New High-Oleic Peanut Cultivars Grown in the Southwestern United States

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ABSTRACT: The chemical composition of five high-oleic peanut lines grown in Oklahoma was examined. Tamrun OL 01, Tamrun OL 02, TX 977164, and TX 977239 were developed using conventional breeding procedures. SunOleic and Tamrun 96 were the parent lines. These lines demonstrated outstanding agronomic characteristics in Oklahoma. The peanut seeds analyzed in this study contained 42 to 49% oil, 25 to 29% protein, 9 to 12% total dietary fiber, about 2% ash, and 5% moisture. The peanut seeds were rich in potassium. Phosphorus and calcium were the two other two major minerals present in all the samples. The proximate compositions of all the breeding lines were within the range of the parent lines except they had 80% (w/w) oleic acid, which was significantly higher than the parent lines. This study indicates that conventional genetic selection for high-oleic concentration does not cause substantial unintentional changes in peanut chemical composition.

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KEY WORDS: Conventional breeding, nutritional composition, peanut, peanut oil.

The cultivated peanut (*Arachis hypogaea* L.) is an important oil and food crop and is currently grown on approximately 40 million acres (16.2 million ha) worldwide (1). As an oilseed crop, peanuts rank fourth in world production. Within the United States, the major peanut-producing regions are in the southeastern and southwestern states. The state of Oklahoma ranks seventh in the United States in peanut production (2).

A peanut breeding line containing about 80% oleic acid and 2% linoleic acid was first identified by Norden *et al*. (3). The incorporation of high-oleic genes into new peanut breeding lines resulted in the SunOleic cultivar, a high-oleic variety released by the Florida Agricultural Experiment Station in 1995 (4). The SunOleic peanut variety has a favorable high oleic acid content and consequently extended shelf life. Tamrun 96, released by the Texas Agricultural Experiment Station (TAES), is a popular variety in the southwestern United States because of its high yield, disease resistance, and peg strength. Compared with another popular variety, Florunner, Tamrun 96 appears to exhibit better resistance to several diseases including tomato spotted wilt, southern blight, sclerotinia, and pod rot.

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The TAES, the Oklahoma Agricultural Experiment Station (OAES), and the USDA/ARS initiated a joint breeding program to develop a peanut variety that would possess favorable traits of both SunOleic and Tamrun 96. Four peanut lines—Tamrun OL 01, Tamrun OL 02, TX 977164, and TX 977239—were developed using SunOleic and Tamrun 96 as parental lines. These breeding lines had very good agronomic characteristics when tested in Oklahoma. Tamrun OL 01 was released by the TAES and the OAES, and Tamrun OL 02 has been released by the TAES. The breeding lines TX 977164 and TX 977239 have not yet been released.

The main objective of this study is to examine the chemical composition of Tamrun OL 01, Tamrun OL 02, TX 977164, and TX 977239. The specific objectives include: (i) determination of the nutritional composition of peanut varieties developed for the southwestern United States, (ii) examination of the composition of their parents, and (iii) comparison of the compositions and determination of differences that might present safety or nutritional concerns or health benefits.

MATERIALS AND METHODS

SunOleic, Tamrun 96, Tamrun OL 01, Tamrun OL 02, TX 977164, and TX 97723 peanuts were grown at the Oklahoma State University Department of Plant and Soil Sciences Experiment Station (Fort Cobb, OK) during 2002. Healthy and mature pods from three different plots for each variety were randomly mixed and shelled to obtain about 1 lb (450 g) of seed per variety. The seeds were stored, in their seed coats, in airtight plastic containers at –20°C until analyses.

Sample preparation. Approximately 250 g of stored peanut seeds was brought to room temperature and ground in 50-g (wet basis) portions using a coffee grinder (Black & Decker® Smart Grind™) at medium speed for 1 min. Ground seed was then pooled, mixed well, and stored in airtight plastic containers at –20°C. Moisture content of the ground samples was determined according to the Official Methods of Analysis of AOAC International (Method 950.46) (5).

Constituent analyses. The nitrogen content of peanut samples was determined by standard Kjeldahl (AOAC Method 928.08) method (5). About 0.5 g (wet basis) of finely ground peanuts was digested in a Kjeltec digester (Model 2020 Digester; Tecator, Hoganas, Sweden). No H_2O_2 was used for digestion. The sample was then distilled. The nitrogen content of the sample was determined by titration using a Kjeltec instrument (2300 Kjeltec

analyzer unit; Tecator). The protein content of the samples was calculated by multiplying the nitrogen content by 6.25.

Ash content was estimated according to the Official Methods of Analysis of AOAC International (Method 923.03) (5). Ash was obtained by incineration of 2 g (wet basis) of finely ground peanut sample in a muffle furnace (Isotemp® muffle furnace 600 series, model 58; Fisher Scientific, Pittsburgh, PA) at 525°C for 5 h.

The major minerals in peanut samples were determined by ashing the peanut sample in a muffle furnace at 525°C for 5 h and then extracting the ash in 1 N HCl. Metals were analyzed by using an inductively coupled plasma spectrophotometer (Spectro Ciros, Fitchburg, MA).

The oil percentage of the samples was determined according to the Official Methods of Analysis of AOAC International (Method 960.39) (5). Approximately 1 g (wet basis) of finely ground peanuts was extracted with petroleum ether (Certified ACS grade; Fisher Chemicals, Fairlawn, NJ) using a Soxtec unit (Soxtec system HT; Tecator).

The total dietary fiber (TDF) content of the peanut samples was determined by the enzymatic–gravimetric method of the Official Methods of Analysis of AOAC International (Method 985.29) (5). Three grams of ground peanut sample (wet basis) was treated with heat-stable α-amylase and then digested with protease and amyloglucosidase. Ethanol was added to precipitate the soluble dietary fiber. The residue was then filtered and washed with ethanol and acetone. The residue was weighed after drying. Samples were equally divided for protein and ash analyses. TDF content was determined as the weight of the residue less the weight of the protein and ash.

Approximately 10 g (wet basis) of finely ground peanut seeds was extracted with petroleum ether using an accelerated solvent extractor (ASE 300; Dionex, Sunnyvale, CA) (6). Solvent was evaporated from the extracts at 40°C under vacuum using a Rapidvap evaporator (Model 79000-02; Labconco, Kansas City, MO).

FA composition of the extracted oil was analyzed with an HP 6890 Plus gas chromatograph equipped with an FID (Hewlett-Packard Company, Wilmington, DE). Methylation of the FA was carried out according to the AOCS Official Method Ce 2-66 (7). An Omegawax 250 fused-silica capillary column, 30 m × 0.25 mm × 0.25 μm film thickness (Supelco, Bellefonte, PA) was used for FA analysis. FA standards were purchased from Supelco (Supelco 37 component FAME mix). The helium carrier gas flow rate was 30 cm/s. The injector temperature was maintained at 250°C. A temperature program with total run time of 82 min was used. The column temperature, after an initial isothermal period of 2 min at 50°C, was increased to 220°C at a rate of 4°C/min and then maintained at this temperature for 37.5 min. The detector conditions were as follows: temperature 260°C, H_2 flow 40 mL/min, air flow 450 mL/min, and makeup gas (He) flow 45 mL/min. Oil samples (1 μL) were injected by an autosampler (HP 7683; Hewlett-Packard). Peak areas were calculated, and data collection was managed using an HP Chemstation (Revision. A.09.01; Agilent Technologies, Palo Alto, CA). FA peaks were identified by using authentic standards. Undecanoic acid (11:0) was used as an internal standard for quantification.

Statistical analysis. All data were reported as the mean of triplicate analyses. ANOVA of the results was performed using the General Linear Model of SAS (Software version 8.1; SAS Institute Inc., Cary, NC). Multiple comparisons of the various means were carried out by least significant difference tests at $P = 0.05$.

RESULTS AND DISCUSSION

The oil content of high-oleic peanut lines developed through conventional breeding varied between 41.7% for Tamrun OL 02 and 48.6% (w/w) for TX 977164 (Table 1). The oil contents of these two varieties were significantly different from that of the parent lines, Tamrun 96 and SunOleic. However, these results were within the range of oil content reported for peanuts in the literature (8–10).

The protein content of these peanut varieties varied between 24.8 and 28.9% (w/w) (Table 1). There was no significant difference between the parents and the breeding lines in protein content. These results were also similar to the peanut protein content reported in the literature (8,11–13).

The TDF content of the samples ranged from 9 to 12% (w/w) (Table 1). There was no significant difference among the TDF contents of parents and breeding lines. Lintas and Cappelloni (14) reported TDF values of 10.9% (w/w) for peanuts using AOAC Method 985.29 (5). However, other methods such as AOAC Method 991.43 (5) may result in lower values than those reported in this study (15).

The ash contents of all peanut breeding lines (Table 1) examined in this study were similar and were about 2% (w/w). Derise *et al.* (16) also reported a very similar ash content for Virginia-type peanuts.

TABLE 1
Proximate Composition (%, w/w) of Peanut Seeds Developed Through Conventional Breeding[a]

Sample	SunOleic	Tamrun 96	Tamrun OL 01	Tamrun OL 02	TX 977164	TX 977239
Oil	43.4^{c}	44.3^{b,c}	41.7^{d}	45.6^{b}	48.6^{a}	44.0^{c}
Protein	26.6^{a,b,c}	28.1^{a,b}	28.9^{a}	27.1^{a,b,c}	26.2^{b,c}	24.8^{c}
TDF	11.9^{a}	11.2^{a,b}	10.8^{a,b}	10.4^{a,b}	10.4^{a,b}	9.3^{b}
Moisture	4.6^{a,b}	4.7^{a,b}	4.8^{a}	4.9^{a}	4.5^{b}	4.7^{a,b}
Ash	2.3^{a}	2.2^{a,b}	2.3^{a}	2.3^{a}	2.2^{a,b}	2.1^{b}

[a]Means in the same row with the same superscript roman letter are not significantly different at $P > 0.05$. TDF, total dietary fiber.

TABLE 2
Mineral Composition (mg/100 g) of Peanut Seeds Developed Through Conventional Breeding[a]

Sample	P	Ca	K	Mg	Cu	Fe	Zn	Na
SunOleic	331.3^{c}	100.1^{a}	611.2^{b}	179.9^{a,b}	1.0^{b,c}	2.2^{a}	4.6^{a,b}	24.1^{a}
Tamrun 96	364.0^{a}	90.4^{b,c}	600.2^{b,c}	178.5^{a,b}	1.1^{a}	2.0^{a,b}	4.9^{a}	23.6^{a}
Tamrun OL 01	328.9^{c}	83.5^{c,d}	640.1^{a}	166.6^{c}	1.0^{a,b}	1.8^{b,c}	4.3^{a,b,c}	23.4^{a}
Tamrun OL 02	345.4^{b}	79.4^{d,e}	639.6^{a}	177.3^{b}	0.9^{c,d}	1.9^{b,c}	3.8^{c}	22.5^{a}
TX 977164	341.0^{b}	72.3^{e}	591.6^{c}	183.5^{a}	0.8^{d}	1.8^{c}	4.0^{b,c}	23.4^{a}
TX 977239	336.8^{b,c}	95.1^{a,b}	607.3^{b}	166.5^{c}	1.1^{a,b}	2.1^{a}	3.9^{b,c}	22.4^{a}

[a]Means in the same column with the same superscript roman letter are not significantly different at $P > 0.05$.

TABLE 3
FA Composition (%, w/w) of Peanut Lines Developed Through Conventional Breeding[a]

FA	SunOleic	Tamrun 96	Tamrun OL 01	Tamrun OL 02	TX 977164	TX 977239
10:0	0.18^{a}	0.20^{a}	0.20^{a}	0.22^{a}	0.22^{a}	0.23^{a}
12:0	0.17^{a}	0.19^{a}	0.19^{a}	0.21^{a}	0.21^{a}	0.22^{a}
14:0	0.18^{a}	0.21^{a}	0.20^{a}	0.21^{a}	0.22^{a}	0.22^{a}
16:0	4.85^{b}	6.75^{a}	3.98^{d}	4.23^{c}	4.26^{c}	4.02^{d}
16:1	0.21^{b}	0.23^{a,b}	0.26^{a,b}	0.27^{a}	0.28^{a}	0.26^{a}
18:0	1.53^{c}	1.67^{b,c}	1.91^{b}	1.52^{c}	2.35^{a}	1.75^{b,c}
18:1n-9*c*	68.2^{c}	45.6^{d}	80.1^{a,b}	80.2^{a,b}	81.0^{a}	79.6^{b}
18:2n-6*c*	15.6^{b}	35.9^{a}	3.70^{d}	3.90^{d}	2.31^{e}	4.33^{c}
18:3n-3	0.23^{a}	0.27^{a}	0.27^{a}	0.26^{a}	0.25^{a}	0.28^{a}
20:0	1.01^{c}	1.10^{b}	1.12^{b}	1.09^{b}	1.35^{a}	1.10^{b}
20:1n-9*c*11	1.80^{b}	1.43^{e}	1.84^{a,b}	1.75^{c}	1.50^{d}	1.85^{a}
20:3n-6*c*8	0.19^{a}	0.21^{a}	0.21^{a}	0.22^{a}	0.22^{a}	0.23^{a}
20:4n-6	0.17^{a}	0.19^{a}	0.19^{a}	0.21^{a}	0.21^{a}	0.22^{a}
20:5*c*5,8,11,14,17	0.18^{a}	0.19^{a}	0.19^{a}	0.20^{a}	0.21^{a}	0.22^{a}
22:0	2.47^{b}	2.68^{a}	2.37^{c}	2.34^{c}	2.47^{b}	2.33^{c}
22:1n-9	0.36^{a,b}	0.33^{b,c}	0.39^{a}	0.36^{a,b}	0.3^{c}	0.39^{a}
24:0	1.68^{a}	1.67^{a}	1.68^{a}	1.56^{b}	1.44^{c}	1.59^{b}

[a]Means in the same row with the same superscript roman letter are not significantly different at $P > 0.05$.

The mineral composition of peanut seeds is given in Table 2. These peanut seeds were very rich in potassium (590 to 640 mg/100 g). Phosphorus (330 to 364 mg/100 g), calcium (80 to 100 mg/100 g), and magnesium (166 to 185 mg/100 g) were the other major minerals present in the seeds. Although there were some statistically significant differences among some of the peanut lines, differences were not substantial. The results of this study showed the same orders of magnitude for mineral content as various peanut varieties reported in the literature (16,17).

Oleic acid (18:1) accounted for about of 80% of the total FA in the selected peanut varieties (Table 3). These results were expected since these varieties have been developed for high oleic acid content. However, it should be noted that SunOleic had a significantly lower oleic acid content (68%) than expected (about 80%). A number of studies have indicated that growing season and geographic location affect the FA composition of peanuts (3,18–21). Oleic acid content of Tamrun 96 was quite low (about 45%) as compared with the other peanut lines examined in this study. All the other breeding lines showed a significant improvement in oleic acid content over both parent lines. The increase in oleic acid resulted in significant decreases in linoleic acid (18:2) content in the seeds. The concentrations of all the other FA in breeding lines were less than 3% except palmitic acid (16:0), which varied between 4 and 7%.

Although there were some statistical differences in chemical composition among the peanut breeding lines, these variations were within the range reported for traditional peanut varieties.

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