COMPOSITION OF THE TRIACYLGLYCEROLS OF THE PHLOEM OF *Larix sibirica*

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The annual dynamics of the amount of acylglycerols in the phloem of the Siberian larch has been established. It has been shown that, depending on the phenological state of the wood their amount varies between 0.192 and 1.435%. The triacylglycerols of the phloem form the bulk of the acylglycerols of this tissue over the whole of the annual cycle. The stereovariety composition of the triacylglycerls of the phloem has been studied by the method of stereospecific analysis. It has been established that they have an asymmetric structure. The bulk of them contains acylglycerols in the molecules of which the sn-2 positions are acylated by unsaturated acids.

Triacylglycerols are the most important chemical form for the prolonged storage of energy in plant cells. To elucidate the mechanism of their transformation into the cambial zone of trees in the annual cycle a source of information is necessary on the amount and composition of the triacylglycerols in the reserve tissues of the tree. The prime role in this respect is played by the phloem tissue. There is no information in the literature on the amount and composition of the triacylglycerides of the phloem of woody plants.

We have studied the triacylglycerols of the phloem of the Siberian larch. They were obtained from the phloem of the same trees as were used for the investigation of the acylglycerols of the cambial zone [1]. The amount of acylglycerols in the phloem was determined at different periods of the annual cycle corresponding to various phenological states of the tree. The vegetation period was considered in detail, since it is connected with an intense activity of the cambium.

Below we give the amounts of acylglycerols in the phloem of the Siberian larch (averages of three-year investigations, percent on the absolutely dry initial tissue):

	Jan.	April	May	June	July	Sept.	Nov.
1(3)-Monoacylglycerols	0,120	0,018	0,017	0,050	0,051	0,108	0,151
2-Monoacylglycerols	0,133	0,053	0,037	0.033	0,0[illegible]2	0,058	0,126
1,2(2,3)-Diacylglycerols	0,181	0,023	0,023	0,046	0,031	0,218	0,216
Triacylglycerols	0,027	0,006	0,005	0,010	0,015	0,021	0,023
	0,829	0,177	0,110	0,127	0,165	0,477	0,919
Total	1,290	0,277	0,192	0,266	0,325	0,832	1,435

The results obtained show that the acylglycerols of the phloem of the Siberian larch are represented by a combination of mono-, di-, and triacylglycerols. The maximum amount of acylglycerols is present in the phloem in the period of dormancy (November) – 1.435% – and the minimum in the vegetation period (May) – 0.192%. The dynamics of the amounts of mono-, di-, and triacylglycerols in the course of the annual cycle are identical in nature.

The bulk of the acylglycerols consisted of triacylglycerols. Their amount as a proportion of the total exceeded 50% through the annual cycle.

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TABLE 1. Composition of the Fatty Acids Acylating the sn-1, sn-2, and sn-3 Positions of the Molecules of the Triacylglycerols of the Phloem of the Siberian Larch

Month	Position	Amount mol.%										
		$C_{12:0}$	$C_{14:0}$	$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:0}$	$C_{20:1}$	$C_{22:0}$	$C_{24:0}$
Jan.	*sn*-1	2 17	1,50	17,02	5,88	49,22	7,00	9,87	4 02	1,63	0,97	0,72
	sn-2	0,12	0,10	4,43	1,00	64,77	16,31	11,43	0,59	1.00	0,15	0,10
	sn-3	0,20	0,32	5,07	3,47	63,61	4,35	18,33	0,37	3,76	0,20	0,32
April	*sn*-1	3,08	3,56	16,96	9,90	43,24	2,11	1,21	10,11	7,24	1 34	1,25
	sn-2	0,44	0 35	16,96	7,73	56,77	5,41	1,73	7,47	2,34	0,38	0,42
	sn-3	2,27	1,22	12,10	3,88	56.41	1,57	3,09	9.84	8,39	0,71	0,52
May	*sn*-1	0,57	0,82	15,65	7,22	51,22	3,42	2,45	12,32	4,88	0,82	0,62
	sn-2	0,37	0,32	15,81	6,02	63,77	5,99	2,41	2,54	2.00	0,46	0,31
	sn-3	0,43	0,51	10,33	3,05	61,20	2,56	4,14	9,14	7,73	0,61	0,30
June	*sn*-1	1,29	0,72	15,11	2,29	4,44	52,26	6 35	3.39	12,63	1.11	0,41
	sn-2	0,37	0,12	15,25	2,70	6,13	63.87	7,34	0,80	3,10	0,18	0,14
	sn-3	0,74	0.30	7,02	4,55	3,41	62,73	4,22	5,83	10,49	0,42	0,29
July	*sn*-1	1,13	0,07	12 37	3,13	4,98	49,82	9,12	3,98	14,02	0,72	0,66
	sn-2	0,43	1,21	11,98	2,95	7,38	64.12	3,41	1 21	7,02	0,18	0,11
	sn-3	0,74	0,04	8,14	4,12	3,00	66,03	5,83	7,20	4,25	0,51	0,25
Sept.	*sn*-1	0,76	0,85	12,75	6,84	5,95	51,33	7,80	1,81	10,18	1,10	0,63
	sn-2	0,22	0.31	9,98	7,00	10,74	64,20	2,78	0,31	3.64	0,44	0,38
	sn-3	0,34	0,55	9,22	10,58	4,70	63,99	1,03	4,30	1,00	0,95	0,34
Nov.	*sn*-1	1,83	1,52	13,11	11,98	7,86	52,38	3,68	1,80	4,23	0,90	0,71
	sn-2	0,27	0,23	3,38	12.18	16,93	64,15	2,05	0,24	0 35	0 10	0,12
	sn-3	0,15	0,20	4,90	21,35	5,33	63,83	1,41	2,16	0,22	0,14	0,31

The composition of the fatty acids acylating the sn-1, sn-2, and sn-3 positions in the triacylglycerol molecules was determined with the aid of stereospecific analysis. The amounts of fatty acids were determined on the basis of the results obtained by gas–liquid chromatography.

The compositions of the fatty acids of the triacylglycerols of the phloem of the Siberian larch are given in Table 1. Unsaturated fatty acids predominate. Their amounts in the sn-1, sn-2, and sn-3 positions of the triglycerol molecules of the phloem change during the annual cycle. The unsaturated acids of the C_{18} series are the main unsaturated acids of the triacylglycerols of the phloem.

The sn-2 positions in the triacylglycerol molecules of the phloem are acylated preferentially by unsaturated acids. Their amount on the total of acids in the sn-2 positions varied in the annual cycle from 65.26% (April) to 83.48% (November).

From the figures of Table 1 we calculated the selectivity factor and the saturation index of the $C_{18:1}$, $C_{18:2}$, and $C_{18:3}$ acids in the sn-2 positions of the triacylglycerol molecules of the phloem by means of a formula given in the literature [2]:

Month	Selectivity factor			Proportion of the acid in the sn-2 position, %		
	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$
Jan.	0,99	1,60	0.73	36,38	58,96	26.81
April	1.04	1,70	0.86	36,26	59,50	28,68
May	1,03	1,43	0,76	36,16	50,00	26,67
June	1.03	1.27	0,88	35,66	43.83	28,30
July	1.03	1,38	0,83	35,60	48,00	28,90
Sept.	1,00	1,43	0,82	35.00	50,20	26.63
Nov.	0,99	1,44	0,75	35,56	56,20	26,76

It can be seen from Table 2 that with respect to their capacity for acylating the sn-2 positions in the triacylglycerol molecules oleic, linoleic, and linolenic acids form the following sequence of decreasing sensitivity factors: L > O > Le, where L represents linoleic, O oleic, and Le linolenic acids, i.e., the sequence of the majority of plant acylglycerols is retained. The fatty acids in the triacylglycerol molecules of the phloem are distributed

TABLE 2. Basic Stereovariety Composition of the Triacylglycerols of the Phloem of the Siberian Larch (mole % on the sum of the triacylglycerols)

Name*	Jan.	April	May	June	July	Sept.	Nov.
OOO	20,28	13,85	19,99	20,94	21,09	22,08	21,45
LOO	2,88	0,36	1,33	1,78	2,11	2,56	3,22
OOL	1,39	0,39	0,84	1,14	0,96	1,55	1,79
OOLe	5,84	0,75	1,35	1,52	1,32	3,49	7,17
LeOO	4,07	0,39	0,96	0,92	1,33	2,94	4,91
LOLe	0,83	0,02	0,09	0,13	0,13	0,41	1,08
LeOLe	1,17	0,02	0,06	0,07	0,08	0,46	1,64
OOE	1,20	2,06	2,52	1,95	2,30	1,42	0,76
AOO	1,66	3,23	4,80	5,06	5,94	4,38	1,73
OOA	0,11	2,42	2,99	3,50	1,36	0,33	0,10
SOO	2,42	3,17	2,82	2,54	3,86	3,35	1,51
POLe	2,02	0,30	0 41	0,44	0,33	0,87	1,80
OOP	1,62	2 97	3,37	2,34	2 60	3,04	1,65
POO	7,01	5,43	6,11	6,05	5,24	5,48	5,37
POP	0,56	1 17	1,03	0,68	0 65	0,75	0,41
OLO	5,11	1,32	1,88	2,00	2,43	3,69	5,66
LeLO	1,02	0,04	0,09	0,09	0,15	0,49	1,29
OLLe	1,47	0,07	0,13	0,15	0,15	0,58	1,89
PLO	1,77	0,52	0,57	0,58	0,60	0,92	1,42
OLeO	3,58	0,42	0,76	0,89	0,97	2,41	4,07
OLeLe	1,03	0,02	0 05	0,06	0,06	0,38	1,36
PLeO	1,24	0,17	0,23	0,26	0,24	0,60	1,02
OPO	1,39	4,14	4,96	5,00	3,94	3,43	1,13
OPP	0,11	0,89	0,84	0,56	0,49	0,47	0,09
OAO	0,18	1,82	0,80	1,00	2,31	1,25	0,12
OSO	0,31	1,89	1,89	2,41	0,13	0,96	0,69

* O, L, Le, E, A, S, and P represent the acyl radicals of oleic, linoleic, linolenic, eicosenoic, arachidic, stearic, and palmitic acids.

nonuniformly between the sn-1 and sn-3 positions, i.e., the triacylglycerols have an asymmetric structure. The amounts of oleic, eicosenoic and linolenic acids in the sn-3 position are greater than in the sn-1 position throughout the annual cycle.

On the basis of the experimental results (Table 1) we determined the stereovariety composition of the triacylglycerols of the phloem and its change in the course of the annual cycle. The basic stereovariety compositions of the triacylglycerols of the phloem are given in Table 2. From them we calculated the stereovariety composition (without including minor components the amount of which was less than 0.02 mole %):

Type of triacylglycerols	Jan.	April	May	June	July	Sept.	Nov.
UUU	56,84	24,23	34,64	34.99	37,55	46,90	63,78
SSS	0,08	4 03	1,91	1,93	1.31	0,64	0,03
SUS	2,94	8,72	6,51	6,11	5,68	4.16	1,73
SUU	25,56	22,12	22,02	21,90	21,76	20.46	21.16
USU	3,88	12,17	11,88	12,46	10,48	9.93	4,22
USS	0,35	4,14	3.41	3,42	2,72	1,90	0,28
UUS	7,24	9,22	10,58	9,88	10,02	9,91	6,10
SSU	1,58	11,29	7,49	7,59	5,93	4,20	1,21

As we see, the bulk of the triacylglycerols of the phloem consisted of acylglycerols in which the sn-2 position was acylated by unsaturated acids. Among this type of triacylglycerols those in which the sn-2 position was occupied by acyl radicals of oleic acid predominated. The amount of triacylglycerols having the stereovariety composition UUU was considerable and amounted to 63.78% in the period of dormancy (November). Their bulk consisted of glycerol trioleate — 21.45% on the total triacylglycerols.

The amount of triacylglycerols in which the sn-2 positions were acylated by saturated acids was smaller. Among them those in which the sn-2 positions were acylated with palmitic acid predominated. The bulk of these triacylglycerols consisted of sn-glycerol 1.3-dioleate 2-palmitate.

Among the stereoisomers USS and SSU, and also UUS and SUU, those in which the sn-3 positions were acylated with unsaturated acids predominate.

In the course of the annual cycle, the composition of the triacylglycerols changes. The amount of triacylglycerols having the stereotypic compositions UUU, SUS, SUU, and UUS, i.e., those in the molecules of which the sn-2 position is acylated by unsaturated acids, is a minimum in the period of activation of the cambium (April), while in the period of dormancy, conversely, its amount is greatest. Consequently, in the metabolic processes in the phloem during the whole annual cycle those triacylglycerols are involved preferentially in which the sn-2 position is acylated by unsaturated acids — in particular, oleic, linoleic, and linolenic.

EXPERIMENTAL

The triacylglycerols were isolated from the neutral lipids of the phloem by the procedure described in [1], excluding hydrolysis of the initial triacylglycerols to mono- and diacylglycerols in the course of isolation. The neutral lipids were obtained as described in [1]. Stereospecific analysis was carried out as in [3]. For the gas-chromatographic analysis of the fatty acids we used a LKhM-72 instrument with a thermal conductivity detector and programmed heating of the column. As the stationary phase we used PEGA deposited in an amount of 15% on Celite 545 with a grain size of 60-80 mesh. The column was heated from 200 to 240°C at the rate of 1°C/min. The carrier gas was helium and its rate of flow 60 ml/min.

SUMMARY

1. The dynamics of the amounts of mono-, di-, and triacylglycerols in the phloem of the Siberian larch in various periods of the annual cycle have been determined. The triacylglycerols of the phloem form the bulk of the acylglycerols of this tissue throughout the annual cycle.

2. The stereovariety composition of the phloem triacylglycerols has been studied. The fatty acids in the triacylglycerol molecules are distributed between the sn-1 and sn-3 positions nonuniformly, i.e., the molecules have a asymmetric structure.

3. In the bulk of the triacylglycerols of the phloem, the sn-2 positions of the molecules are acylated by unsaturated acids.

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PHOSPHOLIPIDS OF THE SEEDS OF EXPERIMENTAL VARIETIES OF KENAF

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Phospholipids of the seeds of kenaf of the variety Opytnyi-1931 are similar with respect to their set of components and the qualitative composition of the fatty acids of homogeneous classes to the phospholipids of the variety Opytnyi-1972, but differ with respect to the amounts of individual acids. The fatty-acid composition of the lysophosphatidylcholines and lysophosphatidylinositols of experimental varieties of kenaf seeds have been studied for the first time.

Continuing investigations into the lipids of the seeds of various plants of the family Malvaceae, we have studied the phospholipids (PLs) of kenaf seeds of the varieties Opytnyi-

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