FATTY ACID COMPOSITION OF THE PHOSPHOLIPIDS OF THE GENERATIVE ORGANS OF THE COTTON PLANT OF VARIETY 159-F IN THE PERIOD OF MASS FRUIT FORMATION

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The qualitative and quantitative fatty acid compositions of the phospholipids of the generative organs of the cotton plant of variety 150-F in the period of mass fruit-formation has been studied.

There is information in the literature on the fatty acid composition of ripe cotton seeds [1, 2] and the fatty acid composition of the lipids of the vegative and generative organs of the cotton plant [3] which shows that the qualitative and quantitative compositions of the lipids of different organs and plant differ in their complexity from the lipid composition of ripe seeds.

The aim of the present investigation was to study the fatty acid composition distribution of the fatty acids in individual phospholipids (PLs) isolated from the generative organs of the cotton plant of variety 159-F in the period of mass fruit-formation — buds, flowers of the first and second days, and bolls.

As we have reported previously, the qualitative and quantitative compositions of the phospholipids in different organs differ from one another and, correspondingly, their fatty acid compositions are not identical. It can be seen from the results obtained that in the PLs of the generative organs there are three times as many fatty acid (FAs) in the qualitative respect than in the PLs of the ripe seeds [5], which explains the far higher number of molecular species of the individual PLs. This is apparently normal for the regular development of the plant. The main fatty acids are the 16:0, 18:1, 18:2, and 18:3 acids, while there is none of the 18:3 acid in the ripe seeds.

In the buds (Table 1), the amount of unsaturated acid, which is high in the PCs,* falls in the sequence PCs > PAs > PEs > Y_3 > PIs > X_3 > Y_1 > X_1. In position 1 of the PCs there is a larger amount of unsaturated FAs than in the PEs and far more than in the PAs in which there are more saturated FAs in position 1 and more unsaturated FAs in position 2. It was found that in the PL Y_3 there was more of the 10:0 acid than in the other PLs, and in the PL X_1 more of the 16:0 and 16:1 acids.

The flowers of the first day were collected immediately after their opening in the practically unpollinated state, while in the flowers of the second day pollination was total (Table 2 and 3). In the flowers of the first day the amount of the 15:0 acid fell in the sequence X_1 > PIs > PEs > X_3 > PAs > Y_5 > PCs, and an increased amount of the 16:1 acid was observed. The largest amount of 16:1 acid was found in the PL X_1 and it decreased in the sequence X_1 > Y_1 > PEs > PIs. The total unsaturation of the fatty acid radicals was greatest in the PCs and least in the PL X_1: PCs > PEs > PAs > Y_3 > PIs > X_3 > Y_1 > Y_5 > X_1. With respect to the amount of unsaturated acid in position 2, the sequence was PEs = PCs > PIs, and position 2 was more unsaturated than position 1. As compared with the other organs, in the flowers of the first day the amount of the 20:0 acid was higher in a large number of PLs (apart from the PLs Y_1 and Y_3 from the buds) and decreased in the sequence Y_5 > Y_1 > Y_3 > X_3 > X_1 > PAs > PEs.

*PCs — phosphatidylcholines; PEs — phosphatidylethanolamines; PIs — phosphatidylinositols; X and Y — unidentified phospholipids [9].

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TABLE 1. Composition and Position Distribution of the FAs in the PLs from the Buds

Fatty acid	PIs		PCs		PEs		PAs	Y_1	X_1	X_2	Y_2
	total	pos. 2	total	pos. 2	total	pos. 2					
9:0	—	—	0,1	0,1	0,2	0,3	—	—	—	—	—
10:0	0,2	0,2	0,4	0,7	0,4	0,7	3,4	5,2	11,3	4,2	11,9
11:0	0,1	0,1	—	—	—	—	0,1	—	0,2	0,3	0,2
12:0	1,2	0,2	0,7	0,2	1,0	1,9	0,8	0,4	1,0	4,0	1,0
Unidentified	1,8	0,4	—	—	—	—	—	1,6	3,0	—	—
	0,1	0,1	0,1	0,1	0,2	0,3	0,1	0,4	0,3	1,6	0,2
Iso-14:0	—	—	0,1	0,1	—	—	—	0,2	—	—	—
14:0	2,1	1,5	0,9	0,7	1,4	2,6	0,6	1,4	1,1	1,4	0,8
Unidentified	0,3	0,3	—	—	—	—	—	0,5	—	0,3	—
	1,6	0,7	0,4	0,4	0,9	1,6	0,5	1,1	1,5	1,0	0,8
Iso-16:0	0,2	0,2	0,2	0,1	—	—	0,2	0,3	Сл.	0,3	0,3
16:0	38,5	35,0	22,9	18,6	29,8	1,7	17,9	26,7	45,4	26,3	21,6
16:1	1,8	1,8	0,5	0,8	0,6	1,0	0,9	2,5	6,5	3,9	0,6
Unidentified	2,7	0,6	0,7	0,4	1,1	2,0	0,5	0,9	—	0,4	0,5
	—	—	0,5	—	—	—	—	—	—	—	—
Iso-18:0	1,3	0,9	0,4	0,7	0,8	0,3	1,0	1,8	1,5	1,3	0,8
18:0	4,7	2,3	3,2	1,1	3,0	5,3	1,8	4,7	3,3	2,8	2,1
18:1	3,9	7,6	16,0	15,4	3,6	6,2	12,5	6,5	5,1	,9	12,2
18:2	20,6	28,0	34,9	38,6	37,8	40,3	38,6	10,8	5,7	22,1	28,6
18:3	16,4	18,8	17,3	20,8	17,0	16,5	15,6	7,5	5,4	5,5	14,8
20:0	2,5	1,3	0,7	1,2	2,2	4,3	5,5	27,5	8,7	18,7	3,6
Σ_S	57,3	43,8	31,3	24,4	41,0	36,0	32,4	72,7	77,3	62,6	43,8
Σ_U	42,7	56,2	68,7	75,6	59,0	64,0	67,6	27,3	22,7	37,4	56,2

In the PLs of the flowers of the second day, the total unsaturation fell in the sequence PAs > PCs > PIs > Y_3 > PEs > Y_1 > Y_5 > X_1. The highest amount of the 16:1 acid was found in the PL Y_5.

Phospholipids form one of the main components of biological membranes and they are characterized by the phenomenon of asymmetry which is shown by the distribution of the FAs over the positions of attachment — a larger amount of unsaturated FAs is usually attached in position 2 than in position 1.

It has been shown [6, 7], that only the 18:1 FA behaves anomalously — in the PLs it adds equally or even to a greater extent in position 1 than in position 2.

Similar anomalies were observed in the distribution of the FAs of the PLs of the generative organs, but now not only with the 18:1 FA but also with the 18:2 and the 18:3 FAs — 18:1 in the PCs of the buds, the PCs and the PIs of the flowers of the first day, the PCs of the flowers of the second day, the PCs and the PEs of the 18:2 in the PCs of the flowers of the second day; and 18:3 in the PCs from the buds. A completely anomalous addition of the FAs has been observed only by Bergelson and Dyatlovitskaya [8]. We have detected the same phenomenon in the PIs of the flowers of the second day: 70% of unsaturated FAs in position 1 and 70% of saturated FAs in position 2.

On comparing the flowers of the first and second days with one another, we see the following differences: anomalous PIs in the flowers of the second day: The total unsaturation in the position 1 of the PEs decreased as a consequence of a marked fall in the amount of the 18:2 and 18:3 FAs; the sums of the unsaturated FAs in the PL Y_5 of the two types of flowers were similar but in the flowers of the first day the amount of 10:0 acid was far higher; in the flowers of the second day the 20:0 FA was present in larger amounts in all the PLs.

In the PLs isolated from the bolls (Table 4), the total unsaturation was greatest in the PL X_3 and fell in the sequence X_3 > PAs > Y_3 > PCs > X_1 > Y_1 > PI > PEs, while unsaturation in the FAs in position 2 decreased in the sequence PIs > PEs > PCs. In comparison with the PLs of the other generative organs, an increased amount of the 20:0 acid in position 2 of the PCs was observed.

It was observed that in all the PEs apart form the PEs from the buds, the 16:1 FA predominated in position 1.

TABLE 2. Composition and Position Distribution of the Fatty Acids in the Phospholipids from the Flowers of the First Day

Fatty acid	PIs		PCs		PEs		PAs	y_1	x_1	x_2	y_3	y_2
	tot.	pos. 2	tot.	pos. 2	tot.	pos. 2						
9:0	0,3	—	0,1	0,1	0,2	—	—	—	—	0 9	—	—
10:0	0 6	1,1	1,2	2 2	1,8	2,1	—	0,4	—	—	0,6	16,1
Unidentified	—	—	0,1	—	—	—	—	—	—	0,6	—	—
11:0	0,1	0,1	0,2	0,2	—	—	—	—	—	—	0,2	0 3
Unidentified	—	—	0,2	0 2	—	—	—	—	0,4	—	0,9	—
12:0	0,8	0,6	0,6	0,6	1,3	0,3	0,9	0,8	0,9	2,8	2,0	0,6
Unidentified	1,9	1,5	0,3	—	1,3	1,1	—	1,7	—	—	—	2,0
	—	—	0,1	—	—	—	—	0,4	0,1	—	0,6	0 5
Iso-14:0	—	—	0,1	—	—	—	—	—	—	0,4	—	0 5
14:0	1,4	1,2	0,8	0,8	1,0	0,6	1,0	2,3	1,4	1,4	1 0	1,5
Anteiso-15:0	—	—	—	—	0,3	0,3	—	—	—	—	0,3	—
Unidentified	1,8	0 6	0,5	0 4	0,7	0,4	0,9	2,4	1,1	1,1	0,6	1,5
Iso-16:0	—	—	0,2	0,2	0,1	0,1	0,7	Сл.	—	0,4	0,1	0,4
16:0	37,0	30,3	24,9	18,3	28,9	12,3	28,3	26,7	53,5	29,7	26,1	27,5
16:1	3,6	2,2	1,0	0,7	4,1	0,9	1,4	5,4	5,8	2,6	1,4	2,8
Unidentified	1,0	0,7	0,3	0,2	1,2	1,1	0,7	1 6	0,4	0,8	0,2	1,1
Iso-18:0	1,2	0,8	1,1	0,8	1,4	0,6	1,8	0,9	0,9	1,0	0,5	1,3
18:0	3,4	2,3	2,8	1,4	2,3	0,6	3,4	5,3	4,3	2,6	1,6	3,0
18:1	7,8	7,9	11,1	11,5	8,0	4,8	9,2	9,8	8,3	6,2	7,2	6,0
18:2	20,8	27,5	34,0	36,4	26,2	40,1	27,5	13,9	8 4	26,2	27,4	8,5
20:0	1,3	2,4	0,9	1,6	3,5	6,7	6,9	19,1	9,9	11,0	11,4	22,9
18:3	17,0	20,8	19,5	24,4	17,7	28,0	17,3	9,3	4,6	12,3	17,9	3,5
Σ_S	50,8	41,6	34,4	27,0	44,0	26,2	44,6	61,6	72,9	52,7	46,1	65,2
Σ_U	49,2	58,4	65,6	73,0	56,0	73,8	55,4	38,4	27,1	47,3	53,9	34,8

TABLE 3. Composition and Position Distribution of the Fatty Acids in the Phospholipids of the Flowers of the Second Day

Fatty acid	PIs		PCs		PEs		PAs	y_1	x_1	y_3	y_2
	tot.	pos. 2	tot	pos. 2	tot.	pos. 2					
10:0	0,4	0,6	0,5	0,9	0,4	0,7	—	—	0,7	—	0,7
Unidentified	—	—	—	—	1,2	—	1,0	—	5,1	—	—
11:0	—	—	0,1	0,1	0,1	0,1	—	—	—	—	—
12:0	0,8	0,6	0 8	0,4	1,4	0,4	0,5	0,9	—	0,8	3,8
Unidentified	1,0	1,4	0,8	0,9	2,1	—	0,5	—	1,5	—	4,6
	0,2	0,2	0,2	—	0,1	0,1	—	—	0,7	—	—
	—	—	—	—	—	—	—	—	1,9	0,4	0,2
14:0	1,3	2,4	0,8	1,1	1,3	0,9	—	0,5	1,8	—	3,0
Unidentified	—	—	—	—	—	—	0,8	1,2	—	1,3	—
Anteiso-15:0	0,2	0,2	—	—	0,6	—	0,3	1,4	—	0,8	0,8
Unidentified	0,8	1,4	0,6	0,7	1,0	0,7	0,7	1,4	1,8	1,2	2,9
Iso-16:0	—	—	0,3	0,4	0,4	—	0,2	0,8	—	1,0	0,6
16:0	31,4	45,4	25,7	23,3	38,0	19,6	26,5	47,7	48,1	35,6	41,5
16:1	2,4	3,2	1,2	1,9	3,0	1,7	2,9	4,2	4,5	3,1	8,4
Unidentified	1,0	0,9	0,8	0,6	1,1	0,4	1,1	1,8	2,0	2,0	1,8
	—	—	—	—	—	—	—	1,3	—	—	—
Iso-18:0	1,6	1,1	1 8	1,0	1,3	0,5	0,6	1,4	2,5	2,4	1,3
18:0	4,5	4,6	4,2	2,7	5,9	1,9	4,0	6,2	4,0	5,2	8,8
18:1	6,8	6 8	11,1	9,9	6,9	5,4	10,9	12,5	8,3	12,0	13,1
18:2	27,2	17,8	34,2	31,5	23,6	44,9	35,0	10,1	9,1	24,3	5,1
20:0	2,2	2,0	3,0	6,0	0,8	1,6	—	—	—	—	—
13:3	18,2	11,4	13,9	18,6	10,8	21,1	15,0	8,6	8,0	9,9	3,4
Σ_S	45,4	60,8	39,6	38,1	55,7	26,9	36,2	64,6	70,1	50,7	70,0
Σ_U	54,6	39,2	60,4	61,9	44,3	73,1	63,8	35,4	29,9	49,3	30,0

Having considered generally the PLs of the generative organs of the cotton plant of variety 159-F in the stage of mass fruit formation the following observation can be made:

TABLE 4. Composition and Position Distribution of the Fatty Acids in the Phospholipids from the Bolls

Fatty acid	PIs		PCs		PEs		PAs	y_1	x_1	x_2	y_2
	tot.	pos. 2	tot.	pos. 2	tot.	pos. 2					
9:0	—	—	—	—	0,6	0,1	0,4	—	0,3	—	—
10:0	0,5	0,6	3,9	7,7	0,4	0,3	—	1,5	0,3	0,4	0,3
Unidentified	0,6	0,1	0,3	—	—	—	—	—	—	—	—
11:0	—	—	0,1	0,1	—	—	—	0,1	—	0,1	0,4
Unidentified	—	—	—	—	—	—	—	0,2	0,5	—	—
12:0	1,3	0,2	0,1	0,2	1,8	0,2	0,5	0,9	0,3	0,3	—
Unidentified	1,6	0,5	0,4	0,7	2,0	—	—	—	—	—	0,2
	—	—	0,2	0,2	—	—	0,1	0,2	—	0,1	—
Iso-14:0	—	—	—	—	0,4	—	—	—	—	0,1	—
14:0	0,5	0,8	0,8	0,4	2,1	0,4	1,2	1,3	1,1	0,9	1,0
Unidentified	0,8	—	—	—	—	—	—	—	—	—	—
Anteiso-15:0	—	—	0,2	0,2	—	—	—	0,2	—	0,1	—
Unidentified	0,5	0,2	0,4	0,3	1,7	0,5	1,1	1,0	0,8	0,7	0,6
Iso-16:0	0,3	0,1	0,2	0,2	0,6	0,1	0,2	0,2	—	0,1	0,3
16:0	39,0	10,9	25,6	13,2	34,2	14,4	18,8	25,2	35,0	20,1	26,5
16:1	0,9	0,5	1,0	0,6	3,4	1,0	1,0	1,5	2,8	1,8	1,0
Unidentified	0,7	1,0	0,8	0,7	1,2	0,8	2,6	0,9	Tr.	0,4	1,1
	0,7	—	0,6	—	—	—	—	0,7	—	—	—
Iso-18:0	1,2	0,3	1,3	0,8	1,3	0,3	0,7	1,0	1,2	0,6	1,4
18:0	2,7	0,7	2,7	1,1	4,0	2,0	5,0	3,1	2,1	1,8	1,6
18:1	7,2	7,6	15,0	14,7	8,2	7,9	10,3	11,2	8,9	7,1	12,8
18:2	20,6	36,6	23,0	26,8	19,6	38,9	30,5	21,4	18,7	42,5	32,6
20:0	1,1	1,3	4,2	8,3	2,6	1,8	2,4	9,6	4,2	4,7	3,2
18:3	19,8	38,6	19,2	23,8	15,9	31,3	25,2	19,8	23,8	18,2	17,0
Σ_S	51,5	16,7	41,8	34,1	52,9	20,9	33,0	46,1	45,8	30,4	36,6
Σ_U	48,5	83,3	58,2	65,9	47,1	79,1	67,0	53,9	54,2	69,6	63,4

different qualitative and quantitative compositions of the fatty acids of the PLs;

different position distributions of the PAs in the PLs with the predominant distribution of the unsaturated FAs in position 2 but with exception both on the whole and in details.

EXPERIMENTAL

The investigation was carried out basically in the same way as in [5, 9]. The FAs were identified by comparison with standard acids, and also from their retention times [10, 11].

SUMMARY

1. The qualitative and quantitative fatty acid compositions of the individual PLs of the generative organs of the cotton plant — the buds, the flowers of the first and the second days, and the bolls — have been studied. As compared with the ripe seeds, three times as many fatty acids have been detected qualitatively.

2. The position distribution of the FAs in the PCs, PEs, and PIs of the generative organs have been determined. The predominant distribution of the unsaturated FAs in position 2 has been observed, but there are exceptions both in general (anomalous PIs in the flowers of the second day) and in details without disturbing the general position asymmetry but with a change in the internal ratios of some FAs.

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FATTY ACID COMPOSITION OF THE PHOSPHOLIPIDS OF THE VEGETATIVE ORGANS OF THE COTTON PLANT OF VARIETY 159-F AT THE STAGE OF MASS FRUIT FORMATION

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The qualitative and quantitative compositions of the fatty acids (FAs) of the individual phospholipids (PLs) of the vegetative organs of the cotton plant of variety 159-F have been studied. In the PLs of the stems there was a wide range of FAs (26), a large proportion of which have retention times in GLC shorter than those of the 16:0 FA. The position distribution of the FAs in the phosphatidylcholine, phosphatidylethanolamine, and phosphatidylinositols of the vegetative organs have been established.

The total fatty acid compositions of all phospholipids (PLs) of the generative organs of the cotton plant and the position distributions of the fatty acids (FAs) in the main PLs — the phosphatidylcholines (PCs), phosphatidylethanolamines (PEs), and phosphatidylinositols (PIs) — have been established previously (see [1]). Continuing work in this direction, we have isolated individual PLs from the vegetative organs — the leaves, bark of the stems, stems without the bark, and roots — and have determined their total fatty acid compositions and the position distributions of the FAs in the PCs, PEs, and PIs.

In the leaves (Table 1), the PL X_1 contain the largest amount of unsaturated FAs, and the degree of unsaturation increased in the sequence X_1 > PCs > PAs > PEs > PIs > Y_3. The degree of unsaturation in position 2 of the main PLs decreased in the sequence PIs > PCs > PEs. In the PIs of the leaves there was a pronounced asymmetry of the distribution of the FAs: In position 1 there was 91% of the saturated FAs, of which 37.3% was due to the 16:0 acid, and in position 2 there was 81.8% of the unsaturated FAs, the main representatives of them being the 18:3 acid (51.2%) and the 18:2 acid (26.1%). As in the PLs of the generative organs, in the PLs of the vegetative organs an anomalous distribution of the FAs was observed: In the PCs of the leaves there were larger amounts of the 18:1 and 18:3 acids in position 1 than in position 2, in the PEs the same was observed with the 18:1 FA. In the PL X_1 of the leaves there was more of the 16:1 acid (10.8%), and in the PIs, PEs, and the PL X_1 there was none of the iso-16:0 acid. As compared with all other vegetative and generative organs there was more of the 18:3 acid in the PCs, PIs, and PEs of the leaves, and more unsaturated FAs in the phosphatidic acid (PAs).

The most unsaturated PLs from the bark of the stems were the PAs (Table 2), and the degree of unsaturation decreased in the sequence PAs > Y_1 > PEs > Y_4 > PCs > PIs > X_3. The asymmetry of the addition of the FAs was pronounced in the PIs (91.3% of saturated FAs in position 1 and 81% of unsaturated FAs in position 2). In the PEs an anomalous addition of more of the 18:3 FA in position 1 than in position 2 was observed. The 20:0 acid was present only in the PIs and PCs. The PEs of the bark contained more of the 18:2 acid than the PEs of the other organs.

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