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COMPOSITION OF THE LIPIDS AND CARBOHYDRATES OF THE SEEDS OF *Amaranthus caudatus*

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The chemical composition of the seed lipids of Amaranthus caudatus *L. has been investigated. The fatty acid compositions of the neutral lipids and of the phospho- and glycolipids have been determined. The hydrocarbon components of* A. caudatus *have been identified and its alcohol-soluble carbohydrates, water-soluble polysaccharides, and pectin substances have been characterized.*

Plants of the Amaranthaceae family are widely distributed in Nature, and there is a large number of species in Uzbekistan [1]. Some species of amaranth are grown as crops and are widely used in human nutrition and as animal fodders. In their content of protein, amino acids, vitamins, micro- and macroelements, and biologically active substances, amaranth seeds are superior to traditional food crops [2, 3].

Pharmacological investigations have shown that the oil of *A. rohitufia* seeds has similar properties to that of sea buckthorn seeds and can be used in the treatment of diseases of the stomach [4].

We have investigated the lipids and carbohydrates of the seeds of *Amaranthus caudata* L. (love-lies-bleeding).

The amount of lipids on the absolutely dry weight (a.d.w.) was 4.8%. CC on silica gel was used for their separation into neutral and polar components. We obtained 72.5% of neutral lipids (NLs), 16.3% of phospholipids (PLs), and 11.2% of glycolipids (GLs). In the separation of the NLs by PTLC on silica gel (systems 1 and 2) we revealed the following set of the main classes of lipids (% by weight): hydrocarbons, 0.8; sterol esters, 0.5; squalene, 2.8; triacylglycerols (TAGs), 82.4, epoxyacylglycerols (EP-TAGs) with free fatty acids (FFAs), 6.9; sterols + diacylglycerols, 3.6; and unidentified components, 3.0. Predominating in the NLs were TAGs and the unsaturated aliphatic hydrocarbon squalene, which has been found in the oil of many plants [5]; however, its amount did not exceed 332 mg/100 g of oil.

According to mass spectra, the hydrocarbons consisted of a mixture of the homologs $C_{20:2}$ (M^+ 278), $C_{16:3}-C_{17:3}$ (M^+ 220-234), $C_{22:4}$, $C_{29:4}-C_{31:4}$ (M^+ 302, 400, 414, 428), $C_{30:5}$ (M^+ 412), and $C_{19:6}$ (M^+ 256).

The sterol fraction was composed of β-sitosterol (M^+ 414), stigmasterol (M^+ 412), campesterol (M^+ 400), and cholesterol (M^+ 386). The predominant fraction was β-sitosterol.

Squalene was freed from impurities by TLC in system 3, in which it had R_f 0.65. The mass spectrum of squalene contained peaks with *m/z* 410 (M^+), 395 ($M^+ - 15$), 367 ($M^+ - 43$), and 431 ($M^+ - 69$), which are characteristic for its breakdown [6].

With the aid of two-dimensional TLC (systems 4 and 5) we detected six phospholipids, of which four were identified: phosphatidylcholine (PhC), phosphatidylethanolamine (PhE), phosphatidylinositol (PhI) and phosphatidic acid (PhA).

After separating the GLs on silica gel (system 6) we identified four types of compounds: sulfoquinovosyldiglycerides, digalactosyldiglycerides, ceramidooligosides, and monogalactosyldiglycerides.

Table 1 gives the fatty acid compositions of the lipid classes. All of them contained six fatty acids, with the 16:0, 18:1, and 18:2 species predominating. The NLs were distinguished by a greater degree of unsaturation, and the total amounts of saturated and unsaturated acids in the PLs and GLs were the same, although they differed in the amounts of the 18:1 and 18:2 acids. In the FFAs, the proportion of saturated fatty acids was higher than in the other classes because of the greater proportion of the 16:0 species.

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TABLE 1. Composition of the Fatty Acids of Amaranth Lipids, % GLC

Acid	NLs	PLs	GLs	FFAs
14:0	1.4	2.0	2.8	2.3
15:0	0.3	0.5	0.4	0.7
16:0	21.2	26.9	27.2	32.2
16:1	0.5	0.8	0.2	3.1
18:1	32.4	33.9	35.7	37.2
18:2	44.2	35.9	33.7	24.5
Σ_{sat}	22.9	29.4	30.4	35.2
Σ_{unsat}	77.1	70.6	69.6	64.8

After the lipids had been extracted, the protein content of the meal was 26.9%. Successive extraction with alcohol, water, and oxalic acid solution led to the alcohol-soluble carbohydrates (ASCHs), a water-soluble polysaccharide (WSPS), and pectin substances (PcSs). The yield of ASCHs was 1.5% (PC, system 7). We detected glucose and galactose and two oligosaccharides with R_{fsuc} 0.64 and 0.27, respectively.

The WSPS was obtained in the highest yield (15.2%), and PC (in system 7) revealed glucose in the products of its complete acid hydrolysis. On reaction with iodine, the WSPS gave a deep blue coloration; i.e., it was starch [7].

The yield of PcSs was 2.7%. The monosaccharide composition of the CSs was represented by galacturonic acid, glucose, galactose, arabinose, rhamnose, and xylose (PC, system 7).

According to the results of titrimetric analysis [8], the degree of esterification of the PcSs was 72.4%; i.e., the pectin from *A. caudatus* seeds is of the high-methoxyl type.

The IR spectrum of the PcSs of the seeds was characteristic for pectins of plant origin [9]. An absorption band at 835-840 cm^{-1} showed the α-configuration of the glycosidic bonds, while absorption bands of the stretching vibrations of the carboxy methyl ester group lay in the 1740 cm^{-1} region. Absorption bands at 1025 and 1080 cm^{-1} related to the vibrations of a pyranose ring, and one at 890 cm^{-1} to those of a 1-4 glycosidic bond.

EXPERIMENTAL

Mass spectra were taken on a MKh-1310 instrument at an energy of the ionizing electrons of 40/50 eV and a temperature of the ionization chamber of 100/80°C. IR spectra were taken on a UR-20 instrument (Carl Zeiss, Jena) using tablets molded with potassium bromide. GLC was conducted on a Chrom-4 instrument with a flame-ionization detector.

Solvent systems: 1, 2) $C_2H_5OC_2H_5$ — C_6H_{14} (3:7, 2:8); 3) $CH_3(CH_2)_5CH_3-C_6H_6$ (9:1); 4) $CHCl_3-MeOH$ — 28% NH_4OH (65:35:5); 5) $CHCl_3CH_3COCH_3-MeOH-CH_3COOH-H_2O$) (5:2:1:1:0.5); 6) $CH_3COCH_3-C_6H_5CH_3-CH_3COOH-H_2O$ (60:60:2:1); 7) $C_4H_9OH-C_6H_5N-H_2O$ (6:4:3). The saponification of the lipids and the isolation of the fatty acids were carried out as in [10].

Isolation of the Lipids and the Carbohydrate Components. The total lipids from the ground amaranth seeds were exhaustively extracted with a 2:1 v/v mixture of chloroform and methanol. The PcSs were isolated with 80% ethyl alcohol at the boil. The extract was evaporated to a viscous syrup, freed from impurities with activated carbon, and subjected to PC (system 7). To extract the WSPS, the residual raw material was extracted with water, the extract was evaporated to a syrup, and, after elimination of proteins by Sevag's method [11], this was precipitated with alcohol in a ratio of 1:2. The WSPS was hydrolyzed with 2 N H_2SO_4 for 8 h, and the hydrolysate was neutralized and, after appropriate treatment, subjected to PC (system 7). The pectin was isolated with a 0.5% solution of oxalic acid at 70°C for 1 h twice in a ratio of 1:2. The treatment of the combined extracts and acid hydrolysis were carried out as in [12]. The monosaccharide composition of the PcSs was established by PC (system 7). The degree of esterification was determined as in [13].

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