Fatty Acid Composition of Spanish Peanut Oils as Influenced by Planting Location, Soil Moisture Conditions, Variety, and Season[1,2]

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ABSTRACT

Nine varieties or strains of Spanish type peanuts were grown in the National Variety Test in Georgia and Oklahoma with and without irrigation for two growing seasons. The oil of sound kernels was analyzed for fatty acid composition. Although no consistent pattern was found, in general, variation in fatty acid composition due to variety was much less in Oklahoma than in Georgia for both the irrigated and nonirrigated peanuts. Also, location effect and soil moisture conditions gave higher percentages of palmitic and oleic with a lower percentage of linoleic in the Georgia samples and in the nonirrigated samples from both locations. Several significant first and second order interactions with the three major fatty acids involving variety, location, and soil moisture conditions were observed.

INTRODUCTION

Fatty acid composition of peanut seed oils has been reported to be influenced by varietal and seasonal effects (1,2), genotypic variation (3,4), environment (5,6), and maturity (7,8). Tai (9) has shown that the cultivar by year interaction was statistically significant when examining the oleic/linoleic (O/L) ratios of peanut cultivars grown 2 years at 2 locations within a state. The variance for cultivar by location and cultivar by location by year interactions were both small and nonsignificant. The rather detailed literature reviews in the two recent papers by Worthington, et al., (2) and Young, et al., (8) are timely and not repeated in this article.

Previous studies have been with either Spanish grown in the Southwest or Spanish and other types grown in the Southeast. Therefore, a detailed study of location effects upon commercial varieties (and new potential commercial varieties) of peanuts was needed. Also the effect of supplemental irrigation on fatty acid composition had not been examined in detail. The primary purpose of the present investigation was to examine the influence of location and soil moisture conditions along with seasonal variation on the fatty acid composition of peanut oils from several Spanish type peanut cultivars.

EXPERIMENTAL PROCEDURES

This study included nine Spanish botanical type (*Arachis hypogaea* L. subsp. *fastigiata* var. *vulgaris*) peanut varieties grown in the National Variety Test in both Georgia and Oklahoma in 1968 and in Oklahoma in 1969; seven varieties were grown in Georgia in 1969. The tests included normal rainfall (NIR) and rainfall plus irrigation (IRR) conditions. A randomized split plot design was used. Location, soil type, rainfall and irrigation data are reported in the preceding article (10) in which free amino acid values were reported. The peanuts were field cured, harvested, and machine shelled before the end of the calendar year. Sound kernels riding a standard 15/64 x 3/4 in. slotted grading screen were stored at 34 F and 60% relative humidity until analyzed. These peanut kernels would be similar to Spanish type purchased by the salted nut or the peanut butter processing industries.

Oils were extracted and stored as previously described by Young, et al. (8). Fatty acid esters were prepared by transesterification of the oil using a 3% solution of sulfuric acid in methanol as described by Jellum and Worthington (11) and analyzed on a MicroTek 220 gas chromatograph equipped with an Infotronics electronic integrator. A 1.8 m x 4.0 mm inside diameter glass U-shaped column packed with 10% diethylene glycolsuccinate (DEGS) 70/80 mesh Chromosorb W (AW) (DMCS) was used with a helium flow rate of 100 ml/min. In 1968, the detector, injection port, and column temperatures were maintained at 300, 275, and 200 C, respectively. In 1969, column temperature was programed from 195-225 C at 3 C/min. Added details and the typical chromatograms of peanut oil have been published previously (2,4,12). Single analysis (1968) and duplicate analyses (1969) were made on oils extracted from 100 g sample from each replicaton. Fatty acid levels were calculated by normalization of peak areas and the values of each reported as relative proportions of the total fatty acids present. The data were subjected to statistical analyses (13) to obtain estimates of the magnitudes of the factors and interactions affecting the fatty acid composition of peanut oils. The interactions from variety by state, variety by state by soil moisture conditions within each of the 2 year study were examined.

RESULTS AND DISCUSSION

Figure 1 shows variation in fatty acid composition of nine varieties of peanuts as affected by state location (Georgia vs Oklahoma) and treatment (NIR vs IRR) within years. The oleic/linoleic fatty acid ratio (O/L) also is shown. Table I contains a summary of the mean square values and the level of significance obtained on palmitic (16:0), oleic (18:1), linoleic (18:2), and the O/L ratio. (Complete detailed data used to obtain Figure 1 and Table I will be sent upon request.)

Examination of the data in Figure 1 illustrates yearly differences in fatty acid composition, and Table 1 shows the significant first and second order interactions within years. Because of these significant interactions, a statistical combination of the 1968 and 1969 data was not appropriate (13). Thus, the 1968 data will be discussed first in detail and be followed by a discussion of within year effects on these variables.

The analyses of variance are summarized in Table I for three of the various fatty acid variables tested. The level of significance is indicated. It should be noted that three fatty

[1]Presented at the AOCS Meeting, New Orleans, May 1973.

[2]Journal paper 2707 of the Oklahoma Agricultural Experiment Station.

[3]ARS, USDA.

TABLE I

Summary of Mean Square Values and Level of Significance Obtained from Fatty Acid Data on Peanuts from 1968 and 1969 National Variety Test

Source	df[a]	16:0	18:1	18:2	O/L
			1968		
Total	71				
State (S)	1	3.6405**	115.0897**	178.7939**	0.4884**
Irrigation (I)	1	10.1325**	11.6725**	33.6747**	0.0728**
S x I	1	0.3029**	0.1144NS	0.3042NS	0.0000NS
Pooled error (a)	4	0.0378	0.1229	0.2536	0.0004
Variety (V)	8	0.2837**	4.9327**	4.7406**	0.0144**
V x S	8	0.1956*	1.1379**	0.7412NS	0.0033**
V x I	8	0.0235NS	0.8408*	0.7798NS	0.0026*
V x I x S	8	0.0615NS	0.8730*	1.1256*	0.0030**
Pooled error (b)	32	0.0799	0.3021	0.3937	0.0009
Grand mean		12.65	42.92	37.52	1.15
CV(a)%[e]		1.5	0.8	1.3	1.8
CV(b)%		2.2	1.3	1.7	2.6
			1969		
Total	111				
State (S)	1	8.3986**	59.1022**	159.4372**	0.4488**
Irrigation (I)	1	7.7227**	2.5561NS	3.9788NS	0.0135NS
S x I	1	0.2405*	1.8309NS	0.1125NS	0.0008NS
Pooled error (a)	4	0.0163	1.2513	0.8803	0.0039
Variety (V)	6	0.7728**	1.4823**	2.1535**	0.0070**
V x S	6	0.8101**	0.1822NS	0.6136**	0.0007NS
V x I	6	0.1708NS	0.6047**	0.2544NS	0.0011*
V x I x S	6	0.0719NS	0.2818NS	0.2252NS	0.0008NS
Pooled error (b)	80	0.1098	0.1688	0.1602	0.0004
Grand mean		11.8	43.21	34.97	1.24
CV(a)%		1.1	2.6	2.7	5.1
CV(b)%		2.8	1.0	1.2	1.7

[a]df = degrees of freedom.
**1% level.
NS = not significant.
*5% level.
CV = coefficient of variation.

acids (palmitic, linoleic, and oleic) make up more than 90% of the total fatty acids.

The graphic presentation of variation for 1968 of palmitic acid (16:0) composition is shown in Figure 1. The average of the nine varieties are pointed out by the arrows on the left side of the graph. The variety variation is much less in Oklahoma than in Georgia for both IRR and NIR. Differences between states are seen in this figure. Peanuts of most varieties grown in Georgia contained more palmitic acid than the Oklahoma peanuts regardless of treatment. Also, this figure shows that more palmitic acid was in the nonirrigated peanuts than in the irrigated for both states. A significant state x irrigation (S x I) interaction for palmitic acid was obtained. This result indicates that the irrigation response was significantly different within each state as noted by the wider spread between IRR and NIR in Oklahoma as compared to Georgia. It should be noted, however, that the wider differences between IRR and NIR observed in Oklahoma may have been related in part to the fact that the IRR plots were ca. 150 miles from the NIR plots. Further study is needed to delineate these differences. In Georgia, the IRR and NIR plots were located on one research farm. Although the variety x irrigation (V x I) interaction was not significant for palmitic acid, it is interesting to note that palmitic acid content of variety nine in relation to the other varieties decreased when grown in Georgia under irrigation and the opposite was true for variety six grown in Oklahoma.

The other significant first order interaction involved states and varieties. The palmitic acid content did not vary nearly as much among the varieties in Oklahoma as it did in Georgia.

In Table I, the coefficients of variation, CV(a) and CV(b), are given. The CV values are relatively low for palmitic, oleic, and linoleic acids. These values are a measure of the unaccounted for variation and are due mostly to the variation in precision and accuracy. CV(a) is between plot variation, and CV(b) is within plot variation. Since CV(b) is larger than CV(a), the variation within plots was greater than the variation between plots.

Significant differences in the mean values of oleic acid (18:1) content were found between states, between IRR and NIR plots, and among varieties. This is indicated by the significant second order interaction (V x I x S), whereas palmitic acid had not shown a signficant second order interaction. For oleic acid, two first order interactions also were present (V x S) and (V x I). It was interesting that the S x I interaction was not significant. The NIR and IRR tended to respond similarly in each state. The values for oleic acid in IRR test for Oklahoma was ca. 2.7 percentage points lower than the IRR test in Georgia while the linoleic acid values were higher by ca. the same magnitude. These differences are reflected in the corresponding O/L ratios.

The coefficients of variation for these three fatty acid data were small, while the cvs in the other fatty acids ranged from 6-30%. The smaller variations for these latter fatty acids in 1969 will be discussed later.

Arachidic (20:0) and behenic (22:0) acids have been implicated circumstantially with abnormal cardiovascular conditions in laboratory animals (14). The percentage of these fatty acids was not significantly affected by any of the parameters considered in this study. The coefficients of variation were 13.0 and 15.1% respectively. The mean fatty acid percentages were 1.13 and 1.96 for arachidic and behenic, respectively.

Only traces of linolenic (18:3) acid have been shown to be present in peanut oils (12), thus the eicosenoic (20:1) peak would contain insignificant traces of linolenic acid. The mean squares for eicosenoic (20:1) acid were significant between states and irrigation treatments. Those mean squares for the other sources of variation were not significant. The percentage of this fatty acid made up a

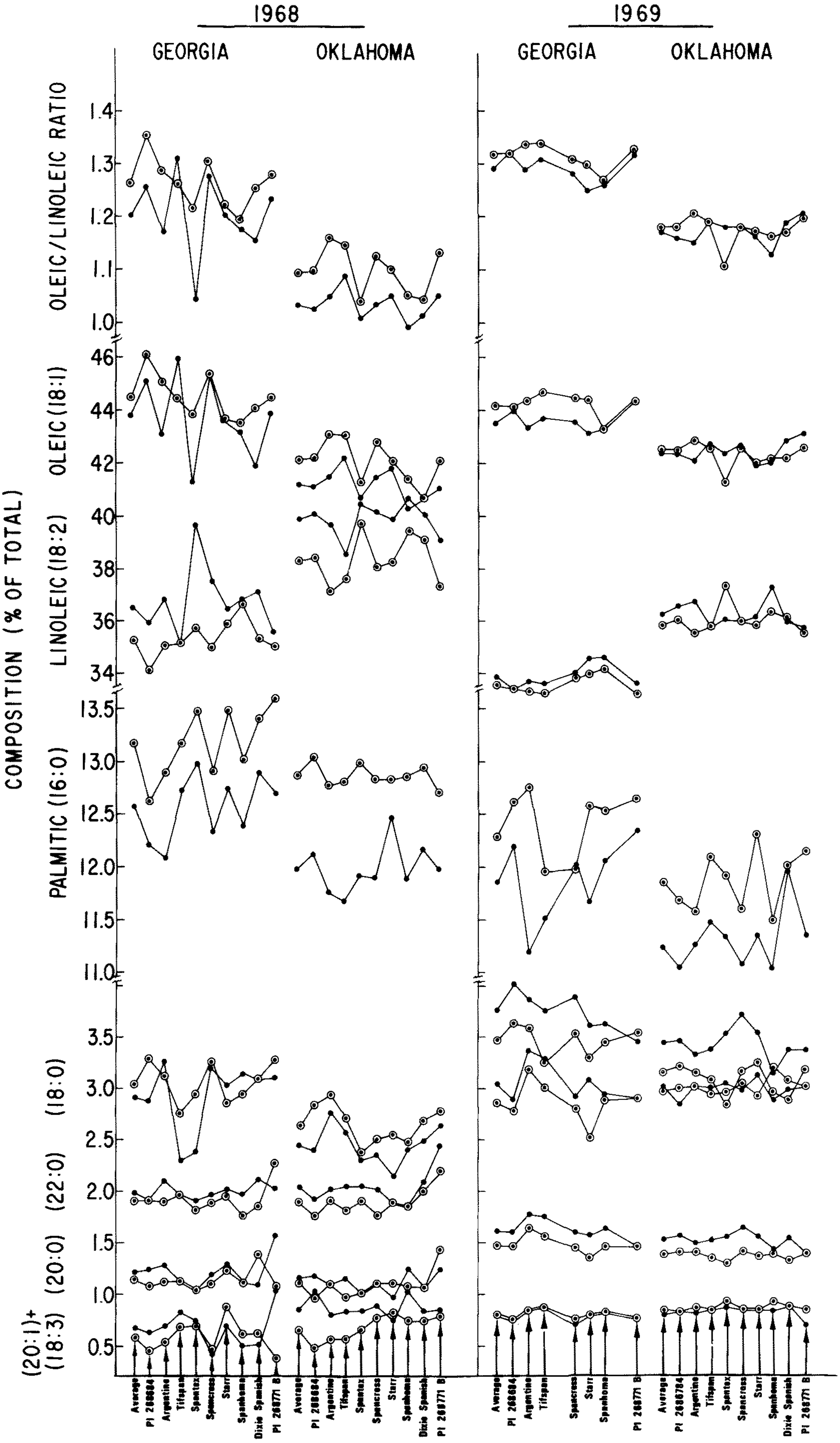

FIG. 1. Effect of season, planting location, and soil moisture conditions upon fatty acid composition on 9 Spanish type peanut cultivars. ● = irrigated and ⊙ = nonirrigated.

small portion of the total and the coefficient of variation was higher than for the other fatty acids.

When the two major fatty acids (oleic plus linoleic) were combined, there were significant differences between Georgia and Oklahoma, between IRR and NIR, and among varieties. The mean squares for the four interactions were not significantly different.

The O/L ratio is considered to be an important factor in estimating stability of peanuts, peanut oil, and peanut products. The O/L ratio statistical analyses showed the same type of interactions, including the second order interaction that oleic and linoleic acids had shown. Thus, the O/L ratio data were chosen for further examination. The Tifspan and Spantex varieties appeared to be the samples causing the problems in the interpretation of the data. The analysis of variance was made on the NIR vs IRR treatments in each state. In both locations, there was significant effect on O/L ratios due to irrigation and variety. The I x V interaction for the Georgia samples was significant due to the wide variations in Tifspan and Spantex while the Oklahoma I x V interaction was not significant. Thus, it was concluded that the pooled data from Georgia vs Oklahoma, NIR vs IRR, and varieties were essentially valid for statistical analysis of the data for most of the varieties tested. Further studies on Tifspan and Spantex should be made since these results do not follow the response for O/L ratio that the other varieties in this study showed.

With the 1969 samples, temperature programing with duplicate analyses on each sample was used. This gave a better measure of 20:0, 20:1, and 22:0 and consequently lower CVs. In addition, lignoceric acid (24:0) also was determined in 1969. The cv values on the 16:0, 18:0, 18:1, and 18:2 fatty acids for both years tended to be of similar magnitude. In general except for 16:0 and 18:0, the fatty acid composition was more uniform with smaller effects due to variety and more noticeably to irrigation.

Stability tests on the 1968 oils (15) had shown that the solvent extracted oils from the Georgia peanuts had better than a 50% longer shelf-life as measured by the oxygen uptake method of Olcott and Einset (16), than those grown in Oklahoma. Whereas, oils from these same peanuts prepared by hydraulic pressing did not show a difference in stability. Mention should be made of the large significant effect of state on the three major fatty acids. Because of these significant differences in fatty acid composition of peanuts grown in the Southeast and Southwest area, which were thought to be due primarily to the lower temperatures in the Southwest area during seed maturation, the peanut processing industry has been interested in developing a peanut for the Southwest that would have an O/L ratio similar to the Southeast area peanuts (9). But based upon the above discussed results, there appears to be additional factors other than fatty acid composition that influence the stability of peanut oils. Certainly, there needs to be additional studies to more precisely measure, define, and identify these and additional factors contributing to these differences in fatty acid composition and oil stability of peanuts as influenced by production location. Maturity has been shown to influence fatty acid composition (7,8) but was not examined in this study.

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