Comparison of Fatty Acid Composition and Oxidative Stability of Peanut Oils Prepared from Spring and Fall Crops of Peanuts

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Spring and fall crops of peanut are grown each year in Taiwan. Fatty acid composition of oils prepared from peanuts of spring and fall crops of Tainan 9 and 11 cultivars planted consecutively from 1991 to 1993 were analyzed. For both cultivars, the oleic/linoleic (O/L) ratio was higher in oils prepared from spring crops than that from fall crops. When the harvested in-shell peanuts were stored at ambient and refrigeration temperatures for 5 months, conjugated diene hydroperoxide (CDHP) contents were significantly higher in spring crops than in fall crops. CDHP and free fatty acid contents increased more rapidly with time at ambient temperature than they did at refrigeration temperature. Growing season and storage time were the prime causes to result in significant changes of fatty acid composition. When the oils were subjected to an oven test at 75 °C, oils prepared from in-shell peanuts of spring crops of both cultivars after 3 months of storage at both temperatures were comparatively more stable against peroxidation than other test oils.

Keywords: *Peanut; growing season; fatty acid composition; oil oxidation*

INTRODUCTION

Peanut production in Taiwan is unique. Spring and fall crops are grown each year. In general, spring crops are planted in February in southern Taiwan and in March in northern areas. Peanuts are harvested, respectively, in June and July. Fall crops are planted in July and August and harvested in November and December from the south to the north. Rotation crops include rice, corn, sweet potato, sorghum, and watermelon.

Taiwan is located in tropical and subtropical areas and its geographical nature and weather pattern vary considerably with location (Chen et al., 1993). The weather pattern during the planting period of spring and fall crops varies in a reverse manner (Table 1). Spring crops are harvested in summer, and fall crops are harvested in winter. In addition to the temperature difference during the planted period, peanuts are also exposed to different weather patterns during post-harvest handling and storage.

The influence of cultivars, growing location, soil moisture conditions, yearly season, and some of their interactions on the fatty acid composition of peanuts has been extensively investigated (Worthington et al., 1972; Holaday and Pearson, 1974; Young et al., 1974; Brown et al., 1975). Worthington et al. (1972) reported that not only are there marked variations in the major and minor fatty acids due to genetic differences of the genotypes but the yearly variations of the fatty acids within the same genotype are also significant. Holaday and Pearson (1974) have demonstrated that fatty acid composition of peanut oils are significantly different year to year, location to location, and interactions between location and year of production. Young et al. (1974) reported that variation in fatty acid composition due to cultivar is much less in Oklahoma than in Georgia for both irrigated and nonirrigated peanuts. In addition, several significant first- and second-order interactions with the three major fatty acids (palmitic, oleic, and linoleic acids) are influenced by cultivar, location, and soil moisture conditions. Brown et al. (1975) reported that changes in the fatty acid composition as affected by cultivar and growing location of Spanish-type peanuts are not as large as those in virginia and runner types. Most of the comparison was made between years. For a specific cultivar, climatic situation, soil condition, irrigation, and planting practice, interaction among these parameters makes it difficult to offer a straightforward explanation for variations of fatty acid composition.

In this study, for the purpose of establishing a simplified situation of growing location and soil condition, two crops of peanuts were consecutively planted in the same area but not on the same plot for three consecutive years. Fatty acid composition of the kernel oils was determined. In-shell peanuts from the 1992 fall and 1993 spring crops were further subjected to storage at ambient and refrigeration temperatures for repeated determinations of fatty acid composition and evaluation of oil oxidative stability.

Table 1. Average Monthly Temperature Recorded in Chiayi Area from 1991 to 1993

month	year and temperature,[a] °C		
	1991	1992	1993
January	16.8	15.6	15.5
February	17.2	15.9	18.0
March	21.2	20.3	19.5
April	23.0	22.6	22.3
May	26.1	24.5	25.8
June	28.4	27.5	28.0
July	28.4	28.2	29.0
August	28.5	27.8	28.5
September	26.8	27.0	27.0
October	23.1	22.6	23.7
November	20.4	19.8	22.1
December	17.8	18.8	17.7

[a] Data were kindly supplied by Chiayi Weather Investigation Station, Central Weather Bureau, Executive Yean, ROC.

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0021-8561/95/1443-0676$09.00/0

Table 2. Fatty Acid Composition of Peanut Oils Prepared from Tainan 9 and Tainan 11 Cultivar Peanuts Grown in Spring and Fall Seasons (n = 3)

cultivar and crop	fatty acid, %[a]								
	16:0	18:0	18:1	18:2	20:0	20:1	22:0	24:0	O/L[b]
Tainan 9									
spring crop									
1991	12.83 ± 0.54	3.98 ± 0.04	40.59 ± 0.51	37.00 ± 0.41	1.41 ± 0.11	0.55 ± 0.05	2.58 ± 0.28	1.04 ± 0.06	1.10
1992	13.83 ± 0.20	3.51 ± 0.13	39.79 ± 0.42	38.26 ± 0.56	1.22 ± 0.08	0.64 ± 0.02	1.98 ± 0.14	0.59 ± 0.03	1.04
1993	12.71 ± 0.34	4.07 ± 0.15	42.40 ± 0.27	34.91 ± 0.29	1.53 ± 0.07	0.73 ± 0.02	2.50 ± 0.09	0.94 ± 0.02	1.21
fall crop									
1991	11.87 ± 0.66	3.49 ± 0.13	37.86 ± 0.18	39.97 ± 0.37	1.59 ± 0.02	0.91 ± 0.07	3.06 ± 0.38	1.18 ± 0.07	0.95
1992	11.40 ± 0.10	2.88 ± 0.05	37.44 ± 0.25	41.23 ± 0.14	1.42 ± 0.02	1.13 ± 0.05	3.04 ± 0.05	1.17 ± 0.03	0.91
Tainan 11									
spring crop									
1991	13.93 ± 0.27	3.29 ± 0.08	41.28 ± 0.15	35.86 ± 0.44	1.29 ± 0.10	0.76 ± 0.06	2.37 ± 0.25	1.10 ± 0.16	1.15
1992	11.72 ± 0.23	2.30 ± 0.13	40.40 ± 0.52	38.29 ± 0.49	1.15 ± 0.02	1.24 ± 0.01	3.27 ± 0.10	1.43 ± 0.09	1.06
1993	13.10 ± 0.22	3.48 ± 0.20	43.61 ± 0.49	33.93 ± 0.48	1.38 ± 0.03	0.81 ± 0.01	2.41 ± 0.03	1.08 ± 0.01	1.28
fall crop									
1991	11.57 ± 0.27	2.40 ± 0.39	39.38 ± 0.16	39.88 ± 0.33	1.22 ± 0.05	1.19 ± 0.02	3.17 ± 0.23	1.37 ± 0.05	0.99
1992	11.19 ± 0.07	1.98 ± 0.06	38.61 ± 0.27	40.91 ± 0.18	1.12 ± 0.02	1.55 ± 0.09	3.09 ± 0.13	1.31 ± 0.27	0.94

[a] Means of three determinations with standard deviation. [b] O/L: oleic/linoleic ratio.

MATERIALS AND METHODS

Peanuts. Tainan 9 and 11 (two Spanish cultivars) were planted from 1991 to 1993 in experimental fields at National Chiayi Institute of Agriculture located at Chungpu, Chiayi, Taiwan. Two crops, i.e., spring and fall crops, were planted but not on the same plot. The same experimental design reported previously (Chiou et al., 1992) was followed. The spring crop was planted in February and harvested in June and the fall crop was planted in July and harvested in November. Peanuts were harvested 80 days after flowering and the mature peanut pods were removed from the vines immediately after digging and sun-dried on a cement slab. The dried in-shell peanuts were hand shelled, sorted, and graded with a sieve (19.05 mm × 5.95 mm slots). U.S. no. 1 kernels were subjected to peanut oil preparation and fatty acid composition determination.

Peanut Oil Preparation and Chemical Analyses. For peanut oil preparation, size-graded (U.S. no. 1) kernels were precooled at −30 °C for 2 h and then freeze-dried. Skins and hearts were removed and cotyledons were pressed hydraulically (150−200 kg/cm^2) and centrifuged (8500g at 20 °C for 5 min) to pellet the suspended particles. The supernatant oils were deposited in brown glass vials and stored at −25 °C for further analysis.

The fatty acid composition of peanut oils was determined using the methylation procedure reported by Chiou et al. (1992). Gas chromatography was used for fatty acid analysis (Chiou et al., 1993). The free fatty acid (FFA) content in oils was determined using a colorimetric (copper soap) method (Koops and Klomp, 1977; Shipe et al., 1980; Chiou et al., 1993). The conjugated diene hydroperoxide (CDHP) contents in oils were determined using the procedure described by Yoon et al. (1985) and Chiou et al. (1991).

In-Shell Peanut Storage. Dried in-shell peanuts from 1992 fall and 1993 spring crops were packed in polyethylene (PE) plastic net bags and respectively stored at ambient and refrigeration (2 °C) temperatures for 5 months. After 0, 1, 3, and 5 months, 500 peanut pods were randomly sampled, hand shelled, sorted, and graded. U.S. no. 1 kernels were subjected to moisture content determination and oil preparation for determining FFA and CDHP contents. A small portion of the kernels were randomly selected and ground with a cyclone mill into meals. The moisture content of meals was determined by heating weighed samples at 105 °C for sufficient time to reach a constant weight. The oils were further subjected to an oven test at 75 °C for 3 days during which CDHP contents in the oils were determined daily.

Statistics. Two cultivars of peanuts were studied and three replications were conducted. Means of determinations with standard deviations are reported. A split plot design and a multiple range test in accordance with ANOVA were administered for the difference analysis of the compositional changes of in-shell peanuts from 1992 fall and 1993 spring crops subjected to storage at ambient and refrigeration temperatures.

RESULTS AND DISCUSSION

The fatty acid composition of peanut oils prepared from Tainan 9 and Tainan 11 peanuts of spring and fall crops from 1991 to 1993 is presented in Table 2. For both cultivars, the oleic/linoleic (O/L) ratio was higher in oils prepared from spring crops than in oils prepared from fall crops. The yearly variation in fatty acid composition of oils prepared from peanuts of the same crop was minor. Oleic acid (18:1) content was higher in oils prepared from spring crops compared to fall crops. This may be attributed to differences in soil temperature during the maturing period as a result of different growing seasons with different ambient temperature patterns (Table 1). According to the report of Holaday and Pearson (1974), monounsaturated fatty acids increase and polyunsaturated fatty acids decrease with an increase of soil temperature. They explained that a higher soil temperature leads to lower polyunsaturation and higher monosaturation due to higher metabolic rate recorded at elevated temperatures and to decreased availability of oxygen for reoxidizing the desaturase enzyme system required to synthesize linoleate and linolenate. However, in this study, it was not true for eicosenoic acid (20:1) since it was comparatively higher in fall crops than in spring crops. The possibility that some linoleic acid had been oxidized before harvest or during curing may exist and result in lower linoleic acid content in spring crops than in fall crops. This was evidenced by the observation that the CDHP content of oils from spring crops subjected to storage were significantly higher than those in fall crops for both cultivars (Tables 3 and 4). Peanuts from spring crops, in particular, were harvested during the summer. Thus, the difference of CDHP content and variation in fatty acid composition of peanut oils in spring and fall crops mainly resulted from differences in the growing season.

In-shell peanuts from 1992 fall and 1993 spring crops of Tainan 9 and 11 cultivars were stored at ambient and refrigeration temperatures for 0, 1, 3, and 5 months and moisture contents of peanut kernels, CDHP, and FFA contents of oils were determined (Tables 3 and 4). Moisture contents in peanut kernels from spring crops were lower than those from fall crops. During storage, moisture contents of peanut kernels decreased for fall crops and increased for spring crops. The effect of storage temperature on change of moisture content was significant for Tainan 11 and insignificant for Tainan 9.

The CDHP contents during storage were significantly

Table 3. Moisture, Conjugated Diene Hydroperoxide (CDHP), and Free Fatty Acid Contents, Fatty Acid Profile, and Oleic/Linoleic Ratio of Spring and Fall Crops of Tainan 9 Peanuts Subjected to Storage at Ambient and Refrigeration Temperatures for 5 Months

	treatment^{a}							
	crop		temperature		storage time, months			
item	spring	fall	ambient	refrigeration	0	1	3	5
				Moisture Content, %				
	4.84^{b}	5.10^{a}	5.01^{a}	4.93^{a}	4.98^{a}	5.10^{a}	5.03^{a}	4.77^{b}
				CDHP, Absorbance 234 nm/mg of Oil				
	0.19^{a}	0.12^{b}	0.18^{a}	0.14^{b}	0.11^{d}	0.13^{c}	0.18^{b}	0.21^{a}
				FFA, mg/g of Oil				
	0.19^{a}	0.16^{a}	0.23^{a}	0.11^{b}	0.05^{c}	0.13^{b}	0.25^{a}	0.26^{a}
				Fatty Acid, %				
16:0	12.68^{a}	11.63^{b}	12.09^{b}	12.21^{a}	12.06^{a}	12.15^{a}	12.17^{a}	12.23^{a}
18:0	3.95^{a}	2.93^{b}	3.44^{a}	3.44^{a}	3.47^{ab}	3.57a	3.39^{b}	3.32^{b}
18:1	42.37^{a}	37.58^{b}	40.01^{a}	39.93^{a}	39.92^{a}	40.09^{a}	40.00^{a}	39.87^{a}
18:2	35.07^{b}	41.02^{a}	38.03^{a}	38.07^{a}	38.07^{ab}	37.89^{b}	38.19^{a}	38.04^{ab}
20:0	1.52^{a}	1.40^{b}	1.46^{a}	1.45^{a}	1.48^{a}	1.46^{a}	1.44^{a}	1.45^{a}
20:1	0.74^{b}	1.09^{a}	0.93^{a}	0.90^{b}	0.92^{a}	0.90^{a}	0.90^{a}	0.93^{a}
22:0	2.51^{b}	2.98^{a}	2.76^{a}	2.73^{a}	2.77^{ab}	2.71^{bc}	2.66^{c}	2.84^{a}
24:0	0.92^{b}	1.10^{a}	1.04^{a}	0.97^{a}	1.07^{a}	0.92^{b}	0.98^{ab}	1.05^{ab}
				Oleic/Linoleic Ratio				
	1.21^{a}	0.92^{b}	1.06^{a}	1.06^{a}	1.06^{a}	1.07^{a}	1.06^{a}	1.06^{a}

[a] Value in the same row for each treatment, i.e., growing season (crop), storage temperature, and storage time, which are not followed by the same letter are significantly different ($p < 0.05$).

Table 4. Moisture, Conjugated Diene Hydroperoxide (CDHP), and Free Fatty Acid Contents, Fatty Acid Profile, and Oleic/Linoleic Ratio of Spring and Fall Crops of Tainan 11 Peanuts Subjected to Storage at Ambient and Refrigeration Temperatures for 5 Months

	treatment^{a}							
	crop		temperature		storage time, mon			
item	spring	fall	ambient	refrigeration	0	1	3	5
				Moisture, %				
	4.36^{b}	5.28^{a}	4.90^{a}	4.75^{b}	4.98^{a}	4.89^{ab}	4.78^{b}	4.64^{c}
				CDHP, Absorbance 234 nm/mg of Oil				
	0.21^{a}	0.11^{b}	0.18^{a}	0.14^{b}	0.11^{d}	0.13^{c}	0.19^{b}	0.21^{a}
				FFA, mg/g of Oil				
	0.25^{a}	0.18^{b}	0.28^{a}	0.15^{b}	0.06^{c}	0.22^{b}	0.27^{ab}	0.30^{a}
				Fatty Acid, %				
16:0	11.47^{b}	13.21^{a}	12.35^{a}	12.33^{a}	12.15^{b}	12.44^{a}	12.32^{ab}	12.45^{a}
18:0	2.04^{b}	3.25^{a}	2.65^{a}	2.64^{a}	2.73^{a}	2.70^{a}	2.64^{ab}	2.50^{b}
18:1	43.30^{a}	38.37^{b}	40.80^{a}	40.87^{a}	41.11^{a}	40.86^{ab}	40.79^{ab}	40.58^{b}
18:2	34.44^{b}	40.68^{a}	37.56^{a}	37.56^{a}	37.42^{ab}	37.39^{b}	37.62^{ab}	37.81^{a}
20:0	1.34^{a}	1.08^{b}	1.21^{a}	1.21^{a}	1.24^{a}	1.21^{b}	1.21^{b}	1.18^{c}
20:1	0.83^{b}	1.46^{a}	1.14^{a}	1.15^{a}	1.18^{a}	1.12^{b}	1.13^{ab}	1.15^{ab}
22:0	2.38^{b}	3.16^{a}	2.79^{a}	2.75^{a}	2.75^{a}	2.73^{a}	2.79^{a}	2.81^{a}
24:0	1.08^{b}	1.45^{a}	1.27^{a}	1.26^{a}	1.19^{a}	1.27^{a}	1.28^{a}	1.30^{a}
				Oleic/Linoleic Ratio				
	1.26^{a}	0.94^{b}	1.10^{a}	1.10^{a}	1.11^{a}	1.11^{a}	1.10^{ab}	1.08^{b}

[a] Value in the same row for each treatment, i.e., growing season (crop), storage temperature, and storage time, which are not followed by the same letter are significantly different ($p < 0.05$).

higher in the oils prepared from spring crops than in the oils prepared from fall crops of both cultivars. This difference was not closely related to differences in O/L ratios of the oils (Table 2). Considerable importance has been ascribed to the role of the O/L ratio in governing product shelf life (Young et al., 1974; Worthington et al., 1972). Worthington et al. (1972) demonstrated that oil stability can be correlated with O/L ratio but correlations are highly variable from year to year. Worthington and Hammons (1971) suggested that variations in climatic conditions, soil moisture during maturation, and temperature during curing are possible causes. When a comparison was made between storage temperatures, CDHP contents increased more rapidly at ambient than at refrigeration temperature. During storage, CDHP contents increased with time for all oils.

In comparison, the FFA contents in the oil samples of Tainan 11 were significantly higher in spring crops than in fall crops and insignificant between spring and fall crops for Tainan 9. FFA content increased more rapidly when the oils were stored at ambient temperature than at refrigeration temperature for both cultivars. During storage, FFA contents of both cultivars and two crops increased significantly with storage time. Concerning fatty acid composition, growing season and storage time were the prime causes to result in significant changes of fatty acid profile.

When peanut oils prepared from kernels of stored in-shell peanuts were subjected to an oven test at 75 °C, changes of CDHP contents varied (Figure 1). For both cultivars, when a comparison was made at each time of sampling and determination, initial CDHP contents in the oils from spring crops were higher than those from fall crops. CDHP contents in oils prepared from spring in-shell peanuts after 0 and 1 month of storage increased more rapidly than did oils prepared from fall

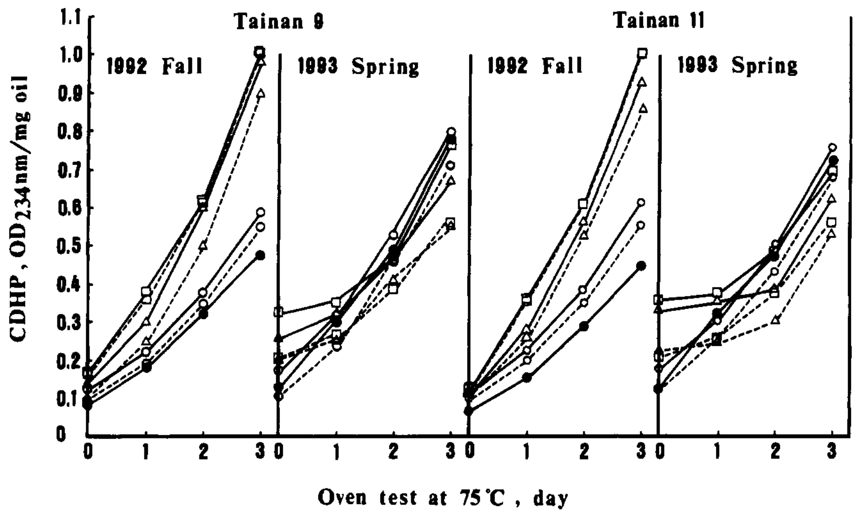

Figure 1. Changes of conjugated diene hydroperoxide (CDHP) content of peanut oils prepared from Tainan 9 and 11 in-shell peanuts harvested from 1992 fall and 1993 spring crops and stored at ambient (—) and refrigeration (- - -) temperatures for up to 5 months and subjected to an oven test at 75 °C for 3 days: (●) 0 months; (○) 1 month; (△) 3 months; (□) 5 months.

crops. However, after 3 months of storage, a reverse result was observed. The difference indicates that oxidative stability of the extracted oils may change due to extension of storage period of the in-shell peanuts.

In comparison, the effect of storage temperature of the in-shell peanuts on increasing the CDHP content in the extracted oils at 75 °C was more pronounced for fall crops than for spring crops. For fall crops, the higher the initial CDHP content in the oil subjected to the oven test, the more rapid the increase in CDHP content in oils as storage progressed. For spring crops, oils prepared from in-shell peanuts after more than 3 months of storage were comparatively more stable against peroxidation than others during the first days of the oven test.

In conclusion, when the fatty acid compositions of oils prepared from peanuts of spring and fall crops of Tainan 9 and 11 cultivars planted consecutively for 3 years were analyzed, the oleic/linoleic (O/L) ratio was higher in oils prepared from peanuts of spring crops than in oils prepared from fall crops. During storage of the harvested in-shell peanuts at ambient and refrigeration temperatures for 5 months, CDHP and FFA contents in oils prepared from peanuts of spring crops were higher than those from fall crops. Fatty acid composition of the oils varied significantly as affected by growing season and storage time. When oils were prepared from kernels of the in-shell peanuts during storage and subjected to an oven test at 75 °C, oils of spring crops for both cultivars after 3 months of storage at the ambient and refrigeration temperatures were comparatively more stable against peroxidation than were other test oils.

ACKNOWLEDGMENT

The kind supply of weather records by the Central Weather Bureau, Republic of China, valuable advice on manuscript preparation by Dr. Larry R. Beuchat, University of Georgia, and helpful assistance by Ms. S. H. Lin and H. J. Hu in the laboratory are acknowledged.

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Received for review August 29, 1994. Accepted December 30, 1994.[⊗] The financial support by the National Science Council (NSC 82-0406-E021-003) is acknowledged.

JF9404915

[⊗] Abstract published in *Advance ACS Abstracts,* February 15, 1995.