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Technical Note

Fatty Acids and Sterols of *Amaranthus tricolor* L.

ABSTRACT

The fatty acids and sterols of Amaranthus tricolor *L. were examined by gas chromatography. The major unsaturated fatty acid in the seeds and stems was linoleic acid, while in leaves it was linolenic. The major saturated fatty acid found in seeds, stems and leaves was palmitic acid. Linolenic, lignoceric and arachidic were also present in seeds but in trace amounts. Five sterols were identified and spinasterol was present in the highest amounts. Among the seeds, stems and leaves a small amount of 24-methylenecycloartenol was found in the seeds only.*

INTRODUCTION

The *Amaranthus* are fast-growing plants that occur in tropical and temperate areas of the world and are considered as pioneer plants in the early successional stages of vegetation development. Recently some of the vegetable types such as *A. tricolor*, *A. hybridus* and *A. hypochondriacus* are attracting attention because of the potential value of their seeds as sources of grain (Burger, 1983). Not only are the seeds relatively high in protein, i.e. 13·1% (Osuntogun & Oke, 1983), but they contain exceptionally high levels of protein lysine, which is a critical amino acid usually deficient in plant protein (Anon., 1975). Thus the *Amaranthus* plant could serve as a convenient, easy to produce source of plant protein in the developing countries of the world. The protein composition of *Amaranthus* has been investigated (Downton, 1973); however, we are not

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aware of any studies to determine the fatty acid and sterol composition of this plant which should be done if human consumption of *Amaranthus* is to be encouraged. We now report the fatty acid and sterol composition of seeds, leaves and stems of *A. tricolor*.

MATERIALS AND METHODS

The plant tissue used in this study was obtained from 6-month-old *A. tricolor* plants grown in the field in Maryland. After harvest the plants were separated into seeds, leaves and stems which were freeze-dried and weighed. Tissue was ground and the lipids extracted in a Soxhlet apparatus using $CHCl_3$–MeOH (2:1, v/v). The lipid extract was saponified with KOH (in 70% EtOH), extracted with ether and methylated with boron trichloride in methanol. The methylated lipid was partitioned with hexane and the fatty acids separated from sterols by column chromatography. Fatty acids and sterols were identified using a Varian Model 3700 gas chromatograph by comparing their retention times relative to a known fatty acid and sterol (Patterson, 1970, 1971). Known amounts of heptadecanoic acid and cholesterol were added as internal standards for fatty acid and sterol analyses. The operating conditions for fatty acids were: column 1·8 m × 3·4 mm i.d., 15% Hi Eff 1 BP on Gas Chrom P (Applied Science Laboratories) 20 psi and 165 °C; detector 250 °C; and flash heater, 205 °C and for sterols: column 1·8 m × 3·4 mm i.d., 3% SE 30 on Gas Chrom Q (Applied Science Laboratories), 20 psi and 224 °C; detector 300 °C; and flash heater 300 °C.

RESULTS AND DISCUSSION

We recently reported on the sterol and fatty acid composition of the various parts of the winged bean plant *Psophocarpus tetragonolobus* (Bean *et al.*, 1984). Winged beans are similar to *Amaranthus* in that they also contain extremely high amounts of protein, are easy to grow and thus are potentially important sources of plant proteins in the developing countries of the world. Whereas winged beans contain only 3 major sterols—campesterol, stigmasterol and sitosterol—*Amaranthus* contains 4 major sterols plus limited amounts of a 5th sterol, 24-methylenecycloartanol (Table 1). Whereas spinasterol was the major sterol present in

TABLE 1
Sterol Composition of *Amaranthus tricolor* Plant Parts[a]

Sterols	*Seeds*	*Stems*	*Leaves*
Stigmasterol	0·020 (5·7)	0·234 (15·7)	0·031 (10·2)
Δ^{-7} Ergosterol	0·054 (15·4)	0·131 (8·8)	0·021 (6·9)
Spinasterol	0·188 (53·7)	0·996 (66·7)	0·248 (81·6)
Δ^{-7} Stigmastenol	0·066 (18·9)	0·133 (8·9)	0·004 (1·3)
24-Methylenecycloartanol	0·022 (6·3)	— —	— —
Total (mg g^{-1} dry wt)	0·350	1·494	0·304

[a] Quantities expressed as mg g^{-1} dry weight and (%) of total sterol.

seeds, stems and leaves of *Amaranthus*, 53·7, 66·7 and 81·6% respectively, spinasterol was not detected in winged bean; sitosterol was the major sterol present in the latter. *Amaranthus* also differed in sterol composition from winged bean in that the former contained Δ^{-7} ergosterol, Δ^{-7} stigmastenol and small amounts of 24-methylenecycloartanol which were not detected in winged bean. The differences in sterol composition of the two plant species is of 'academic' interest; the absence of detectable cholesterol in both *Amaranthus* and winged bean would suggest that there is no nutritional reason why either of these plants should not be consumed as sources of proteins.

The major unsaturated fatty acids in *Amaranthus* were linoleic in seeds and stems and linolenic in leaves (Table 2). In winged beans, oleic acid

TABLE 2
Fatty Acid Composition of *Amaranthus tricolor* Plant Parts[a]

Fatty acids	*Seeds*	*Stems*	*Leaves*
Myristic	0·055 (0·1)	0·017 (0·7)	— —
Palmitic	7·841 (20·0)	0·642 (26·3)	1·040 (26·2)
Stearic	1·546 (4·0)	0·071 (2·9)	0·129 (3·2)
Oleic	9·733 (24·9)	0·354 (14·5)	0·497 (12·5)
Linoleic	19·094 (48·8)	1·131 (46·3)	0·636 (16·0)
Linolenic	0·378 (1·0)	0·228 (9·3)	1·673 (42·1)
Arachidic	0·278 (0·7)	— —	— —
Lignoceric	0·223 (0·5)	— —	— —
Ratio (sat./unsat.)	0·34	0·65	2·51

[a] Quantities expressed as mg g^{-1} dry weight and (%) of total fatty acid.

was the major unsaturated fatty acid in the seeds, linolenic in the leaves, whereas in the remaining plant parts, i.e. immature seeds and pods, stems, roots and tubers, the major unsaturated fatty acid was linoleic acid. The major saturated fatty acid in *Amaranthus* seeds, stems and leaves was palmitic acid while in winged bean the saturated fatty acid that occurred in highest amount was behenic acid in seeds (13·6% of total fatty acid). Since behenic acid was been reported to have antinutritional properties (Homma *et al.*, 1983) consumption of winged bean probably should be avoided until adequate nutritional testing of its seed is completed. The absence of behenic acid and other reported antinutritional fatty acids such as parinaric acid in *Amaranthus* (Cerney *et al.*, 1971) indicates that the *Amaranthus* plant could safely be used as a source of plant protein particularly in developing countries where a convenient source of protein is often unavailable.

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