Peanut Triacylglycerols: Effect of Season and Production Location

T.H. SANDERS, U.S. Department of Agriculture, National Peanut Research Laboratory, 600 Forrester Drive, Dawson, GA 31742

ABSTRACT

Stereospecific analysis of triacylglycerols from 4 peanut varieties grown for up to 3 years at 4 locations showed diversity in percentage fatty acid placement. Distribution of oleic and linoleic acids at each position was significantly correlated to the amount in the total triacylglycerol for varieties grown at one location. However, correlations for the *sn*-3 position were not significant when data from more than one location were analyzed together. Generally, higher percentages of oleic or linoleic acid in the triacylglycerol resulted in a greater proportion of the particular fatty acid in the *sn*-2 position. Apparently, fatty acid concentrations as influenced by growing location have a significant influence on peanut triacylglycerol structure.

INTRODUCTION

Production location has a significant effect on the fatty acid composition of peanut oil (1-3). The increase in unsaturated fatty acids generally associated with cooler climates during the fruiting period may be related to increased oxygen concentration in developing fruit. Harris and James (4) suggest that oxygen is the major rate-limiting factor of desaturation of fatty acids in nonphotosynthetic tissue and, because oxygen concentration in solution increases with cooler temperature, unsaturation increases.

de la Roche et al. (5) found that the fatty acids at each position of corn oil triacylglycerols were influenced by the fatty acid concentration in the total triacylglycerol except for saturates in the *sn*-2 position. Investigations of fatty acid positional distribution in triacylglycerols from different peanut varieties demonstrated similar fatty acid concentration effects (6-8). A recent study of acylglycerol structure of peanut oils from unnamed varieties from 3 continents (9) substantiated previous studies (6-8) in concluding that natural peanut oils possess markedly nonrandom structures of highly asymmetric positional placement of the long-chain saturated fatty acids. Fatty acid composition of peanut triacylglycerols is similar to that of the whole oil from which the triacylglycerols are isolated (10); thus, differences in fatty acid composition attributed to location should result in triacylglycerols of concomitantly different structure. This investigation was undertaken to determine the effects of different seasons and production locations on the structure of triacylglycerols in 4 peanut varieties.

MATERIALS AND METHODS

Peanuts used in this investigation were drawn from pooled replicates from the 1975, 1976 and 1977 National Peanut Performance Trials. In each year, all seed peanuts for planting at all locations were derived from a common source. Peanuts were harvested and cured using conventional methods recommended in each state. Shelled peanuts riding a 0.635 × 1.905 cm shaker screen were stored in plastic bags at 4 C and most analyses were completed in 1978/79. Mean temperatures of the locations during the 6-week period immediately preceding harvest were determined by averaging the mean daily maximal and minimal temperatures.

As reported earlier (6) for lipid extraction, random 10-g samples of sound, mature, intact peanuts were blended with petroleum ether. After filtration and solvent removal, triacylglycerols were separated by thin layer chromatography (TLC). Careful attention was given to prevention of autoxidation by using a nitrogen atmosphere when possible and spraying or adding butylated hydroxy toluene in each step of isolation and stereospecific analysis.

Methyl esters were prepared with boron trifluoride/methanol (14% w/v, Applied Science Laboratories, Inc.) according to a modified Morrison and Smith (11) procedure. Benzene was replaced with toluene in the methylation mixture of methyl alcohol;benzene;boron trifluoride/methanol (11:4:5). Lipids were transmethylated in 9-mL vials sealed with Teflon cap liner and tape. The vials were heated in an oven at 100 C for 20-30 min, depending on the lipid type. Water (1 mL) was added to the cooled mixture, and the methyl esters were extracted with two 3-mL portions of hexane; then they were analyzed by gas liquid chromatography (GLC). The gas chromatograph, equipped with an FID and a 6.35 mm × 1.83 m stainless steel column packed with 10% EGSS-X on 100/120 Gas-Chrom P (Applied Science Laboratories, Inc.), was operated isothermally at 210 C. Carrier gas was helium at 100 mL/min. Fatty acid percentages were determined by digital integration and normalization of peak areas.

Stereospecific analysis was conducted essentially according to Brockerhoff (12) as modified by Weber et al. (13). The method for preparing phosphatidyl phenols was modified such that diacylglycerols in no more than 0.5 mL diethyl ether were added slowly, with shaking, to 2 mL pyridine (spectrophotometric grade, Aldrich Chemical Company) and 0.12 mL phenyl dichlorophosphate (Aldrich Chemical Company) to prevent precipitate formation. Each value reported is the mean of at least 3 analyses.

RESULTS AND DISCUSSION

The individual triacylglycerol fatty acid compositions from both Early Bunch and Florunner peanut varieties were essentially the same for 3 successive years in peanuts produced at Gainvesville, FL, or at Stephenville, TX (Tables I and II). The largest difference noted in a major (>10%) fatty acid was 1.8 mole %. Between locations, however, there were substantial differences in fatty acid composition, the largest differences occurring in oleic and linoleic acids. In both varieties, higher linoleic acid percentages occurred when the peanuts were grown in the cooler climate of Stephenville, TX. Mean temperatures for the 6-week period immediately preceding harvest were Gainesville, 1975 – 26.7 C, 1976 – 26.6 C, 1977 – 27.8 C; Stephenville, 1975 – 19.4 C, 1976 – 14.7 C, 1977 – 15.9 C. Yearly consistency of fatty acid composition was noted by Worthington and Hammons (14), who compared whole oil from 14 varieties grown over 3 years in Tifton, GA. Several reports (1-3) document whole oil fatty acid variation within a variety at different locations. Stereospecific structure of the triacylglycerols followed trends similar to total fatty

TABLE I

Yearly Variation in Early Bunch Triacylglycerol (TG) Structure at Gainesville, FL (G), and Stephenville, TX (S)

Year	Location		Fatty acid distribution (mol %)							
			16:0	18:0	18:1	18:2	20:1	20:1	22:0	24:0
1975	G	TG	13.1	2.6	41.9	37.2	1.4	0.9	2.0	0.9
		1	22.1	3.2	40.6	32.2	0.5	0.6	0.6	0.3
		2	1.5	0.2	40.2	58.1	–	–	–	–
		3	15.6	4.4	45.1	21.4	3.7	2.0	5.4	2.4
	Percent in $\frac{1+3}{2}$				68.1 / 35.9	48.0 / 52.0				
1976	G	TG	13.4	2.1	41.9	37.8	1.1	0.8	2.0	1.0
		1	19.7	2.8	41.5	34.9	–	0.4	0.6	0.2
		2	2.3	–	44.7	53.0	–	–	–	–
		3	18.1	3.5	39.4	25.5	3.2	2.1	5.4	2.7
	Percent in $\frac{1+3}{2}$				64.4 / 35.6	53.3 / 46.7				
1977	G	TG	13.4	2.3	41.7	38.2	1.1	0.8	1.8	0.7
		1	25.6	3.4	38.1	31.9	0.2	0.3	0.4	0.1
		2	4.3	0.9	38.6	56.2	–	–	–	–
		3	10.3	2.5	48.6	26.5	3.2	2.0	4.9	2.1
	Percent in $\frac{1+3}{2}$				69.3 / 30.8	50.9 / 49.0				
1975	S	TG	11.7	1.8	37.5	43.1	1.2	1.2	2.3	1.1
		1	20.7	2.3	36.6	38.2	0.2	0.8	0.8	0.4
		2	1.0	0.1	31.3	67.6	–	–	–	–
		3	13.5	3.1	44.7	23.7	3.4	2.9	5.9	2.9
	Percent in $\frac{1+3}{2}$				72.2 / 27.8	47.8 / 52.2				
1976	S	TG	12.4	1.6	37.9	43.0	1.2	1.1	2.0	0.8
		1	22.6	2.8	34.4	38.8	0.5	0.5	0.4	–
		2	2.9	0.6	31.6	64.2	0.1	0.2	0.3	0.1
		3	11.5	1.4	47.8	25.9	3.1	2.7	5.4	2.2
	Percent in $\frac{1+3}{2}$				72.3 / 27.8	50.2 / 49.8				
1977	S	TG	11.8	1.5	36.3	44.3	1.0	1.3	2.5	1.3
		1	22.5	2.0	34.1	39.9	–	0.7	0.6	0.2
		2	2.5	0.4	29.4	67.7	–	–	–	–
		3	10.5	2.1	45.5	25.3	3.0	3.3	6.8	3.6
	Percent in $\frac{1+3}{2}$				73.1 / 26.9	49.0 / 50.9				

acids in that yearly variation at a location was usually small; however, between locations, differences in structure were evident.

In an earlier publication (6), we found that, in 6 different commercial varieties grown in Headland, AL, the amount of oleic or linoleic acid at a given position was influenced by the total amount of that fatty acid in the triacylglycerol fraction. This relationship had previously been reported for other seed oils (5,13). Regression analysis of the oleic and linoleic acid data in Tables I and II for both varieties grown at either location produced correlations (Table III) similar to those previously reported. However, when the data from either variety grown at the 2 different locations was analyzed, correlation coefficients at the *sn*-3 position were not significant (Table III). This indicates that some factor related to growing location had a direct influence on triacylglycerol structure. de la Roche et al. (5) reported that regression slope values for the relationship between fatty acids in corn oil total triacylglycerol and fatty acids at each position suggested that the fatty acid composition at the *sn*-3 position was the most strongly influenced by the concentration of various fatty acids in the total triacylglycerol. Weber et al. (13) observed the least amount of positional specificity at the *sn*-3 position of corn oil triacylglycerol. Application of these observations to peanut oil triacylglycerols suggests that the fatty acid concentration variations resulting from environments of different temperature would have the most effect on the *sn*-3 position.

Fatemi and Hammond (15) indicated that the slopes of all 3 triacylglycerol positions for an acid should average 1 and, in each case in Table III, the slopes average 1. Slopes higher than 1 indicate that the placement of the fatty acids were favored on that position, and the higher it is, the more the placement is favored (15). Interestingly, the slopes for the *sn*-2 position are considerably higher for a variety grown at 2 locations than for 2 varieties grown at a location, whereas the opposite is true for the *sn*-3 position, suggesting further the influence of fatty acid concentrations. de la Roche et al. (5) concluded that fatty acid distribution in maize triacylglycerols was the result of 2 major effects, fatty acid concentration and positional specificity. As proportion is an expression of position specificity (5), the data in Tables I and II indicate that positional specificity was not of noticeable effect. This is evident in that, as the distribution of oleic and linoleic acids at all 3 positions differed depending on variety of growing location, the proportion of those fatty acids at the *sn*-1 + *sn*-3 and *sn*-2 positions was also different. A substantial positional specificity effect would have resulted in similar propor-

TABLE II

Yearly Variation in Florunner Triacylglycerol (TG) Structure at Gainesville, FL (G), and Stephenville, TX (S)

Year	Location		Fatty acid distribution (mol %) 16:0	18:0	18:1	18:2	20:1	20:1	22:0	24:0
1975	G	TG	11.4	2.1	51.6	28.9	1.2	1.2	2.6	1.1
		1	19.7	2.6	50.9	24.6	0.4	0.8	0.7	0.3
		2	1.2	0.1	52.9	45.8	–	–	–	–
		3	13.1	3.5	51.0	16.3	3.3	2.7	7.1	3.0
	Percent in	1+3			65.8	47.2				
		2			34.2	52.8				
1976	G	TG	11.9	1.8	52.7	29.7	0.8	0.8	1.8	0.6
		1	20.3	2.8	51.2	25.0	0.1	0.5	–	–
		2	1.8	0.6	52.2	45.5	–	–	–	–
		3	13.6	2.2	54.7	18.6	2.2	2.0	5.0	1.7
	Percent in	1+3			67.0	48.9				
		2			33.0	51.1				
1977	G	TG	11.5	1.7	52.3	29.0	1.0	1.1	2.2	1.1
		1	20.7	2.2	50.5	24.8	0.2	0.7	0.5	0.4
		2	2.2	0.3	50.4	47.2	–	–	–	–
		3	11.8	2.7	56.1	15.1	2.8	2.6	6.2	2.8
	Percent in	1+3			68.0	45.8				
		2			32.0	54.2				
1975	S	TG	11.3	1.6	44.7	36.5	1.1	1.5	2.3	1.1
		1	18.9	2.0	45.4	31.0	0.4	1.0	0.9	0.4
		2	1.2	0.1	39.5	59.1	–	–	0.1	–
		3	13.7	2.7	49.2	19.4	2.9	3.4	5.8	2.9
	Percent in	1+3			70.5	46.0				
		2			29.5	54.0				
1976	S	TG	11.1	1.3	44.5	37.4	0.9	1.6	2.3	0.9
		1	20.4	2.0	44.0	31.8	0.2	1.0	0.7	–
		2	1.9	0.5	36.9	60.4	0.1	0.1	0.1	–
		3	11.0	1.3	52.5	20.1	2.5	3.8	6.2	2.6
	Percent in	1+3			72.3	46.2				
		2			27.6	53.8				
1977	S	TG	11.3	1.4	46.1	35.6	1.0	1.3	2.1	1.1
		1	19.3	1.7	45.3	32.0	–	0.7	0.6	0.3
		2	1.7	0.2	40.9	57.2	–	–	–	–
		3	12.9	2.3	52.2	17.7	2.9	3.1	5.8	3.1
	Percent in	1+3			70.5	46.5				
		2			29.6	53.6				

TABLE III

Linear Regression Analyses and Correlation Coefficients for the Relationship of Fatty Acids in Total Triacylglycerols and Fatty Acids at Each Position for Early Bunch (EB) and Florunner (FR) Varieties Grown in 1975, 1976 and 1977 at Stephenville, TX (S), and Gainesville, FL (G)

Variety	Location	Position	18:1 Slope	18:1 y Intercept	18:1 r[a]	18:2 Slope	18:2 y Intercept	18:2 r[a]
EB	S & G	1	1.08	-5.36	0.90	1.03	-5.91	0.94
		2	2.25	-53.31	0.94	1.82	-12.90	0.93
		3	-0.32	58.05	-0.25[b]	0.14	18.92	0.24[b]
FR	S & G	1	0.82	7.59	0.98	0.90	-1.64	0.98
		2	1.77	-40.85	0.98	1.73	-4.35	0.99
		3	0.40	32.95	0.64[b]	0.36	5.90	0.77[b]
EB & FR	G	1	1.04	-3.46	0.98	0.95	-3.06	0.97
		2	1.03	-2.56	0.95	1.10	14.12	0.93
		3	0.92	5.49	0.84	0.94	11.00	0.93
EB & FR	S	1	1.23	-10.78	0.98	1.03	-6.00	0.98
		2	1.08	-9.78	0.98	1.11	18.21	0.96
		3	0.67	20.75	0.90	0.84	-11.95	0.97

[a]r = Correlation coefficient.
[b]Not significant.

TABLE IV

Variation in Florunner Triacylglycerol (TG) Structure at Four Locations in 1976

Location		Fatty acid distribution (mol %)							
		16:0	18:0	18:1	18:2	20:0	20:1	22:0	24:0
Gainesville, FL	TG	11.9	1.8	52.7	29.7	0.8	0.8	1.8	0.6
	1	20.3	2.8	51.2	25.0	0.1	0.5	0.2	–
	2	1.8	0.6	52.2	45.5	–	–	–	–
	3	13.6	2.2	54.7	18.6	2.2	2.0	5.0	1.7
Percent in	1+3			67.0	48.9				
	2			33.0	51.1				
Headland, AL	TG	11.4	2.1	50.9	29.1	1.6	1.1	2.4	1.3
	1	20.7	3.5	49.5	24.4	0.3	0.7	0.5	0.5
	2	2.1	0.6	47.8	48.8	0.1	0.4	0.1	0.1
	3	11.5	2.3	55.5	14.2	4.4	2.3	6.5	3.4
Percent in	1+3			68.7	44.1				
	2			31.3	55.9				
Suffolk, VA	TG	11.5	1.6	46.1	35.9	0.8	1.1	2.2	0.8
	1	19.7	2.7	46.0	30.6	0.2	0.6	0.2	–
	2	1.9	0.7	41.0	56.2	0.1	0.1	–	–
	3	12.9	1.2	51.4	20.9	2.0	2.8	6.4	2.4
Percent in	1+3			70.4	47.8				
	2			29.6	52.2				
Stephenville, TX	TG	11.1	1.3	44.5	37.4	0.9	1.6	2.3	0.9
	1	20.4	2.0	44.0	31.8	0.2	1.0	0.7	–
	2	1.9	0.5	36.9	60.4	0.1	0.1	0.1	–
	3	11.0	1.3	52.5	20.1	2.5	3.8	6.2	2.6
Percent in	1+3			72.3	46.2				
	2			27.6	53.8				

TABLE V

Variation in Florigiant Triacylglycerol (TG) Structure at Four Locations in 1976

Location		Fatty acid distribution (mol %)							
		16:0	18:0	18:1	18:2	20:0	20:1	22:0	24:0
Gainesville, FL	TG	10.7	2.8	54.8	26.1	1.4	0.9	2.3	1.1
	1	14.8	3.2	56.1	24.4	0.3	0.5	0.6	0.2
	2	1.8	–	65.1	33.1	–	–	–	–
	3	15.4	5.3	43.3	20.8	3.8	2.2	6.2	3.1
Percent in	1+3			60.4	57.7				
	2			39.6	42.3				
Headland, AL	TG	10.8	2.9	53.1	27.3	1.8	1.0	1.9	1.1
	1	20.1	4.9	50.7	22.4	0.5	0.7	0.4	0.3
	2	2.2	0.7	51.5	45.3	0.1	0.1	0.1	–
	3	10.3	3.3	57.2	14.2	4.8	2.0	5.3	3.0
Percent in	1+3			67.7	44.7				
	2			32.3	55.3				
Suffolk, VA	TG	11.3	2.1	45.9	34.7	1.3	1.2	2.5	1.0
	1	20.2	3.1	43.9	31.0	0.5	0.6	0.5	0.2
	2	2.6	0.4	41.9	55.0	–	–	0.1	–
	3	11.0	2.8	51.9	18.1	3.5	3.0	6.9	2.8
Percent in	1+3			69.6	47.2				
	2			30.4	52.8				
Stephenville, TX	TG	11.5	1.7	44.7	36.7	1.0	1.2	2.4	0.9
	1	21.1	2.6	41.8	33.8	0.1	0.2	0.4	–
	2	2.1	0.6	40.2	56.9	–	0.1	0.1	–
	3	11.3	1.8	52.2	19.3	2.9	3.3	6.5	2.7
Percent in	1+3			70.1	48.2				
	2			30.0	51.7				

tions, even though distributions changed.

Temperature effects on fatty acid composition are evident in Tables IV-VII in which data from 4 different varieties grown at 4 locations are presented. Mean temperatures for the 6-week period immediately preceding harvest at the 4 locations were Gainesville, FL, 26.6 C; Headland, AL, 25.5 C; Suffolk, VA, 21.7 C; and Stephenville, TX, 14.7 C. As temperature at the growing location decreased, linoleic acid concentration increased and oleic acid concentration decreased. Concomitantly, the percentage distribution

TABLE VI

Variation in Starr Triacylglycerol (TG) Structure at Four Locations in 1976

Location		Fatty acid distribution (mol %)							
		16:0	18:0	18:1	18:2	20:0	20:1	22:0	24:0
Gainesville, FL	TG	15.1	2.7	43.7	32.6	1.3	0.9	2.8	0.9
	1	27.0	3.8	40.3	28.2	0.1	0.2	0.5	–
	2	3.6	1.0	47.3	48.1	–	–	–	–
	3	14.6	3.3	43.5	21.6	3.9	2.5	7.8	2.8
Percent in $\frac{1+3}{2}$				$\frac{63.9}{36.1}$	$\frac{50.9}{49.1}$				
Headland, AL	TG	14.2	3.3	43.3	32.9	1.8	1.1	2.7	0.7
	1	24.2	4.9	40.4	28.5	0.4	0.6	0.7	0.3
	2	2.4	0.8	39.5	56.9	0.1	0.2	0.1	–
	3	16.1	4.2	50.0	13.2	4.8	2.6	7.4	1.9
Percent in $\frac{1+3}{2}$				$\frac{69.6}{30.4}$	$\frac{42.3}{57.6}$				
Suffolk, VA	TG	14.4	2.3	41.6	36.0	1.6	0.9	2.8	0.5
	1	24.4	4.2	38.1	31.8	0.6	0.5	0.5	–
	2	2.9	0.7	37.2	58.9	–	0.1	0.2	–
	3	15.9	2.0	49.6	17.4	4.1	1.9	7.6	1.5
Percent in $\frac{1+3}{2}$				$\frac{70.2}{29.8}$	$\frac{45.5}{54.5}$				
Stephenville, TX	TG	13.6	3.0	40.9	36.8	1.5	0.7	2.8	0.7
	1	24.8	4.0	37.9	32.4	0.1	0.3	0.5	–
	2	2.2	0.6	36.3	60.8	–	–	–	–
	3	13.8	4.5	48.6	17.2	4.4	1.8	7.8	2.0
Percent in $\frac{1+3}{2}$				$\frac{70.5}{29.6}$	$\frac{44.9}{55.1}$				

TABLE VII

Variation in Early Bunch Triacylglycerol (TG) Structure at Four Locations in 1976

Location		Fatty acid distribution (mol %)							
		16:0	18:0	18:1	18:2	20:0	20:1	22:0	24:0
Gainesville, FL	TG	13.4	2.1	41.9	37.8	1.1	0.8	2.0	1.0
	1	19.7	2.8	41.5	34.9	–	0.4	0.6	0.2
	2	2.3	–	44.7	53.0	–	–	–	–
	3	18.1	3.5	39.4	25.5	3.2	2.1	5.4	2.7
Percent in $\frac{1+3}{2}$				$\frac{64.4}{35.6}$	$\frac{53.3}{46.7}$				
Headland, AL	TG	13.3	2.6	42.0	36.3	1.5	0.9	2.4	1.1
	1	24.7	4.4	38.3	31.2	0.3	0.4	0.5	0.2
	2	3.5	1.5	37.2	57.4	0.1	0.2	–	–
	3	11.8	2.0	50.6	20.3	4.0	1.9	6.5	3.0
Percent in $\frac{1+3}{2}$				$\frac{70.5}{29.5}$	$\frac{47.3}{52.7}$				
Suffolk, VA	TG	12.4	1.8	37.3	42.7	1.1	1.3	2.6	0.9
	1	21.5	2.6	34.4	39.6	0.5	0.7	0.6	0.2
	2	2.0	0.3	30.0	67.5	–	0.1	0.2	–
	3	13.8	2.4	47.5	20.9	2.8	3.1	7.0	2.5
Percent in $\frac{1+3}{2}$				$\frac{73.2}{26.8}$	$\frac{47.2}{52.7}$				
Stephenville, TX	TG	12.4	1.6	37.9	43.0	1.2	1.1	2.0	0.8
	1	22.6	2.8	34.4	38.8	0.5	0.5	0.4	–
	2	2.9	0.6	31.5	64.2	0.1	0.2	0.3	0.1
	3	11.5	1.4	47.8	25.9	3.1	2.7	5.4	2.2
Percent in $\frac{1+3}{2}$				$\frac{72.3}{27.7}$	$\frac{50.2}{49.8}$				

(mole %) of linoleic acid at the *sn*-2 position generally increased whereas oleic acid percentage decreased. As concentration of oleic acid in the triacylglycerol decreased, the percentage distribution of that fatty acid in the *sn*-1 position also decreased. These observed relationships are substantiated by significant correlation coefficients for the amount of a fatty acid in the triacylglycerol and the amount at the *sn*-1 and *sn*-2 positions. The correlations for the *sn*-3 position, as in Table III, were generally not significant (data not presented).

The proportion of oleic or linoleic acid at the *sn*-1 + *sn*-3 vs the *sn*-2 positions changed in a similar pattern for all 4

varieties. Generally, higher percentages of oleic or linoleic acid in the triacylglycerol resulted in a greater proportion of the fatty acid in the *sn*-2 position and, consequently, less at the exterior positions. The exception to this trend was found in peanuts grown at Headland, AL. In each variety, the proportion of linoleic acid at the *sn*-2 position was greater than at any other growing location, although the concentration in the triacylglycerols was not the highest of the 4 locations.

The data presented make obvious the fact that environment affects not only fatty acid composition of peanut oil, but also, although apparently indirectly, the spatial arrangement of those acids on the triacylglycerol molecules. Because peanut triacylglycerol structure and composition and total oil composition have been associated with such factors as atherogenic potency (16) and oxidative stability (17), the far-reaching implications of different growing locations are obvious.

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Preparation and Composition of a Dry-Milled Flour from Cowpeas[1]

R.D. PHILLIPS, Department of Food Science, University of Georgia Agricultural Experiment Station, Experiment, GA 30212

ABSTRACT

Cowpeas having a smooth, brown, loosely adhering seedcoat (Mississippi Silver Hull Crowder) were milled to a flour by coarsely cracking the dry (12% H_2O) peas on a Morehouse Mill, aspirating the seedcoats on a peanut sheller, and reducing the cotyledon fraction to a flour by several passes through the Morehouse Mill. The flour was produced in 88% yield from the starting peas. The proximate composition of resulting flour differed from that of whole peas principally in fiber content (2.5 vs 7.1% ADF), and also contained (dsb) 26% protein, 1.6% fat, 3.3% ash and ~67% NFE. Seed coat removal also reduced tannin content and effective trypsin inhibitor activity of the flour. The essential amino acid profile of cowpea flour resembled that of soy flour, but was somewhat lower in the limiting sulfur amino acids.

INTRODUCTION

Starchy legumes represent a greatly underused source of protein, calories and B vitamins for world-wide nutrition, and of potential ingredients for the food industry. However, there are relatively few commercial ventures which process non-oilseed legumes into food ingredients.

Cowpeas (*Vigna unguiculata*), more commonly known in the U.S. as Southern, or black-eyed, or crowder peas, depending on the type, are an important source of protein in the developing world, especially West Africa (1). Their potential for increasing protein consumption in the developing countries is such that the Protein Advisory Group (FAO/UN) has recommended this crop be accorded priority research status (2).

In Africa, peas are prepared for consumption in a great variety of ways. Many applications call for removal of the seed coat and grinding the cotyledons to a paste prior to cooking. This is most often accomplished by soaking the peas and manually rubbing to loosen the seed coat. Alternatively, hydratable flours are produced by small-scale, dry, or combined wet and dry milling operations (1).

The laborious, time-consuming nature of traditional seed coat removal and grinding has been emphasized as one of the constraints on increased consumption of peas (1). Accordingly, several researchers have investigated wet and dry milling schemes aimed at circumventing this barrier (3-5). Dry milling has several advantages over wet milling in developing as well as in industrialized countries. Energy requirements are lower due to elimination of the drying step; microbial contamination is more easily avoided; and liquid waste streams are not generated. However, cowpea cotyledons are much softer than cereal endosperm tissue, and higher milling losses of desirable material result when abrasive dry milling is used. Abrasive, rather than attrition, milling of cowpeas has been emphasized because most African varieties have tightly adhering seed coats which are not readily released in the absence of water. In contrast, several cultivars of the "crowder" type, popular in the Southern U.S., have smooth, brittle, loosely adhering seed coats which are easily removed by cracking and aspiration. This paper describes the production and composition of a

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