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Fatty Acid Composition of Fourteen Wood-decaying Basidiomycete Species Growing in Permafrost Conditions

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Abstract: The fatty acid (FA) compositions of 14 wild wood-decaying basidiomycete species (*Bjerkandera adusta*, *Daedaleopsis septentrionalis*, *Dichomitus squalens*, *Inonotus hispidus*, *I. radiatus*, *Irpex lacteus*, *Fomitopsis cajanderi*, *F. pinicola*, *F. rosea*, *Gloeophyllum protractum*, *Lenzites betulina*, *Phellinus pini*, *Trametes gibbosa*, *T. ochracea*) growing in permafrost conditions in Katanga region (Russian Federation) were investigated using GC-MS. Generally, C18:2ω6 (linoleic acid), C18:1ω9 (oleic acid), C16:0 (palmitic acid) and C20:0 (arachinic acid) were found to be the major FA in fungal species. Data about chemical components of *Daedaleopsis septentrionalis*, *Fomitopsis cajanderi* and *Gloeophyllum protractum* were obtained at the first time. Increased level of degree of FA unsaturation was probably a result of extreme environmental conditions.

Keywords: Wood-decaying basidiomycetes; fatty acids; GC-MS; permafrost conditions.

1. Fungal Sources

Lipids are important constituents of basidiomycetes with special role in growth and development of fungal organism. The fatty acids (FA) are the mandatory components of lipid complex. Previous studies were shown that the environmental factors may influence the lipid content and FA composition in fungi. Extreme growth conditions result into significant changes in metabolism of essential nutritional and reserved substances [1]. There is a little adequate scientific information about the chemical composition of mushrooms growing in such extreme conditions like permafrost.

The territory of origin of basidiomycetes samples collection is the Katanga region which lies within the Central Siberian Plateau. This district has the status of the Far North and Permafrost. The

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climate is continental with the temperature reaching -60 °C in winter (from November to April). Snow falls in September and snowbreak observed in May. The basidiomycete species were collected from the area of Erbogachyon village (Katanga district, Irkutsk region, Russian Federation, 61°31′71″ N, 107°94′75″ E) during the 14th Summer IPPB North Expedition (15.VII.2009–3.VIII.2009). Species names, family names, collection time and herbarium numbers are as follows (sample number): *Bjerkandera adusta* (Willd.) P. Karst., *Meruliaceae,* 28.VII.2009, HIPPB-B-12224 (01); *Daedaleopsis septentrionalis* (P. Karst.) Niemelä., *Polyporaceae,* 21.VII.2009, HIPPB-B-12225 (02); *Dichomitus squalens* (P. Karst.) D.A. Reid, *Polyporaceae,* 27.VII.2009, HIPPB-B-12226 (03); *Inonotus hispidus* (Bull.) P. Karst., *Hymenochaetaceae,* 28.VII.2009, HIPPB-B-12227 (04); *Inonotus radiatus* (Sowerby) P. Karst., *Hymenochaetaceae,* 30.VII.2009, HIPPB-B-12228 (05); *Irpex lacteus* (Fr.) Fr., *Phanerochaetaceae,* 25.VII.2009, HIPPB-B-12229 (06); *Fomitopsis cajanderi* (P. Karst.) Kotl. & Pouzar, *Fomitopsidaceae,* 28.VII.2009, HIPPB-B-12230 (07); *Fomitopsis pinicola* (Sw.) P. Karst., *Fomitopsidaceae,* 26.VII.2009, HIPPB-B-12231 (08); *Fomitopsis rosea* (Alb. & Schwein.) P. Karst., *Fomitopsidaceae,* 26.VII.2009, HIPPB-B-12232 (09); *Gloeophyllum protractum* (Fr.) Imazeki, *Gloeophyllaceae,* 20.VII.2009, HIPPB-B-12233 (10); *Lenzites betulina* (L.) Fr., *Polyporaceae,* 25.VII.2009, HIPPB-B-12234 (11); *Phellinus pini* (Brot.) A. Ames, *Hymenochaetaceae,* 26.VII.2009, HIPPB-B-12235 (12); *Trametes gibbosa* (Pers.) Fr., *Polyporaceae,* 22.VII.2009, HIPPB-B-12236 (13); *Trametes ochracea* (Pers.) Gilb. & Ryvarden, *Polyporaceae,* 26.VII.2009, HIPPB-B-12236 (14). The basidiomycete species were identified by one of the authors (T.A. Penzina) with the aid of the works of [2, 3]. The voucher specimens were deposited at the Herbarium of the Siberian Institute of Plant Physiology and Biochemistry (IRK).

2. Previous Studies

Previous investigations led to isolation of simple phenols [2], halogenated phenols [3], ergosterol [4], alkylitaconic acids and esters, squalene, triglycerides [5], essential oil [6] from *Bjerkandera adusta*, organic acids [7], simple phenols [8], diketopiperazines, nucleosides [9], sesquiterpenes [11] from *Dichomitus squalens*, styrylpyrones, phenolic acids [13] from *Inonotus hispidus*, triterpenes [14] from *I. radiatus*, alkylfuranes, methyl 3-*p*-anisoloxypropionate [15], polysaccharides [16] from *Irpex lacteus*, phenolic acids [17], triterpenes [18], polysaccharides [19], essential oil [20] from *Fomitopsis pinicola*, triterpenes [21] from *F. rosea*, benzoquinones [22], pyranones [23], triterpenes [24], polysaccharides [25] from *Lenzites betulina*, polysaccharides [26], styrylpyrones [27], ceramides [28], simple phenols [29] from *Phellinus pini*, polysaccharides [30] from *Trametes gibbosa* and organic acids [31] from *T. ochracea*. There are no scientific data about chemical components of *Daedaleopsis septentrionalis*, *Fomitopsis cajanderi* and *Gloeophyllum protractum,* as well as data about fatty acid composition of all mentioned basidiomycete species.

3. Present Study

The basidiomycete fruit bodies were dried and stored in the laboratory at 18–20 °C throughout the extraction work. The total lipids extraction of the dried and powdered fruit bodies (5 g) of each fungal species was carried out at 70 °C for 10 h by Soxhlet extractor, using mixture of chloroform and methanol (2:1) as a solvent. The solvent was evaporated by a rotary evaporator to give total lipid fraction. The yields of oil fraction are given in Table 1. The fatty acids in all the lipids were esterified into methyl esters (FAMEs) by saponification with 0.5 N methanolic NaOH and transesterified with 14% BF_3 (v/v) in methanol [32].

The FAMEs were analyzed on an Hewlett Packard 6890N model gas chromatograph, equipped with HP-GC mass selective detector (5973B MSD) and fitted to a HP-Innowax capillary column (30 m×0.25 mm×0.50 μm). The instrumental settings were as follows: initial temperature, 40 °C; initial time, 2 min; rate, 2 °C/min; final temperature, 300 °C, final time, 45 min; injection port, 180 °C; carrier gas, He; flow rate, 25.0 mL/min. The MS detector operated at 150 °C; ionization energy, 70 eV. The scan range, 30 to 700 *m/z* at 1 scan per sec. Solvent delay, 9 min. FAMEs were identified using mass spectral libraries search (Wiley 7th, and NIST-98). Each reported result was given as the average value of three GC analyses.

As a result of present study the data about the fatty acid compositions of 14 basidiomycetes species growing in permafrost conditions were obtained. The oil contents were from 0.45% (*Gloeophyllum protractum*) to 2.10% (*Bjerkandera adusta*). The fatty acid compositions of the investigated fungal species are presented in Table 1.

Table 1. Fatty acid composition and oil yield of fourteen wood-decaying basidiomycete species growing in permafrost conditions. [a,b]

Fatty acids	Species number [c]													
	01	02	03	04	05	06	07	08	09	10	11	12	13	14
C12:0	0.7	0.3	-	0.4	-	0.1	-	0.2	0.1	0.5	0.2	0.1	-	0.9
C14:0	0.8	0.8	0.9	1.5	0.4	0.3	0.6	0.9	0.3	0.8	1.0	0.8	0.3	-
C15:0	0.2	1.0	1.2	6.4	1.4	1.3	3.0	0.8	0.5	0.5	0.8	0.6	1.0	0.5
C16:0	9.4	18.3	26.5	1.8	11.9	17.6	27.1	16.6	15.1	14.0	14.4	19.2	12.3	12.4
C17:0	0.4	0.6	0.5	0.6	0.5	0.8	0.3	0.3	0.3	0.5	0.5	0.5	0.4	0.9
C18:0	11.4	5.7	9.5	1.5	3.3	4.0	5.9	4.6	7.0	6.2	6.3	6.1	3.3	4.5
C20:0	18.2	1.7	0.7	47.9	0.6	0.6	-	18.4	15.0	12.0	8.0	2.4	19.6	14.1
C21:0	-	-	-	1.5	0.4	-	-	-	-	-	-	-	0.3	-
C22:0	3.2	3.1	1.0	0.3	1.6	1.5	-	0.1	5.0	6.1	6.3	4.1	1.3	4.2
C23:0	3.0	2.2	-	0.3	1.0	2.1	-	2.3	1.1	1.0	0.3	2.0	0.4	8.0
C24:0	4.2	3.7	-	0.1	-	-	-	0.9	7.3	5.2	4.0	5.3	-	5.0
C25:0	-	1.9	-	-	-	0.9	-	1.8	1.0	1.0	1.0	1.2	-	3.0
C16:1 ω5	-	-	-	0.3	1.2	-	-	-	-	-	-	-	1.3	-
C16:1 ω7	0.3	0.8	2.6	4.5	1.9	0.6	-	0.5	0.8	0.8	0.9	0.7	1.8	0.2
C18:1 ω7	7.0	1.6	-	-	-	0.6	1.9	4.1	5.4	4.4	2.2	0.3	-	5.3
C18:1 ω9	12.5	14.7	14.7	27.9	39.6	19.3	2.0	12.1	8.1	14.6	18.7	14.4	28.1	14.3
C20:1 ω11	-	-	0.6	1.6	0.5	-	-	-	-	-	-	-	9.3	-
C22:1 ω11	-	-	-	0.2	0.4	0.6	-	-	-	-	-	-	0.5	-
C18:2 ω6	28.2	41.7	41.6	3.2	35.2	47.3	59.1	36.3	33.0	32.2	34.1	41.9	19.7	26.2
ΣSFA	51.5	39.3	40.3	62.3	21.1	29.2	36.9	46.9	52.7	47.8	42.8	42.3	38.9	53.5
ΣUFA	48.0	58.8	59.5	37.7	78.8	68.4	63.0	53.0	47.3	52.0	55.9	57.3	60.7	46.0
Oil yield [d]	2.10	0.85	0.72	1.02	0.98	0.69	0.60	1.50	0.21	0.45	0.98	1.02	0.80	1.40

[a] Percentage of total fatty acids. [b] Average of three analyses. [c] Specified in Fungal Sources Section. [d] g / 100 g of dry fruit body.

Total content of saturated fatty acids (SFA) was from 21.1% (*Inonotus radiatus*) to 62.3% (*I. hispidus*). The predominant SFA components were C16:0 (palmitic acid) and C20:0 (arachinic acid). Total content of unsaturated fatty acids (UFA) was from 37.7% (*Inonotus hispidus*) to 78.8% (*I. radiatus*) and the major compounds were C18:2ω6 (linoleic acid) and C18:1ω9 (oleic acid). The presence of both compounds was detected in all investigated species. Moreover, the C18:2ω6 was the prevailing component of fatty acid complex for 11 species. It is known that the characteristic biochemical feature of the lipid complexes of basidial fungi is the predominance of C18:2 (>20%), C18:1 (>10%) and C16:0 (>10%) [33]. The results suggest that close FA compositions was observed for most investigated species except *Inonotus hispidus* which accumulate SFA (62.3%) and arachinic acid as a dominant (47.9%).

The process of biochemical adaptation of the fungal lipid complex to stress environmental conditions is based on changing of desaturation degree of FA [34]. Usually cold temperature result to increasing of UFA, especially C18-UFA (C18:1ω9, C18:2ω6) as a main markers of cold stress [35]. The maximum UFA contents were observed for *Inonotus radiatus* (78.8%), *Irpex lacteus* (68.4%) and *Fomitopsis cajanderi* (63.0%) that demonstrates their best adaptive capacity. Influence of extreme conditions of growth leads to a number of changes in FA profiles. A prevailing sign is relative domination of unsaturated compounds that is a consequence of an adverse environment. The given assumption is confirmed by such indicators of stress as the degree of unsaturation.

Moreover high content of C18:1ω9, C18:2ω6, C16:0 which are effective inhibitors of saprophytic nematodes [36] allow recommending some of investigated wood-decaying fungal species growing in permafrost conditions as promising repellant and nematicidal agents.

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