# Seed Lipid Components of *Solanum argentinum*

Enrique I. Lucini,[†] Nelson R. Grosso,*[,†] Alicia L. Lamarque,[‡] Damián M. Maestri,[‡] Julio A. Zygadlo,[‡] and Carlos A. Guzmán[‡]

Química Biológica, Facultad de Ciencias Agropecuarias (UNC), Avenida Valparaíso s/n, 5000 Córdoba, Argentina, and Química Orgánica, Facultad de Ciencias Exactas Físicas y Naturales (UNC), IMBIV-CONICET, Avenida Velez Sarsfield 299, 5000 Córdoba, Argentina

Seed lipid components of *Solanum argentinum* are reported. The principal fatty acids are linoleic, oleic, and palmitic acids. Hentriacontane, tritriacontane, and pentatriacontane are the predominant alkanes. The sterol composition shows higher percentages of β-sitosterol and stigmasterol. The yields of seeds and oils show *S. argentinum* to be a potentially valuable oilseed plant.

**Keywords:** *Fatty acid; triglycerides; phospholipids; sterol esters; free sterols; alkanes; seeds; Solanum argentinum*

## INTRODUCTION

Solanaceae is a family of worldwide importance; its greatest concentration is found in South America (Hunziker, 1979). *Solanum argentinum* is a perennial shrub up to 2 m high growing in Bolivia and northwestern Argentina. It has reddish-yellow, globose, 6–7 mm in diameter, glabrous, shining berries with few seeds (sometimes only seven per fruit) (Morton, 1976).

The fatty acid composition of seed total lipids was reported for *S. argentinum* and other Solanaceae (Grosso et al., 1991). However, a complete description of seed lipid components has not been undertaken.

The objective was to define the lipid composition and other chemical characteristics of the seed oils of *S. argentinum* to establish its probable utility as an oilseed plant.

## MATERIALS AND METHODS

**Materials.** *S. argentinum* Bitter and Lillo seeds were collected near Córdoba, Argentina. Voucher specimens are on deposit in the Museo Botánico (CORD.) of the Universidad Nacional de Córdoba.

**Chemical Characteristics.** Dry matter was determined at 95–100 °C, and protein levels were determined according to the Kjeldahl method (AOAC, 1980, Method 7.015). Tests for cyanogenetic glycosides (picric acid reagent) and alkaloids (AOAC, 1980, Methods 26.134 and 36.095, respectively) were performed in seeds and oils.

**Preparative Thin-Layer Chromatography (TLC).** The seed oils were extracted with ether in a Soxhlet apparatus. Oil content was calculated by weight difference (AOAC, 1980). The hydrocarbon, sterol ester, triglyceride, and free sterol fractions were purified by preparative TLC using a 20 × 20 cm plate of silica gel 60 G (thickness 0.5 mm) and developed with *n*-hexane/ethyl ether/acetic acid (90:10:1) (Maestri and Guzmán, 1993). The relative proportion of each one was determined by measurement of spot areas (Stahl, 1969). The phospholipids were precipitated and washed from the oil with acetone (Lajara, 1969; Kristappa et al., 1976). These components were purified and analyzed by TLC. Development solvent was chloroform/methanol/14% ammonia (65:35:5 v/v/v). The relative proportion of each one was calculated from TLC yields (Stahl, 1969; Arruda and Dimick, 1991).

**Gas–Liquid Chromatography.** A Shimadzu GC-R1A equipped with a flame ionozation detector was used. Fatty acid methyl esters were obtained by direct transmethylation with 3% sulfuric acid in methanol and analyzed on a capillary column AT-WAX, Superox II (30 m x 0.25 mm i.d.): temperature program, 180–240 °C (4 °C/min); injector, 250 °C. Sterol analysis: capillary column CBP1 (25 m × 0.25 mm i.d.); column temperature, 290 °C; injector, 320 °C (Maestri and Guzmán, 1993). Alkane analysis: Dexil 3% column (0.60 m × 4 mm i.d.); temperature program, 100–320 °C (4 °C/min); injector, 320 °C (Maxzud and Zygadlo, 1991). Nitrogen was the carrier gas. Standards of fatty acids, sterols, and hydrocarbons were run to use retention times in identifying the sample peaks. Component levels were reported as a relative proportion of the total composition.

**Gas Chromatography–Mass Spectrometry (GC–MS).** The fatty acids, sterols, and alkanes were also identified by GC–MS. The fatty acids were analyzed using an SE-54 column (15 m × 0.25 mm), temperature programmed from 90 to 290 °C (8 °C/min): He carrier gas (20 mL/min); injector temperature, 250 °C; ionizing voltage, 70 eV; trap current, 60 μA; accelerated high voltage, 3500 V. The identification of the compounds was carried out by a built-in NIST Peak Matching Library Search System. The alkane GC–MS analyses were performed using an OV-17 column (3%) (1.8 m × 0.2 mm i.d.): He gas carrier (28 mL/min); injector temperature, 250 °C; temperature program, 90–290 °C (12 °C/min). All spectra were obtained at 70 eV; the ion source temperature was 200 °C, with a filament current of 1 mA. The retention times and MS of *n*-alkanes were compared with those of authentic standards and those reported in the literature (Beynon, 1964; Zygadlo et al., 1993). The alkanes were also identified by their IR spectra (2923, 2854, 1481, and 1375 $cm^{-1}$). The sterol GC–MS analyses were performed using an OV-17 column (3%): temperature program, 200–290 °C (10 °C/min); He carrier gas (28 mL/min); ionizing voltage, 70 eV; trap current, 60 μA; accelerated high voltage, 3500 V.

All data are mean values of three determinations. Each determination was obtained from samples of 30 g of seeds. Approximately 6 mL of oil was extracted from each sample.

## RESULTS AND DISCUSSION

The seeds of *S. argentinum* showed 4.8% moisture, 21.1% oil (on a dry matter basis), and 15.2% proteins (on a dry matter basis). The test for cyanogenetic glycosides (picric acid test) and alkaloids gave negative results in oils. The seed oil was separated by TLC and showed 73.5% triglycerides, 2.6% free sterols, 5.3% sterol esters, 1.4% hydrocarbons, and 17.1% other components.

* Author to whom correspondence should be addressed.

[†] Facultad de Ciencias Agropecuarias.

[‡] Facultad de Ciencias Exactas Físicas y Naturales.

0021-8561/94/1442-2743$04.50/0 

**Table 1. Fatty Acid Composition (Relative Percentages) of Total Lipids, Triglycerides, and Sterol Esters of *S. argentinum* Seed Oils**

| | total lipids | | triglycerides | | sterol esters | |
|---|---|---|---|---|---|---|
| fatty acid | mean | SD[a] | mean | SD | mean | SD |
| 14:0 | 3.1 | 0.33 | 3.7 | 0.14 | 5.0 | 0.45 |
| 16:0 | 12.0 | 0.85 | 12.0 | 0.67 | 24.0 | 1.36 |
| 16:1 | Tr[b] | | Tr | | 13.0 | 1.33 |
| 18:0 | 3.6 | 0.15 | 3.4 | 0.27 | 10.6 | 0.54 |
| 18:1 | 10.7 | 0.65 | 10.6 | 0.45 | 20.0 | 1.46 |
| 18:2 | 68.3 | 4.54 | 69.2 | 5.06 | 14.7 | 1.25 |
| 18:3 | 1.0 | 0.12 | 1.0 | 0.06 | Tr | |
| 20:0 | Tr | | Tr | | Tr | |
| 20:1 | Tr | | Tr | | Tr | |
| 22:0 | Tr | | Tr | | 7.0 | 0.66 |
| 24:0 | Tr | | Tr | | 5.7 | 0.35 |

[a] SD, standard deviation. [b] Tr, trace (less than 0.5%).

**Table 2. Fatty Acid Composition (Relative Percentages) and Relative Proportion (Rel Prop.) of Phosphatidylcholine (PC), Phosphatidylethanolamine (PE), and Sphingophospholipids (SP) of *S. argentinum* Seed Oils**

| | phospholipids | | | | | |
|---|---|---|---|---|---|---|
| | PC | | PE | | SP | |
| fatty acid | mean | SD[a] | mean | SD | mean | SD |
| 14:0 | Tr[b] | | Tr | | Tr | |
| 16:0 | 23.1 | 1.07 | 34.4 | 2.24 | 16.0 | 0.77 |
| 16:1 | Tr | | Tr | | Tr | |
| 18:0 | 4.1 | 0.56 | 5.4 | 0.85 | 6.4 | 0.88 |
| 18:1 | 36.8 | 2.47 | 30.0 | 2.79 | 50.1 | 4.35 |
| 18:2 | 33.9 | 1.97 | 27.3 | 1.46 | 20.1 | 1.16 |
| 18:3 | Tr | | 2.6 | 0.34 | 3.3 | 0.43 |
| 20:0 | Tr | | Tr | | 2.7 | 0.23 |
| 20:1 | Tr | | Tr | | 1.2 | 0.25 |
| Rel Prop. (%) | 17.4 | 1.93 | 20.2 | 2.45 | 20.5 | 2.56 |

[a] SD, standard deviation. [b] Tr, trace (less than 0.5%).

The fatty acid composition of total lipids and triglycerides showed linoleic acid to be predominant, followed by oleic and palmitic acids (Table 1), similar to the seed lipids of other Solanaceae (Dasso et al., 1980; Grosso et al., 1991; Maestri and Guzmán, 1993). Besides these constituents, myristic, palmitoleic, stearic, linolenic, arachidic, eicosenoic, behenic, and lignoceric acids were also detected in small quantities. However, the fatty acid composition of the sterol esters showed higher concentrations of palmitic and oleic acids than linoleic acid.

Phosphatidylcholine, phosphatidylethanolamine, sphingophospholipids, and three unidentified phospholipids were detected by TLC. The predominant fatty acids of phospholipids were oleic, linoleic, and palmitic acids (Table 2).

The seed lipids of *S. argentinum* contained cholesterol, campesterol, stigmasterol, β-sitosterol, $\Delta^5$-avenasterol, $\Delta^7$-stigmastenol, and $\Delta^7$-avenasterol. β-Sitosterol, stigmasterol, and $\Delta^5$-avenasterol were the principal constituents (51.9%, 25.8%, and 15.9%, respectively) (Table 3).

The hydrocarbon percentage (1.4%) in the seed oils was similar to that reported in the literature (Kolattuckudy, 1976). The alkane composition of *S. argentinum* seed oils is reported for the first time (Table 4). The predominant constituents were pentatriacontane (12.5%), tritriacontane (11.7%), and hentriacontane (10.3%). Twenty-two other alkanes were also detected.

In preliminary studies, *S. argentinum* produced an annual average of 371.4 fruits/plant ($n$ = 25 plants, standard deviation 87.41), and each fruit has 7.3 seeds ($n$ = 75 fruits, standard deviation = 2.07). The seed and oil yields were 542 and 114 kg/ha, respectively. These plants grow in semiarid zones at low or middle elevations (Morton, 1976). Therefore, they could be considered as potentially valuable oilseed plants for these areas of Argentina.

**Table 3. Sterol Composition (Relative Percentages) of *S. argentinum* Seed Oils**

| | free sterols | | sterol esters | |
|---|---|---|---|---|
| sterol | mean | SD[a] | mean | SD |
| cholesterol | 4.4 | 0.88 | Tr[b] | |
| campesterol | 1.8 | 0.34 | 10.3 | 1.13 |
| stigmasterol | 25.8 | 2.56 | 39.9 | 2.78 |
| β-sitosterol | 51.9 | 4.56 | 44.0 | 4.32 |
| $\Delta^5$-avenasterol | 15.9 | 1.67 | 5.6 | 0.76 |
| $\Delta^7$-stigmastenol | Tr | | | |
| $\Delta^7$-avenasterol | Tr | | | |

[a] SD, standard deviation. [b] Tr, trace (less than 0.5%).

**Table 4. Alkane Composition (Relative Percentages) of *S. argentinum* Seed Oils**

| no. of carbons | percentage | | no. of carbons | percentage | |
|---|---|---|---|---|---|
| | mean | SD[a] | | mean | SD[a] |
| 11 | 0.84 | 0.21 | 24 | 3.43 | 0.18 |
| 12 | 0.49 | 0.13 | 25 | 2.15 | 0.23 |
| 13 | 1.69 | 0.09 | 26 | 2.53 | 0.18 |
| 14 | 1.00 | 0.15 | 27 | 3.50 | 0.26 |
| 15 | 1.89 | 0.23 | 28 | 5.41 | 0.41 |
| 16 | 0.89 | 0.05 | 29 | 6.19 | 0.47 |
| 17 | 2.84 | 0.34 | 30 | 5.12 | 0.37 |
| 18 | 1.20 | 0.08 | 31 | 10.3 | 0.78 |
| 19 | 4.03 | 0.36 | 32 | 3.55 | 0.21 |
| 20 | 1.34 | 0.18 | 33 | 11.7 | 0.87 |
| 21 | 7.92 | 0.43 | 34 | 2.80 | 0.10 |
| 22 | 3.68 | 0.22 | 35 | 12.5 | 0.93 |
| 23 | 2.77 | 0.31 | | | |

[a] SD, standard deviation.

ACKNOWLEDGMENT

Financial assistance for this work was provided by Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Consejo de Investigaciones Científicas y Tecnológicas de la Provincia de Córdoba (CONICOR), and Centro de Excelencia de Productos y Procesos de la Provincia de Córdoba (CEPROCOR).

LITERATURE CITED

AOAC. *Official Methods of Analysis of the Association of Official Analytical Chemists*; Horwitz, W., Ed.; AOAC: Washington, DC, 1980.

Arruda, D. H.; Dimick, P. S. Phospholipid composition of lipid seed crystal isolates from ivory coast cocoa butter. *J. Am. Oil Chem. Soc.* **1991**, *68*, 385–390.

Beynon, J. H. *The Mass Spectra of Organic Molecules*; Elsevier: New York, 1968; p 79.

Dasso, I.; Gross, E. G.; Cattaneo, P. Acidic and sterol composition of some Solanaceas seed oils. *An. Asoc. Quim. Argent.* **1980**, *68*, 109–112.

Grosso, N. R.; Zygadlo, J. A.; Abburrá, R. E.; Decolatti, N. Fatty acid composition in the seminal oil of some *Solanaceae* species. *Herba Hung.* **1991**, *30*, 41–44.

Hunziker, A. T. *South American Solanaceae: a synoptic survey. The Biology and Taxonomy of the Solanaceae*; Hawkes, J. G., Lester, R. N., Skelding, A. D., Eds.; Linnean Society Symposium; Academic: London, 1979; Series 7, pp 49–86.

Kolattuckudy, P. E. *Chemistry and Biochemistry of Natural Waxes*; Elsevier: Amsterdam, 1976; pp 236–250.

Kristappa, G.; Azelmodin, G.; Thirumala Rao, S. D. Studies on the phosphatides of indian vegetables in oil cake XVII–

Powder phosphatides from indian soybean oil. *Paintindia* **1976**, *26*, 21–22.
Lajara, J. Degumming of vegetable oils—Lecithin manufacture. *Grasas Aceites* **1969**, *20*, 242–259.
Maestri, D. M.; Guzmán, C. A. Chemical composition of tobacco seeds (*Nicotiana tabacum* L.) from Argentina. *J. Sci. Food Agric.* **1993**, *61*, 227–229.
Maxzud, M. K.; Zygadlo, J. A. Alkane variation of leaves in some Argentinian species of *Solanum* (Solanaceae). *An. Biol.* **1991**, *17*, 137–140.
Morton, C. V. *A Revision of The Argentine Species of Solanum;* Academia Nacional de Ciencias: Córdoba, Argentina, 1976; pp 181–183.
Stahl, E. *Thin-Layer Chromatography*; Springer Verlag: Berlin, 1969; pp 135–136.
Zygadlo, J. A.; Pignata, M. L.; Gonzalez, C. M.; Levin, A. Alkanes in lichens. *Phytochemistry* **1993**, *32*, 1453–1456.

Received for review January 7, 1994. Revised manuscript received August 8, 1994. Accepted August 26, 1994.[⊗]

[⊗] Abstract published in *Advance ACS Abstracts,* October 1, 1994.