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DISTRIBUTION OF DIACYLGLYCERYLTRIMETHYLHOMOSERINE IN SELECTED SPECIES OF VASCULAR PLANTS

NAOKI SATO and MASAKI FURUYA

Department of Biology, Faculty of Science, University of Tokyo, Hongo, Bunkyo-ku, Tokyo, 113, Japan

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Key Word Index—Angiosperm; gymnosperm; pteridophyte; vascular plants; lipid; trimethylhomoserine lipid.

Abstract—Diacylglyceryltrimethylhomoserine was detected in 15 out of 16 species of pteridophytes but in none of four gymnosperm and seven angiosperm species examined. *Psilotum nudum* was the only pteridophyte species examined that did not contain the lipid.

INTRODUCTION

It is known that some lipid components are distributed in a restricted number of taxonomic groups. Galactolipids, sulfonolipid and phosphatidylglycerol are universally found in all the green plants and algae [1, 2]. Arachidonic acid is distributed in pteridophytes, bryophytes and some species of algae [3]. The occurrence of (9,12,15)- and (6,9,12)-linolenic acids in different groups of plants and animals is discussed from the viewpoint of phylogeny [4].

Recently, we found that the fern *Adiantum capillus-veneris* [5] contained a betaine lipid, 1,2-diacylglyceryl-*O*-4′-(*N*,*N*,*N*-trimethyl)-homoserine (DGTS), which was discovered originally in a chrysophyte *Ochromonas danica* [6] and subsequently in chlorophytes, *Chlamydomonas reinhardtii* [7, 8] and some species of *Dunaliella* [9, 10]. Since the occurrence of this lipid has not been reported in other vascular plants, it was interesting to study its distribution not only in pteridophytes but also in seed plants. In this paper, the presence of DGTS was examined in selected species of pteridophytes, gymnosperms and angiosperms.

RESULTS AND DISCUSSION

Table 1 shows the content of DGTS in 16 species of pteridophytes that were chosen from the four major taxonomic groups [11–13]. DGTS was detected in 15 species of pteridophytes. The content of DGTS in terms of g fr. wt varied from 8 in *Ophioglossum thermale* to 956 nmol/g fr wt in *Pteris vittata*. In terms of mg total lipids, the content varied from 1 to 68 nmol/mg of total lipids.

It is interesting to note that DGTS was not detected in *Psilotum nudum*, and that DGTS was not detected in any of the gymnosperm and angiosperm species tested (Table 1).

The present work clearly demonstrates that DGTS is distributed not only in *Adiantum* [5] but also widely in pteridophytes. The only exception was *Psilotum nudum*, which is distinct from the other groups of pteridophytes from the morphological point of view as well [11, 12]. Thus, DGTS is no longer a peculiar lipid that occurs only in some micro-organisms such as a chrysophyte [6], volvocacean chlorophytes [7–10, 14] and a fungus [15]. Rather, this lipid seems likely to be a common component in most of the green plants other than seed plants, although *Psilotum* is an exception.

The lack of DGTS in seed plants and its occurrence in most of the pteridophytes and some green algae indicate that the pteridophytes are more similar to the green algae than to the seed plants as far as this lipid is concerned. This argument is supported by the fact that arachidonic acid is present in pteridophytes and some green algae but absent in seed plants [3].

Although the amount of DGTS was very different in different species of pteridophytes (Table 1), this difference cannot solely be accounted for by the difference of tissues examined, since a previous study [5] indicated that the content of DGTS was similar in pinnae and stipes of *Adiantum*.

Our literature survey indicated that there are, as yet, no reports on the biosynthesis of DGTS. Studies on the pathway of synthesis of DGTS would be necessary to elucidate the enzyme(s) responsible for the presence in pteridophytes and the absence in seed plants of DGTS.

EXPERIMENTAL

Plant material. Aerial shoots of *Selaginella uncinata* and leaves of *Pteris vittata* were obtained from a greenhouse, Department of Biology, University of Tokyo. Aerial shoots of *Equisetum arvense*, and leaves of *Ginkgo biloba*, *Oenothera lamarckiana*, *Taraxacum officinale* and *Commelina communis* were collected in the Campus of University of Tokyo, Hongo. Aerial shoots of *Psilotum nudum*, *Equisetum hiemale* and *Ephedra sinica*, and leaves of *Angiopteris lygodiifolia*, *Osmunda japonica*, *Lygodium japonicum*, *Polypodium formosanum*, *Asplenium unilaterale*, *Salvinia cucullata*, *Cycas siamensis* and *Pinus densiflora* were obtained from the Botanic Garden, University of Tokyo, Koishikawa. Aerial shoots of *Lycopodium clavatum* and leaves of *Botrychium virginianum* and *Dryopteris crassirhizoma* were obtained from the Botanic Garden, University of Tokyo, Nikko. Seeds of *Pisum sativum* cv. Alaska and *Avena sativa* cv. Zenshin were germinated and grown on vermiculite at 25° for 10 days. Those of *Pharbitis nil* cv. Violet were grown in a field, Department of Biology, University of Tokyo. Leaves of *Ophioglossum thermale* var. *nipponicum* were collected in Mt. Gundari, Chiba prefecture, and kindly supplied by Dr. M. Kato, Botanic Garden, University of Tokyo. Leaves of *Spinacia oleracea* were purchased at a local market.

Table 1. Content of diacylglyceryltrimethylhomoserine (DGTS) in selected species of pteridophytes, gymnosperms and angiosperms.

Species	Portion*	Content of DGTS (nmol/g fr wt)	Content of DGTS (nmol/mg TL†)
Pteridophytes			
Psilotopsida			
Psilotum nudum (L.) Griseb.	S	ND	ND‡
Lycopodiopsida			
Lycopodium clavatum L.§	S	620	52
Selaginella uncinata Spring§	S	860	54
Equisetopsida			
Equisetum arvense L.§	S	133	18
Equisetum hiemale L.	S	39	8
Filicopsida			
Ophioglossales			
Ophioglossum thermale Kom. var. *nipponicum* Nishida	L	8	1
Botrychium virginianum Sw.§	L	22	2
Marattiales			
Angiopteris lygodiifolia Ros.	L	37	3
Filicales			
Osmunda japonica Thunb.§	L	408	21
Lygodium japonicum (Thunb.) Sw.§	L	882	30
Adiantum capillus-veneris L.‖	L	406	30
Pteris vittata L.§	L	956	68
Dryopteris crassirhizoma Nakai§	L	104	8
Polypodium formosanum Bak.	L	77	4
Asplenium unilaterale Lam.	L	368	14
Salvinia cucullata Roxb. ex Bory§	L	390	57
Gymnosperms			
Cycas siamensis Miq.	L	ND	ND
Ginkgo biloba L.	L	ND	ND
Pinus densiflora Sieb. et Zucc.	L	ND	ND
Ephedra sinica Stapf	S	ND	ND
Angiosperms			
Oenothera lamarckiana Ser.	L	ND	ND
Pisum sativum L.	L	ND	ND
Spinacia oleracea L.	L	ND	ND
Pharbitis nil Choisy	L	ND	ND
Taraxacum officinale Weber	L	ND	ND
Avena sativa L.	L	ND	ND
Commelina communis L.	L	ND	ND

Each value was obtained from a single analysis.

*S, aerial shoots; L, leaves.

†TL, total lipids.

‡ND; not detected. The detection limit for DGTS was generally 5 nmol/g fr wt or 0.2 nmol/mg TL.

§DGTS was identified by TLC and IR. In the other cases where DGTS was detected, DGTS was identified only by TLC.

‖The values were taken from ref. [5]. In this case, DGTS was identified by TLC, IR, NMR and MS.

Lipid analysis. Total lipids were obtained from plant tissues according to ref. [16]. DGTS was analysed as described previously [5]. Briefly, in a small scale expt, the total lipids were fractionated by two-dimensional TLC. The spot of DGTS was detected by fluorescence after spraying with primuline and coloration with Dragendorff spray reagent. In a large scale expt, DGTS was isolated by CC and TLC. The amount of DGTS was estimated from the amount of fatty acid Me esters that were produced upon methanolysis. The identity of DGTS was confirmed by IR when a sufficient amount of lipid was obtained. Each analytical determination presented was based on a single sample of plant materials. The experimental error due to the analytical procedures was generally less than 10%.

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