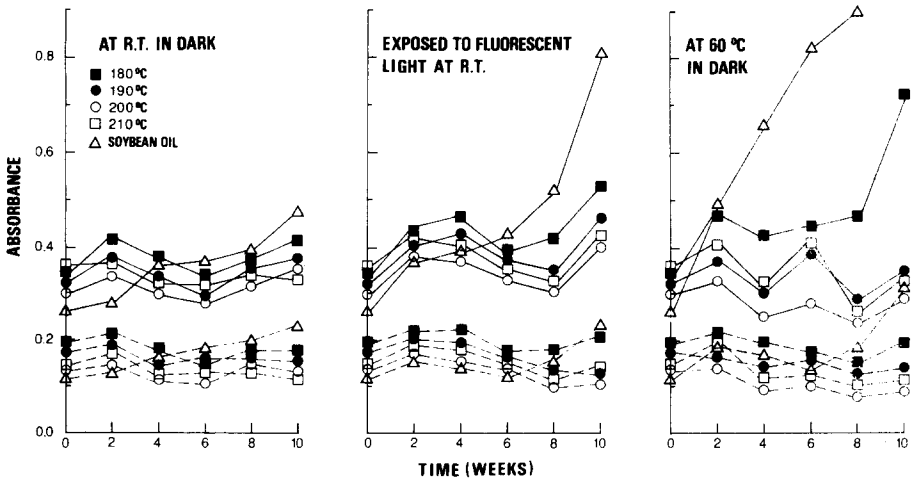

Fig. 2. Change of absorbance at 232 nm (solid line) and 268 nm (dotted line) in sesame oils (prepared with different roasting temperatures) and soybean oil during storage under various conditions.

less marked than the changes in conjugated dienes during the storage period. Although the fresh soybean oil contained the lowest level of conjugated dienes and trienes, the increase of conjugated dienes and trienes in soybean oil was faster than in sesame oils. The high content of conjugated oxidative products in soybean oil after 10 weeks storage can be attributed to the high linoleic acid and linolenic acid contents in soybean oil, since these two fatty acids are readily decomposed to form conjugated hydroperoxides.

Figure 2 also shows that sample D contained the lowest level of conjugated oxidative products when stored in the dark at room temperature, while sample C gave the lowest level of conjugated oxidation products when exposed to fluorescent light or stored in the dark or at 60°C. The results also reveal that the contents of conjugated oxidation products in oil samples exposed to fluorescent light were higher than when stored in the dark at room temperature. The reason for this result may be due to the photoxidation which would produce more hydroperoxide isomers (Dahle *et al.*, 1962).

Correlations between volatiles and flavour scores of oil samples

The hydroperoxides formed from oxidation of unsaturated fatty acids are very unstable and will be further decomposed to secondary products, such as alcohols, acids, ketones and aldehydes. All secondary products are related to the off-flavour from the deterioration of oil. Dupuy *et al.* (1976) found that the production of volatiles in oil was related to the extent of oil deterioration. Therefore, the extent of oil deterioration can be evaluated by the determination of total volatiles (total peak areas) using gas chromatography.

In general, the peak number and area of oil samples determined by direct gas chromatography were increased with storage time. The greatest change of volatiles in soybean oil was in samples stored in the dark at 60°C (Fig. 3). In volatile profiles, two peaks which showed significant changes during storage were identified as pentane and hexanal, respectively. The changes in peaks 1 and 2 in soybean oil exposed to fluorescent light were greater than in oil stored in the dark at room temperature, especially in peak 1.

Figure 4 shows the volatile profiles of sesame oils stored in the dark at 60°C. It clearly demonstrates that the content of pentane and hexanal in sesame oil increased with storage time, especially in sample A. The increasing content of pentane and hexanal in sample A stored at 60°C was greater than in samples exposed to fluorescent light or stored at room temperature (data not shown). Among oil samples, sample C showed the lowest volatiles during storage under various conditions.

As can be seen in Table 1, the contents of pentane, hexanal and total

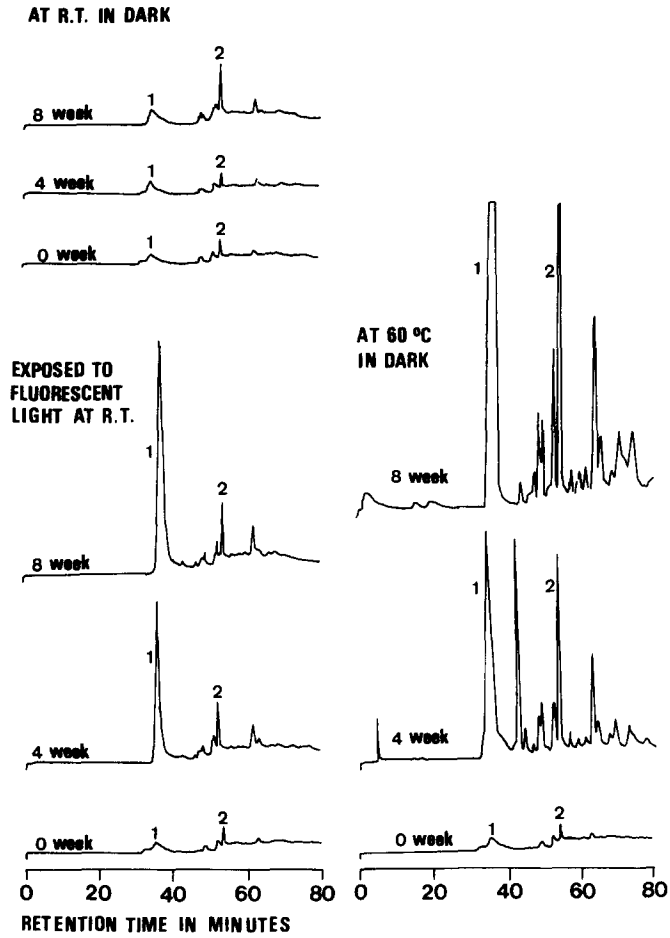

Fig. 3. Profiles of volatiles in soybean oil stored under different conditions: (1) pentane, (2) hexanal.

volatiles (expressed as peak area) in oil samples increased with storage time. In fresh oil (0 week), sample C contained the lowest amounts of pentane, hexanal and total volatiles, compared to the other oil samples. The development of volatiles in oil samples under any storage conditions for 8 weeks was in the order of samples C < D < B < A < soybean oil.

The results of sensory evaluation also clearly illustrate that there were significant differences ($P < 0{\cdot}05$) between sample C and other samples when exposed to fluorescent light for 8 weeks. However, no significant difference was found between samples B, C and D when stored in the dark at room temperature or at 60°C. Generally, the oil sample with higher total volatiles or more peaks gave lower flavour scores. The oil sample exposed to

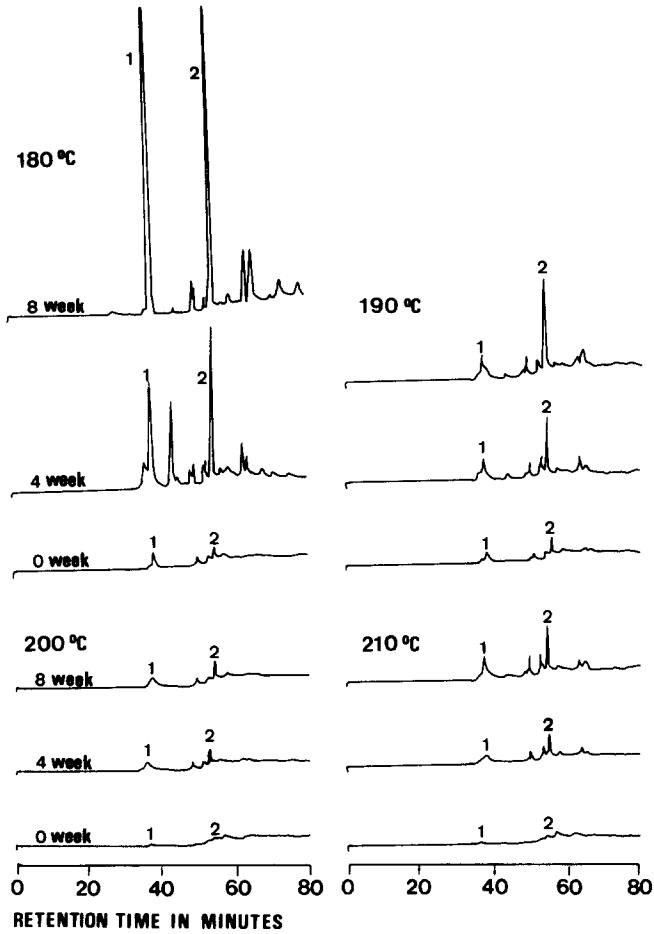

Fig. 4. Profiles of volatiles in sesame oils (prepared with different roasting temperatures) stored in the dark at 60°C: (1) pentane, (2) hexanal.

fluorescent light showed higher volatiles than the sample stored in the dark at room temperature. However, the volatiles of oil samples stored at 60°C were lower than in samples exposed to fluorescent light except for sample A and soybean oil. This result was in agreement with the peroxide value as shown in Fig. 1. It is also interesting to note that oil sample C stored at 60°C showed lower volatiles and higher flavour scores than samples stored at room temperature after 8 weeks' storage. Since soybean oil had higher linoleic acid and linolenic acid contents than sesame oil, rancidity developed in soybean oil when stored at 60°C for 8 weeks, while the sesame oil still maintained good stability in storage under the same conditions except for the sample A.

CONCLUSION

From the results of the present study, it can be concluded that the sesame oil prepared under optimum processing conditions (200°C roasting temperature, 30 min roasting time and 7 min cooking time) exhibited the best oxidative stability. Therefore, the control of roasting temperature during processing should be an important parameter for obtaining good quality sesame oil.

ACKNOWLEDGEMENT

The authors thank the Council of Agriculture, Executive Yuan, Republic of China, for their financial support.

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