Quality Factors in Exported Peanuts from Argentina, China and the United States

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In three crop years (1986–1988), peanuts exported from Argentina, China and the United States were evaluated for biochemical composition relative to flavor and shelf-life quality potentials and physical size conformity. Relationships were consistent in that oil stability was associated with high tocopherol and oleic/linoleic acid ratio, and with low free fatty acid, peroxide, carbonyl, and copper and iron content. Peanuts from specific origins had recurring component patterns, with highest indications for shelf life and flavor potential in United States samples. Although no single factor or group of factors can be relied on completely as predictors of flavor or quality, these data establish a significant positive relationship between oil quality factors and roasted peanut flavor quality potential. Argentina and United States peanuts were the most consistently sized, and China peanuts generally had the lowest count/weight.

KEY WORDS: *Arachis hypogaea*, export, oil composition, peanuts, quality, shelf life.

Peanuts, produced in many countries throughout the world, are recognized as one of the major oilseed crops and as a rich source of protein. Although many peanuts are utilized in the country of production, major consistent exporters of peanuts for human consumption are the United States, China and Argentina (1). Other countries, such as India, the major producer of peanuts worldwide, less regularly have substantial quantities of peanuts for export (2).

The unique roasted flavor of peanuts is the basis for most marketing of export/import peanuts. Thus, information on factors that indicate and/or affect food quality of peanuts is of considerable importance to the worldwide peanut processing and manufacturing community. Peanuts from different national origins are likely to be genetically different and are grown, harvested, cured, stored and shelled under different environmental, cultural and processing conditions. Quality potential variation as a result of these conditions has been extensively documented (3–13). The vast majority of this work has been directed at the lipid fraction because of the significant impact that oxidized lipids have in development of off-flavors. Because quality variation results in processed food product variation, this study was undertaken to evaluate lipid and lipid-related composition and flavor differences as a measure of potential processed food variation.

The objective of these studies was to develop baseline data as a useful measure of market quality and food product quality potential of typical peanuts in commerce from major exporting countries. This report documents results of composition and shelf-life quality evaluations as well as seed size variation within lots, which relates to roast color variability due to size and maturity distribution differences (12). The descriptive sensory portion of the study will be the subject of a separate report.

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MATERIALS AND METHODS

Through collaboration of peanut warehouse operators, peanut samples were obtained from commercial shipment lots of peanuts arriving in Europe. Lots from China, Argentina and the United States from 1986–1988 crop years were sampled in Rotterdam, The Netherlands, usually in May or June of the following year. Each year, ten shipment lots intended ultimately for comparable processing were randomly identified by Dutch personnel as typical commercial shipments from each of the countries. All lots were 40/50 count/oz except that the China, 1988 sample was 35/40 count/oz. From 15 random bags in each large lot, 0.45-kg probed samples were taken and combined into a single 6.7-kg representative sample. Samples were packaged and shipped to the USDA, ARS, Southern Regional Research Center in New Orleans, LA, after clearing APHIS quarantine inspection in New York, NY. Duplicate subsamples from the lots were packed in sealed glass jars and delivered to the USDA, ARS, National Peanut Research Laboratory (Dawson, GA) where they were held at −15°C until analysis. For each subsample, a minimum of duplicate analyses of each type was performed.

Oil for fatty acid profile (oleic/linoleic acid ratio) and peroxide analyses was extracted by pressing ground peanut meal in a Carver Laboratory press at 15,000 psi for 20 min. Oil was filtered before fatty acid and peroxide analyses were performed. The pressed cake was used for elemental analysis. Three subsamples of the pressed peanut meal of each sampling lot were dry-ashed at 450°C for 4 h, and the residue was dissolved in 5 mL of 3 M HCl prior to diluting to a total volume of 25 mL with deionized water. A subsample of the pressed peanut meal was placed in a drying oven to obtain a dry weight. Concentrations of iron and copper were determined by inductively coupled argon plasma spectrophotometry (ICAP) and reported on a dry-weight basis (14). Fatty acid methyl esters were prepared with BF_3 methanol (Applied Science Laboratories, Inc., State College, PA) as previously described (9). Methyl esters were quantitated with a Hewlett-Packard Model 5840A gas chromatograph equipped with a flame ionization detector (Palo Alto, CA). The stainless steel (3.17 mm × 1.83 m) column was packed with 5% DEGS-PS on 100/120 Supelcoport (Supelco, Inc., Bellefonte, PA). The carrier gas was helium at 30 mL/min, and the column was operated isothermally at 200°C. Fatty acid percentages were determined by digital integration and normalization of peak area. Quantitative accuracy was verified by daily analysis of a standard sample (Std. 21A, NuChek Prep Inc., Elysian, MN).

Peroxide value was determined on 5-g aliquots of pressed oil by AOCS Method CD 8-53 (15). Free fatty acids were determined on oil extracted from 60-g ground peanut subsamples according to AOCS Method AA 6-38 (15). For total carbonyl content, 20–30 g of peanuts were ground in a Krups coffee mill, and duplicate 4-g subsamples were immediately extracted with 40 mL of toluene as the initial step of the carbonyl assay. Total carbonyls were determined by a modification of the 2,4-dinitrophenyl hydrazine method of Henick *et al.* (16). Tocopherol analysis was conducted according to the methods of Cort *et al.* (17), except that 10-g subsamples were used for extraction and 3% tetrahydrofuran in iso-octane was used as high-performance liquid chromatography (HPLC) mobile phase. Quantitation was verified by analysis of a standard mixture of tocopherols.

The stability of press-extracted oil was determined by the method of Olcott and Einset (18). Triplicate oil samples of about 450 mg each were placed in 40-mL crucibles and subjected to 60°C in a forced-air oven. Samples were weighed at regular intervals, and the number of days required for the first rapid weight gain of 1 mg was recorded as the length of stability in oven days.

Oil quality/composition data were subjected to analysis of variance, and means were separated by Duncan's Multiple Range Test.

In the sizing portion of the study, 200–500 g of peanuts from each sample were screened according to thickness over screens with slotted holes of 25.4 mm length and a width of either 8.3 mm, 7.1 mm or 6.4 mm as previously described (19).

RESULTS AND DISCUSSION

Qualitative and quantitative compositional data of peanuts and peanut oil relate directly to storability and flavor characteristics of peanuts and roasted peanut products. The effects of cultivar, environment, maturity and handling practices on peanut oil and peanut quality have been documented (3–13). Those factors that relate to long shelf-life stability, and thus flavor maintenance, are high oleic acid to linoleic acid ratio and tocopherol content and low free fatty acid percentage, peroxide value, total carbonyl content and copper and iron concentrations. The collective results and discussion that follow provide a consistent statement of the relationships of those factors in peanuts on the world market, and the results are usable as accurate indicators of flavor quality, shelf-life stability and flavor preservation potential of roasted peanut products.

Oleic acid/linoleic acid ratio. In many oilseed products, the degree of unsaturation in the total fatty acid component is considered an indicator of product stability, and there is longstanding evidence for peanuts that better stability is related to higher relative proportions of oleic to linoleic fatty acids (O/L ratio) (4). In this study, the United States peanuts consistently contained a significantly higher O/L ratio, followed by Argentina and China peanuts (Table 1). Ratios were relatively consistent for each origin among the three years. How and Young (20) examined fatty acid content of peanuts from six countries, which were imported into the United States in 1981. They reported O/L ratios for Chinese and Argentine peanuts of about 1–1.25, and these data agree well with ratios found in the three years of this study. Within genetic limitations, the degree of unsaturation in peanut oil is influenced by temperature of the growth environment (5,21,22) and maturity (9–11). A cooler growth environment generally results in more unsaturation (21), and maturation generally results in decreased unsaturation and thus an increase in O/L ratio (11,23). The consistent differences in O/L ratio suggest a higher potential for product stability in peanuts from the United States, and further, as the data are related to maturity, differences suggest a higher potential for development of full roast flavor and lower potential for off-flavor in peanut products (13).

Free fatty acids. High free fatty acid percentages may indicate poor handling, immaturity, mold growth or other ester hydrolysis activity. Peanuts from Argentina consistently had the highest free fatty acid percentages, followed by China and the United States (Table 2). In 1986, China and United States samples were not significantly

TABLE 1

Oleic and Linoleic Acid Content and Oleic to Linoleic Fatty Acids (O/L ratio) of Peanuts from 1986, 1987 and 1988 Export Lots from Argentina, China and United States[a]

Country	C18:1 (%)	C18:2 (%)	O/L (ratio)
1986			
Argentina	42.9 B	37.7 A	1.14 B
China	40.5 C	37.3 B	1.09 C
United States	49.5 A	31.0 C	1.60 A
1987			
Argentina	45.2 B	35.4 A	1.28 B
China	42.5 C	35.6 A	1.20 C
United States	51.5 A	28.6 A	1.82 A
1988			
Argentina	44.0 B	35.6 A	1.24 B
China	42.0 C	35.8 A	1.17 C
United States	50.1 A	30.1 B	1.67 A

[a]Means followed by different letters are significantly different by Duncan's Multiple Range Test ($P \leq 0.05$).

TABLE 2

Free Fatty Acid (FFA) Percentage, Peroxide Value (PV) and Total Carbonyl (CARB) Content of Peanuts from 1986, 1987 and 1988 Export Lots from Argentina, China and United States[a]

Country	FFA (%)	PV (MEQ/kg)	CARB (mmol/kg)
1986			
Argentina	0.82 A	0.85 A	2.73 A
China	0.27 B	0.48 B	1.41 B
United States	0.22 B	0.34 C	1.37 B
1987			
Argentina	0.51 A	1.10 A	2.06 A
China	0.43 A	0.84 B	1.57 B
United States	0.24 B	0.53 C	1.68 B
1988			
Argentina	0.42 A	0.88 A	2.05 A
China	0.32 B	0.53 B	1.68 B
United States	0.23 C	0.42 C	1.73 B

[a]Means followed by different letters are significantly different by Duncan's Multiple Range Test ($P \leq 0.05$).

different, and in 1987, samples from Argentina and China were not significantly different. In 1988, however, samples from the three origins were all significantly different. Yearly variation among samples from the same origin was highest for Argentina, then China. Variation by year for the United States samples was extremely small and the low, less variable values may be attributable to consistent mechanized harvesting, handling and storage practices commonly found in the United States.

Free fatty acids are likely to be involved in lipid degradation because they are more reactive than esterified fatty acids, and unsaturated fatty acids are subject to various oxidative mechanisms. Some of these processes are autocatalytic and proceed from reacted fatty acids to various hydroperoxides, which are susceptible to further oxidation or decomposition to form secondary carbonyl reaction products (24). Often these compounds can adversely affect flavor and overall quality.

Peroxide value. Consistent significant differences in peroxide value were found among samples of peanuts from the three origins (Table 2). In each year, peanuts from Argentina contained the highest concentrations, followed by those from China and then the United States. The presence of reactive oxygen is the initial evidence of the development of rancidity (24). None of the peroxide values in Table 2 are excessively high for peanuts. However, peroxides, once formed, are involved as catalysts in the series of reactions of lipid oxidation, and higher values suggest shorter shelf life due to this relationship.

Total carbonyls. As in peroxide value, Argentina-grown peanuts were consistently significantly higher in total carbonyls (Table 2). Samples from China and United States were not significantly different in total carbonyl content in any of the three years examined. Hoover and Nathan (25) found a high correlation between increases in total carbonyl content and decreases in hedonic flavor scores of peanuts. In salted-in-the-shell peanuts, carbonyl content increased about fourfold after one week at 63°C. Earlier work (26) suggested a decrease in the "fresh roasted" aroma with increased total carbonyls in powdered roasted peanut products. The term "bland" was applied to aroma of control product after one-month storage at 22–27°C. Total carbonyls reported here are for raw peanuts; however, limited data by Brown *et al.* (27) indicate a direct relationship in carbonyl content in raw and subsequently roasted peanuts. St. Angelo *et al.* (28) investivated volatile profiles as quality indicators of domestic and imported peanuts from Argentina, China and India. Peanuts with rancid off-flavors had higher concentrations of carbonyls, hexanal and hexanol and other lipid degradation hydrocarbons.

Copper and iron. Copper and iron are catalysts that participate in enzymatic and nonenzymatic oxidation of lipids. Total concentrations do not necessarily indicate active species; however, higher concentrations are generally taken as an indication of increased potential participation in lipid oxidation mechanisms. In Table 3, copper concentrations follow a consistent trend each year with significant differences among all origins. China-grown peanuts were highest, then Argentina-grown, followed by a large numerical decrease to peanuts produced in the United States. Iron concentrations were somewhat more variable than copper. All origins were different in 1986, while China and the United States were significantly lower in 1987. China and Argentina peanuts were different in 1988, with United States not significantly different from either.

TABLE 3

Content of Copper, Iron, Tocopherol (TOCO) and Oil Oven Stability (O.S.) of Peanuts from 1986, 1987 and 1988 Export Lots from Argentina, China and United States[a]

Country	Copper (ppm)	Iron (ppm)	TOCO (ppm)[b]	O.S. (days)
1986				
Argentina	11.80 B	80.28 A	219.0 B	14.25 B
China	12.98 A	72.68 B	183.9 C	14.20 B
United States	6.15 C	62.30 C	243.8 A	17.80 A
1987				
Argentina	15.03 B	66.44 A	204.1 A	16.75 B
China	17.01 A	56.84 B	151.7 B	15.05 C
United States	12.35 C	55.09 B	210.1 A	20.95 A
1988				
Argentina	17.33 B	37.87 B	149.4 B	18.60 B
China	21.22 A	44.70 A	102.9 C	17.55 C
United States	12.18 C	41.04 AB	220.9 A	23.10 A

[a]Means followed by different letters are significantly different by Duncan's Multiple Range Test ($P \leq 0.05$).

[b]Tocopherols = ppm in whole peanuts.

Tocopherols. Tocopherol concentrations were determined by direct extraction from whole peanuts. Total oil concentrations of the peanuts from different origins were similar (data not presented), as were moisture contents at the time of sampling. Calculations with the widest ranges of oil and moisture did not affect the trends in tocopherol content by country of origin. In 1986 and 1988, significant differences occurred among all three origins in the order of United States, Argentina and China (Table 3). In 1987, United States- and Argentina-grown peanuts were not different but were both significantly higher than those from China. Tocopherols are potent antioxidants in some systems; however, activity varies with structure. The α and γ chemical forms were, respectively, the most abundant. Tocopherol concentrations have been reported to be different due to peanut genotype and they decrease at high storage temperatures (37.7°C), possibly due to accelerated oxidative degradation (29).

Oven stability. Oven stability of oil is used as an indication of potential peanut shelf life (11,18). Because many shelf-life complaints include the common term "rancid," which relates to lipid degradation, the test has good comparative features. The simplistic test encompasses many of the previously discussed factors known to affect oil stability and quality (30). The method measures the time (days) required for a significant increase in measured oil weight, presumably due to addition of oxygen. In 1987 and 1988, significant differences among all origins were found, with peanuts grown in the United States having the longest potential storability, followed by Argentina, then China (Table 3). In 1986, United States samples had the highest number of days before significant oil weight gain, with no significant differences between Argentina and China.

Physical size parameters. Within all lots sold on either the basis of size or count/oz, there is some variability in seed size. However, variability is potentially greater in lots

marketed on the basis of count because a large seed and a small seed together may weigh the same as two intermediate-sized seeds. Variation in sized seed is generally limited by the upper and lower screen sizes used to define the size. Additionally, because there is a size-maturity relationship, the potential for more small immature seed is greater in lots sold by count. Consistent roasting characteristics are related to consistency of size within lots to be roasted. Count/oz of peanuts from the export origins examined indicated that Chinese samples generally had lower count and thus more large seed (Table 4). This was verified as the percentages of seed riding an 8.3-mm screen and a 7.1-mm screen were relatively similar. Peanuts from the United States consistently contained a high percentage of seed that rode the 7.1-mm screen, indicating uniformity of seed size in the lot. Peanuts from Argentina contained a high percentage of seed that rode the 7.1-mm screen, and the percentage riding the 8.3-mm screen was higher than for United States peanuts. United States peanuts generally contained the smallest percentage of seed riding the 6.4-mm screen.

TABLE 4

Physical Size Parameters of Peanuts from 1986, 1987 and 1988 Export Lots from Argentina, China and United States[a]

Year	Seed size distribution (%)				Count/oz[b]
	8.3 mm	7.1 mm	6.4 mm	Splits	
Argentina					
1986	27.6	56.9	2.5	12.9	48.5
1987	27.3	64.5	2.7	5.1	48.3
1988	23.1	63.7	4.1	9.2	49.1
China					
1986	39.8	48.1	5.4	6.7	45.7
1987	49.5	42.5	3.1	4.8	43.5
1988[c]	72.8	18.6	0.5	8.1	36.8
United States					
1986	15.4	77.5	1.7	5.3	49.2
1987	20.6	72.5	0.7	6.2	41.7
1988	8.2	83.6	0.9	7.2	47.4

[a] All data are the average of 10 lots and are percent weight.

[b] Count/oz based on whole seed only.

[c] Samples for China 1988 were 35/40 count/oz, all other samples were 40/50 count/oz.

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