Grasas y Aceites
Vol. 50. Fasc. 3 (1999), 203-207

Chemical composition of aboriginal peanut (*Arachis hypogaea* L.) seeds from Uruguay

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RESUMEN

Composición química de semillas de cacahuete aborigen (*Arachis hypogaea* L.) de Uruguay.

Se han estudiado los contenidos en aceite, proteína, hidrato de carbono y ceniza, índice de yodo y composición en ácidos grasos y esteroles en semillas de 9 cultivares aborígenes *Arachis hypogaea* subsp. *fastigiata* var. *vulgaris* originarios de Uruguay. Estos mostraron un nivel alto en proteína como las otras variedades de la subespecie *fastigiata* (estos porcentajes en proteína son mayores que en las variedades de la subespecie *hypogaea*). Se detectaron los ácidos palmltico (16:0), esteárico (18:0), oleico (18:1), linoleico (18:2), araquídico (20:0), eicosenoico (20:1), behénico (22:0) y lignocérico (24:0). El cultivar 7 Uv mostró el mayor contenido en ácido oleíco (42. 53%) y en la relación oleico/linoleico (1.09). Los cultivares 2 Uv y 5 Uv tuvieron los mayores porcentajes en ácido linoleico (43.67% y 43.40%, respectivamente). El cultivar 3 Uv y el 4 Uv exhibieron los más bajos índices de yodo (104.90 y 104.73, respectivamente). En los esteroles se detectaron colesterol, campesterol, estigmasterol, β-sitosterol, Δ^5-avenasterol, Δ^7-estigmasterol y Δ^7- avenasterol; siendo el β-sitosterol el más abundante. Sólo se encontró diferencias significativas para el estigmasterol. La calidad química de estas semillas se caracterizó por sus mayores niveles en proteína y aceites con la más baja relación oleico/linoleico y los mayores índices de yodo.

PALABRAS-CLAVE: Cacahuete - Composición química - Semilla - Uruguay.

SUMMARY

Chemical composition of aboriginal peanut (*Arachis hypogaea* L.) seeds from Uruguay.

Oil, protein, carbohydrate and ash contents, iodine value, and fatty acid and sterol compositions were studied in seed of 9 aboriginal *Arachis hypogaea* subsp. *fastigiata* var. *vulgaris* cultivars originating from Uruguay. They showed a high protein level as other varieties of the subspecie *fastigiata* (these protein percentages are higher than varieties of subspecie *hypogaea*). Palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2), arachidic (20:0), eicosenoic (20:1), behenic (22:0), and lignoceric (24:0) acids were detected. The cultivar 7 Uv showed higher oleic acid content (42.53%) and O/L ratio (1.09). The cultivars 2 Uv and 5 Uv had higher percentage in linoleic acid (43.67% and 43.40%, respectively). The cultivar 3 Uv and 4 Uv exhibited lower iodine value (104.90 and 104.73, respectively). Cholesterol, campesterol, stigmasterol, β-sitosterol, Δ^5-avenasterol, Δ^7-stigmasterol and Δ^7-avenasterol were detected in the sterols. β-sitosterol was the most abundant. Significant difference was only found for stigmasterol. The chemical quality of these seeds is characterized by higher protein levels and oils with lower O/L ratio and higher iodine value.

KEY-WORDS: Chemical composition - Peanut - Seed - Uruguay.

1. INTRODUCTION

Many expeditions have been made in South America for the collection of different genotypes of peanuts and thousands of samples are maintained in germoplasm banks placed in Manfredi, Córdoba, Argentina (Pietrarelli, 1982; Krapovickas and Gregory, 1994). To improve quality of peanut products, many breeding programs are attempting to utilize germoplasm resources from cultivated and species of the genus *Arachis* (Stalker *et al.,* 1989).

Peanut (*Arachis hypogaea* L.) is grown worldwide in the tropics and temperates zones primaraly as an oilseed crop (Bansal *et al.,* 1993). Peanut seeds make an important contribution to the diet in many countries, and its widespread acceptability is attributed to its economic value to the industry and nutritional benefits to consumers. Peanut seeds are a good source of protein, lipid and fatty acids for human nutrition. The fatty acid composition of the endogenous fats plays an important role in determining shelf-life, nutrition, and flavor of food products (Gaydou *et al.,* 1983). The peanut produced in Argentina has lower shelf-life because it show lower oleic acid percentage (Grosso *et al.,* 1994).

Fatty acid composition, protein levels, amino acid composition and other components have been investigated in peanut seeds (Ahmed and Young, 1982). Chemical composition in aboriginal peanut from Perú, Ecuador and Bolivia has been studied (Grosso and Guzmán, 1995 a, b; Grosso *et al.,* 1997). At present, fatty acids, sterols, and other chemical components have not been studied in uruguayan

peanuts. These materials contain new sources of germplasm that can be used to increase the variability in the genetic base of cultivated varieties (Norden *et al.,* 1982).

The objective of this work was to establish the chemical characteristics of peanut cultivar seeds from Uruguay.

2. EXPERIMENTAL

Plant material

Sound and mature seeds of 9 different aboriginal peanut cultivars (*Arachis hypogaea* L.) subsp. *fastigiata* var. *vulgaris* C. Harz) from Uruguay were provided by the INTA (Instituto Nacional de Tecnología Agropecuaria) peanut germplasm bank of Manfredi, Córdoba, Argentina. The taxonomic denomination is agreed with Krapovickas and Gregory (1994). The collection data of the cultivars included in this study are presented in Table I.

Table I

Collection data of *Arachis hypogaea* cultivars originating from Uruguay. The aboriginal cultivars were identified with a number and letters. The letters indicate the country of origin and variety. U: Uruguay, v: var. *vulgaris*

Cultivar	Lot 90/91[a]	Origin of Sample
1 Uv	2544	Estación Experimental La Estanzuela.
2 Uv	2563	Rivera, Ruta 5, Km. 483
3 Uv	2570	Estación Experimental La Estanzuela.
4 Uv	2579	Parada Medina, near Paso de Ataque.
5 Uv	2582	Orgorosa, 56 Km. de Paysandú.
6 Uv	2592	Tacuarembó.
7 Uv	2607	Tranqueras, Ruta 30.
8 Uv	2609	Parada Medina, near Paso de Ataque.
9 Uv	2616	Tacuarembó.

[a] Number of lot in INTA of Manfredi, Córdoba, Argentina.

Oil, protein, ash, carbohydrate and moisture contents

Three samples, each containing ten seeds from every cultivar, were examined for oil, protein, ash and moisture contents. The sampling size was previously calculated (Cochran, 1974) and it was proper to the statistical design.

Seeds were milled and oil was extracted for 16 h with petroleum ether (boiling range 30-60 °C) in a Soxhlet apparatus. The extracted oils were dried over anhydrous sodium sulfate and the solvent removed under reduced pressure in a rotary film evaporator. Oil percentages was determined by weight difference.

Moisture, ash, nitrogen contents were determined on a dry weight basis according to AOAC (1980). Ash determination was performed by incineration in a muffle furnace at 525 °C. The nitrogen content was estimated by the Kjeldahl method and converted to protein percentage by using the conversion factor 5.46 (Young and Hammons, 1973). Carbohydrate content was estimated by difference with the other values.

Fatty acid composition

Fatty acid methyl esters were prepared by transmethylation with a 3% solution of sulfuric acid in methanol, as previously described (Jellum and Worthington, 1966). The fatty acid methyl esters of total lipids were analysed on a Shimadzu GC-R1A gas chromatograph equipped with flame ionization detector (FID). A AT-WAX superox II capillary column (30 m x 0.25 mm i.d.) was used. Column temperature was programmed from 180 °C (held for 10 minute) to 240 °C (4 °C/min). Injector and detector temperatures were 250 °C and 350 °C, respectively. The carrier (nitrogen) had a flow rate of 1 mL/min. A standard fatty acid methyl ester mixture (Sigma Chemical Co.) was used to identify sample peaks. Quantitative analysis of the fatty acids were performed using the heptadecanoic acid methyl ester as internal standard. Iodine values were calculated from fatty acid percentages with using the formula: (% oleic x 0.8601) + (% linoleic x 1.7321) + (% eicosenoic x 0.7854) (Hashim *et al.,* 1993).

Sterol composition

Sterols of the unsaponifiable matter from 5 g of oil (after saponification with alcoholic 1 N potassium hydroxide) were purified by preparative thin-layer chromatography (TLC). TLC was performed on silica gel 60 G (20 x 20 cm, 0.5 mm layer thickness) plates using chloroform - diethyl ether (9:1 v/v) as the developing solvent. The relative R_f values of the 4-desmethylsterols fraction was 0.27. The unsaponifiable matter was dissolved in chloroform (5%) and 150 µL was deposited as a streak of 15 cm length on the plate. Cholesterol was used as standard. The corresponding band of 4-desmethylsterols was scraped off the plate and extracted with chloroform (Gaydou *et al.,* 1983). Purified sterols were analyzed on a Shimadzu GC-R1A gas chromatograph equipped with a FID. A Shimadzu CBP1 capillary column (25 m x 0.25 mm i.d.) was used. Column temperature was programmed from 200 °C to 300 °C (4 °C/min). Injector and detector temperatures were 320 °C and 350 °C, respectively.

The carrier (nitrogen) had a flow rate of 1 mL/min. Standard sterols (Sigma Chemical Co.) were used to identify sample peaks. The amount of sterol was determined using 5 α-cholestane as internal standard.

Statistical analysis

Three replicates for each cultivar were done. An analysis of variance was performed on the data and means were separated using the test of Tukey.

3. RESULTS AND DISCUSSION

Moisture, oil, protein, carbohydrate and ash content are listed in Table II. Between uruguayan cultivars were not found significant differences. These cultivars belong to subsp. *fastigiata* var. *vulgaris* C. Harz (Krapovickas and Gregory, 1994). They showed as higher protein levels as other varieties of the same subspecie (*var. fastigiata* Waldrom, var. *peruviana* Krapov. & Gregory and var. *aequatoriana* Krapov. & Gregory) and exhibited higher protein percentages than those found in varieties of subsp. *hypogaea* (var. *hypogaea* L. and var. *hirsuta* Kohler) (Grosso and Guzmán, 1995 b). The other results of proximate composition were similar to the reported in aboriginal cultivars of Perú, Ecuador and Bolivia (Grosso and Guzmán, 1995 a, b; Grosso *et al.,* 1997).

Table II

Moisture, oil, protein, ash and carbohydrate contents (wt%) of peanut cultivars from Uruguay

Cultivar	Moisture[a]	Oil[a]	Protein[a]	Ash[a]	Carbohydrate[a]
1 Uv	5.60a[b] ± 0.17	48.30a ± 0.61	28.60a ± 1.19	2.57a ± 0.23	20.53a ± 1.62
2 Uv	5.63a ± 0.15	46.50a ± 1.32	28.00a ± 1.05	2.40a ± 0.10	23.07a ± 1.01
3 Uv	5.70a ± 0.20	48.17a ± 1.90	27.73a ± 1.12	2.53a ± 0.15	21.57a ± 0.91
4 Uv	5.70a ± 1.73	47.43a ± 1.69	29.33a ± 1.46	2.67a ± 10.15	20.57a ± 3.00
5 Uv	5.73a ± 0.21	48.07a ± 2.48	28.27a ± 1.23	2.50a ± 0.20	21.17a ± 1.99
6 Uv	5.67a ± 0.06	48.93a ± 1.26	26.37a ± 1.37	2.60a ± 0.20	22.10a ± 1.91
7 Uv	5.47a ± 0.21	47.10a ± 0.40	29.22a ± 1.25	2.70a ± 0.17	20.87a ± 1.50
8 Uv	5.60a ± 0.10	45.60a ± 1.179	28.33a ± 1.21	25.3a ± 2.08	23.50a ± 2.09
9 Uv	5.67a ± 0.15	45.47a ± 1.46	29.33a ± 1.29	2.60a ± 0.17	22.60a ± 1.47

[a] Expressed on dry weight basis.
[b] Means followed by the same letter within each column are not significantly different at P = 0.05.

Palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2), arachidic (20:0), eicosenoic (20:1), behenic (22:0), and lignoceric (24:0) acids were quantified (Table III). Significant differences were observed between oleic and linoleic acid contents among cultivars of uruguayan peanut. The cultivar 7 Uv showed higher oleic acid (42.53%) and O/L ratio (1.09), while the cultivars 2 Uv and 5 Uv had higher percentage of linoleic acid (43.67% and 43.40%, respectively). Iodine value and oleic to linoleic ratio (O/L) are indicators of oil stability and shelf-life (Ahmed and Young, 1982; Branch *et al.,* 1990). Traditionally in U.S., runner market types have been predominantly utilized for the peanut butter trade, and oil composition (specially O/L ratio) likewise plays an important role in the manufacturing of this end-use product. Higher O/L ratios and lower iodine values suggest better stability, longer shelf-life, and quality of the oils (Branch *et al.,* 1990; Bansal *et al.,* 1993). The variety *hypogaea* shows higher oleic acid content and O/L ratio than the other varieties as previously reported in cultivars from other Sudamérica countries (Grosso and Guzmán, 1995 a, b; Grosso *et al.,* 1997). The O/L ratio was lower in uruguayan peanut cultivars of var. *vulgaris* than in cultivars of var. *hypogaea.* On the other hand, Florman, that belows Runner-type peanut and was bred from Florunner, is the main cultivar utilized in Córdoba, Argentina. Runner-type peanut accounted for over 80% of the total production area in Argentina. Florman peanut has a low O/L ratio (approximately 1.20) when it is produced in Argentina (Grosso *et al.,* 1994). However, this ratio is higher than these found in uruguayan peanut. In relation to iodini value, all cultivars had higher values than cultivars of subsp. *hypogaea* from other Sudamérica countries (Grosso and Guzmán, 1995 b). The cultivar 3 Uv and 4 Uv exhibited lower iodine value (104.90 and 104.73, respectively). Iodine value and O/L ratio variations of peanut cultivars from Sudamérica could be due to differences in climatics conditions, soil moisture and air temperature during maturation and temperatures during curing of peanut seed (Holaday and Pearson, 1974).

The peanut oil is unique among vegetable oils in that it contains long chain saturated fatty acids (20-24 carbons) (Treadwell *et al.,* 1983). The range of concentrations of these fatty acids in the samples analysed was similar to the peanut cultivars previously published (Ahmed and Young, 1982; Grosso and Guzmán, 1995 a, b).

The following 4-desmethylsterols were detected (Table IV): cholesterol, campesterol, stigmasterol, β-sitosterol, Δ^5-avenasterol, Δ^7-stigmasterol and Δ^7-avenasterol. These sterols have been found in peanut oil (Padley *et al.,* 1986) and their concentrations were similar to the reported in other cultivars from Sudamérica (Grosso and Guzmán, 1995 a, b; Grosso *et al.,* 1997). Significant difference was only found for stigmasterol. β-sitosterol was the principal constituent followed by campesterol, stigmasterol and Δ^5-avenasterol.

Table III
Fatty acid composition (wt%), O/L ratio and iodine value of peanut cultivars from Uruguay

Cultivar	16:0	18:0	18:1	18:2	20:0	20:1	22:0	24:0	OL[a]	Iodine Value
1 Uv	10.43a[b] ± 0.81	2.73a ± 0.15	38.30bcde ± 1.99	41.37abc ± 1.46	1.07a ± 0.06	1.63a ± 0.25	3.40a ± 0.46	0.97a ± 0.21	0.93bcde ± 0.21	105.87ab ± 1.01
2 Uv	9.33a ± 0.35	3.00a ± 0.27	36.43e ± 1.10	43.67a ± 0.86	1.10a ± 0.10	1.63a ± 0.20	3.67a ± 0.15	1.10a ± 0.20	0.84e ± 0.03	108.23ab ± 0.71
3 Uv	10.03a ± 0.65	2.77a ± 0.15	39.93abcd ± 0.95	39.97bc ± 1.07	1.00a ± 0.27	1.70a ± 0.17	2.23a ± 0.31	1.33a ± 0.12	1.00abcd ± 0.05	104.90b ± 1.15
4 Uv	10.23a ± 0.68	26.0a ± 0.44	40.90ab ± 0.10	39.43bc ± 1.32	1.00a ± 0.17	1.63a ± 0.23	3.10a ± 0.46	1.07a ± 0.15	1.03ab ± 0.04	104.73b ± 2.07
5 Uv	9.77a ± 0.50	2.33a ± 0.35	37.83cde ± 0.57	43.40a ± 1.51	1.03a ± 0.15	1.47a ± 0.15	3.27a ± 0.38	1.00a ± 0.27	0.87de ± 0.04	108.87a ± 2.20
6 Uv	10.53a ± 0.50	2.30a ± 0.36	39.63abcd ± 1.48	41.03abc ± 1.00	1.10a ± 0.17	1.63a ± 0.12	2.80a ± 0.35	1.07a ± 0.15	0.96abcde ± 0.06	106.47ab ± 0.58
7 Uv	9.97a ± 0.25	2.33a ± 0.32	42.53a ± 0.45	39.07c ± 1.10	1.00a ± 0.20	1.33a ± 0.12	3.03a ± 0.42	0.93a ± 0.23	1.09a ± 0.04	105.27ab ± 1.46
8 Uv	9.73a ± 0.55	3.00a ± 0.46	40.83abc ± 0.50	39.87bc ± 0.85	1.13a ± 0.06	1.57a ± 0.15	2.67a ± 0.35	1.20a ± 0.35	1.02abc ± 0.04	105.37ab ± 0.91
9 Uv	9.70a ± 0.20	3.00a ± 0.36	37.77de ± 0.93	42.30ab ± 0.61	1.17a ± 0.23	1.60a ± 0.20	3.37a ± 0.31	1.07a ± 0.31	0.89cde ± 0.03	107.00ab ± 0.53

[a] O/L: Oleic to linoleic ratio.
[b] Means followed by the same letter within each column ar not significantly different at P = 0.05.

Table IV
Sterol composition (wt%) of peanut cultivars from Uruguay

Cultivar	Cholesterol	Campesterol	Stigmasterol	β–sitosterol	Δ^5-avenasterol	Δ^7-stigmasterol	Δ^7-avenasterol
1 Uv	0.63a[a] ± 0.15	15.80a ± 0.85	11.47ab ± 1.46	60.40a ± 1.83	9.33a ± 0.51	1.60a ± 0.36	0.90a ± 0.36
2 Uv	0.53a ± 0.15	18.27a ± 1.380	8.83b ± 0.97	63.70a ± 4.08	8.83a ± 1.12	0.87a ± 0.31	0.60a ± 0.30
3 Uv	0.73a ± 0.15	16.83a ± 1.90	10.73ab ± 0.96	59.67a ± 1.04	9.77a ± 2.08	1.20a ± 0.46	1.03a ± 0.35
4 Uv	0.93a ± 0.15	17.20a ± 2.21	11.87ab ± 1.14	57.30a ± 2.11	11.77a ± 1.07	0.73a ± 0.21	0.60a ± 0.44
5 Uv	0.57a ± 0.21	16.03a ± 1.70	11.77ab ± 0.95	61.23a ± 1.70	9.33a ± 0.95	0.93a ± 0.35	0.77a ± 0.42
6 Uv	6.7a ± 2.08	17.03a ± 1.79	12.80a ± 1.21	57.80a ± 1.73	11.37a ± 1.72	1.33a ± 0.50	1.03a ± 0.45
7 Uv	0.83a ± 0.21	16.50a ± 0.80	9.23b ± 1.01	60.13a ± 1.95	11.50a ± 1.73	1.50a ± 0.46	0.60a ± 0.30
8 Uv	0.73a ± 0.25	18.17a ± 0.86	11.10ab ± 1.65	58.50a ± 1.61	9.57a ± 0.96	1.17a ± 0.45	0.77a ± 0.35
9 Uv	0.73a ± 0.31	15.57a ± 1.29	9.93ab ± 1.20	60.77a ± 3.77	11.33a ± 1.30	1.20a ± 0.60	0.57a ± 0.31

[a] Means followed by the same letter within each column ar not significantly different at P = 0.05.

The present report contributes with an useful information on the genetic quality of germplasm bank materials. Peanut cultivars of var. *vulgaris* from Sudamérica are characterized for the first time. The seeds have a chemical quality similar to the observed in other varieties of subspecie *fastigiata*, with a high protein content and oils with a low O/L ratio and higher iodine value. Therefore, these material are not useful for peanut breeding programs for improving the stability of oils and seeds from Argentina.

ACKNOWLEDGMENT

This work was supported by CONICET, CONICOR and SECYT. We wish to thank J. R. Pietrarelli and R. Sánchez for providing and identifying the seed samples.

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Recibido: Abril 1998
Aceptado: Septiembre 1998