Phytochemistry, Vol. 23, No. 8, pp. 1579–1581, 1984.
Printed in Great Britain.

0031–9422/84 $3.00 + 0.00

CHANGES IN LIPID PROFILES IN THE DEVELOPING HAUSTORIUM OF OIL PALM SEEDS

HUN-TEIK KHOR and KHAIK-CHEANG OO

Department of Biochemistry, University of Malaya, Kuala Lumpur, Malaysia

(*Received* 21 *October* 1983)

Key Word Index—*Elaeis guineënsis*; Palmae; oil palm; germinated seeds; haustorium; lipids; fatty acids.

Abstract—Germinated oil palm seeds were placed in special trays in the field and at different intervals the haustoria were harvested. Changes in haustorial lipids were followed until the eighth week after germination. The moisture content decreased while the lipids increased. The haustorial fatty acid profile was similar to that of the palm kernel. Changes in fatty acid composition at different weeks after germination were observed. The major haustorial lipids were triacylglycerols; free fatty acids and diacylglycerols were also present.

INTRODUCTION

The anatomy and morphology of germinated oil palm seeds have been described [1]. During germination, the haustorium develops from the lower portion of the embryo into an organ for mobilising storage materials in the seeds. Changes in haustorial lipids in germinated West African oil palm seeds have been studied by Boatman and Crombie [1]. They used petrol as the lipid extracting solvent which extracted mainly nonpolar lipids from the haustorium. Later Opute [2] repeated part of the above study by using a more exhaustive lipid extraction with chloroform–methanol (2:1), which could extract both polar and nonpolar lipids. However, Opute's study was confined to the lipid profiles of a single stage of the developing haustorium. In the present study, haustorial lipids were extracted with chloroform–methanol and the changes in the lipid profiles of the haustoria of germinated Malaysian oil palm (*Elaeis guineënsis*) seeds were followed during eight weeks of growth in sunlight.

RESULTS AND DISCUSSION

Thirty or more haustoria were pooled and analysed in each group. Each value presented in this paper represents the average of duplicate analysis. The moisture content decreased from 71.9% at the first week to *ca* 60.6% by the third week and thereafter remained at about the same level up to the eighth week. The total extractable lipids, based on dry wt of haustoria, increased steadily for the first three weeks, that is, from 6.2% to 15.6%; levelled off at the fifth week and then increased again to *ca* 20.5% by the eighth week. Boatman and Crombie [1] found that the content of haustorial lipids peaked at *ca* 40 days after planting out and thereafter decreased steadily.

Analysis of the fatty acid (FA) composition of the haustorial lipids indicated that lauric, myristic, palmitic, oleic and linoleic acids were the major FA with lauric acid as the predominant one (Table 1). In this respect, the haustorial fatty acids were similar to those of the palm kernel [1, 3, 4]. However, the haustorial lipids also contained a small percentage (0.9–2.2%) of fatty acids with chain lengths longer than C_{18} (Table 1). This may imply that the haustorium was capable of fatty acid elongation. The lauric acid content reached a maximum at the third week and thereafter declined slowly. The reverse was observed with myristic acid and oleic acid. Palmitic and linoleic acid contents in the haustorium both decreased after the first week. Similar observations were also made by Boatman and Crombie [1] in their study.

Fractionation of the haustorial lipids by acid-treated Florisil column chromatography [5] revealed that most of

Table 1. Changes in the fatty acid profile in the developing haustorium of germinated oil palm seeds

Week after germination	Fatty acids (mol %)											
	8:0	10:0	12:0	14:0	16:0	16:1	18:0	18:1	18:2	20:0	20:1	22:0
1	tr	0.7	19.5	11.3	17.8	0.2	3.6	16.4	28.2	0.4	0.9	0.9
3	1.4	2.1	47.9	8.8	11.8	0.1	4.9	14.4	7.4	0.2	0.2	0.7
5	0.7	2.6	39.2	14.3	10.6	0.1	4.4	16.9	10.2	0.2	0.3	0.4
8	0.4	3.6	22.9	17.3	11.3	0.2	4.7	24.7	13.5	0.4	0.4	0.6

tr, Less than 0.1%.

the haustorial lipids are neutral lipids. Phospholipids and glycolipids were the remaining lipid components (Table 2). No marked change in the proportion of neutral lipids over the period of study was observed. The content of phospholipids decreased by *ca* 50% after the third week. The content of glycolipids, on the other hand, peaked at the fifth week and thereafter decreased. The higher proportion of neutral lipids in comparison to the complex lipids confirm the role of the haustorium as the centre of fuel reserves in the developing seedlings.

TLC of the haustorial neutral lipids showed that the major components were triacylglycerol, diacylglycerol and free FA (Table 3). The proportion of triacylglycerols decreased slowly with a concurrent increase in the proportion of diacylglycerol and FA. These results imply the existence of lipid hydrolysing activity in the developing haustorium. Assay of lipid activity in the haustorium revealed only a very low level of lipase activity [6]. Therefore the occurrence of diacylglycerol and fatty acid in the haustorium could be due to assimilation of the kernel lipids.

The FA profiles of the triacylglycerol, free FA and diacylglycerol were also examined by GC (Table 4). Our results indicate that both short and long chain FA were found in all three classes of neutral lipids. Opute [2], on the other hand, reported that the short chain FA were exclusively located in the diacylglycerol. However, in our study, myristic, palmitic, stearic and oleic acids were found to be present in greater proportions in the FA fraction than in either the triacylglycerols or diacylglycerols, whilst linoleic acid was higher in the triacylglycerol fraction.

Table 2. Percentage distribution of neutral, glyco- and phospho-lipids in total lipids of developing haustorium at various times after germination of oil palm seeds

Week after germination	Neutral lipids	Glycolipids	Phospholipids
1	nd	nd	nd
3	81.8	2.4	15.7
4	84.6	6.7	8.6
8	88.1	2.7	9.1

nd, Not determined.

Table 3. Percentage distribution of different neutral lipids classes in the total lipids of developing haustorium at various times after germination

Week after germination	Lipid classes (% of total lipids)					
	MG	DG	ST	FA	TG	SE
1	nd	nd	nd	nd	nd	nd
3	2.2	16.0	1.3	6.2	49.9	4.0
5	1.4	20.3	1.4	6.9	49.9	4.1
8	1.7	24.7	1.5	8.8	45.8	2.4

nd, Not determined; MG, monoacylglycerol; DG, diacylglycerol; ST, sterol; FA, fatty acid; TG, triacylglycerol; SE, sterol ester.

EXPERIMENTAL

Plant materials. Mature oil palm (*E. guineënsis* cv tenera) seeds, heat-treated and germinated as described in ref. [7], were supplied by Dr. A. C. Soh, Highland Research Unit, Klang, Selangor, Malaysia. Day zero of germination was taken as the emergence of the shoot tip through the germination pore. The germinated seeds were placed in special trays covered with a polyethylene sheet and left in the field. At the first, third, fifth and eighth week after the germinated seeds were placed in the field as described earlier, the seeds were cracked open manually. The haustoria were carefully cleaned to remove contaminating materials from the kernel (endosperm).

Lipid extraction. The haustoria were weighed and extracted with 20 vols of $CHCl_3$–MeOH (2:1) overnight at 4°. The extract was then filtered and the filtrate washed with 0.25 vols of 0.9% NaCl [8]. The lower $CHCl_3$ fraction was concd on a rotary evaporator and small aliquots were further dried under a stream of N_2 to constant wt.

GC. Fatty acid methyl esters (FAME) of the total haustorial

Table 4. Fatty acid profiles of triacylglycerol, diacylglycerol and free fatty acids fractions of haustorium neutral lipids at various times after germination

Week after germination		Fatty acids (mol %)											
		8:0	10:0	12:0	14:0	16:0	16:1	18:0	18:1	18:2	20:0	20:1	22:0
3	TG	0.3	2.4	48.6	12.5	7.6	0.2	3.1	12.4	10.7	0.2	0.8	1.0
	FA	tr	0.2	25.9	49.3	25.5	0.2	12.1	32.4	3.2	0.2	0.1	1.3
	DG	tr	1.4	59.4	13.1	6.7	0.2	3.6	11.9	2.0	0.2	0.1	1.3
5	TG	2.0	4.1	38.3	11.7	11.0	0.3	4.1	16.5	12.8	0.3	0.3	0.3
	FA	tr	0.1	16.1	27.4	16.4	0.1	10.3	26.5	2.1	0.4	0.2	0.3
	DG	3.8	5.5	58.8	9.8	5.5	tr	3.2	10.9	1.6	0.1	0.1	0.4
8	TG	0.1	2.2	44.4	16.0	9.4	0.1	2.9	14.7	9.2	0.1	0.2	0.4
	FA	tr	0.1	10.1	30.3	17.4	tr	9.5	29.0	2.3	0.4	0.2	0.6
	DG	1.4	4.4	61.7	12.3	5.5	tr	3.1	14.5	1.9	0.2	0.1	0.4

tr, Less than 0.1%; other abbreviations as in Table 3.

lipids and individual lipid class were prepared as described in ref. [9] and analysed on a FID instrument using a glass column (2 m × 4 mm) packed with Chromosorb Q coated with 12% EGSS-X. The analyses were carried out isothermally at 170°. FAME were identified by comparing with authentic standards (Supelco). Peak areas were estimated as given in ref. [10] and individual FA are expressed as mole percent of the total FA.

CC. Total haustorial lipids were fractionated into neutral, glyco- and phospholipids on 12 g of HCl-treated Florisil (1.2 cm × 24 cm) [5]. Each lipid fraction was quantified gravimetrically as described earlier. Recoveries from the column were always greater than 97%.

TLC. Neutral lipids obtained after *CC* were separated on silica gel G coated TLC plates using hexane–Et_2O–HCO_2H (80:20:1). Lipids were visualized by exposure to I_2 vapour and quantified by charring with conc. H_2SO_4 [11]. Individual lipid classes were isolated by prep. TLC using the same solvent system but the plates were sprayed with 2,7-dichlorofluorescein and visualized under UV.

Acknowledgement—This work was supported by research grants, Vote F, 61/77 and 89/76 from the University of Malaya. Technical assistance by Mr. K. C. Neoh and the supply of germinated oil palm seeds by Dr. A. C. Soh are greatly appreciated.

REFERENCES

1. Boatman, S. G. and Crombie, W. M. (1958) *J. Exp. Botany* **9**, 52.
2. Opute, F. I. (1975) *Ann. Botany* **39**, 1057.
3. Kritchevsky, D., Tepper, S. A., Bises, G. and Klurfeld, D. M. (1982) *Atherscler.* **41**, 279.
4. PORIM Technology Bulletin, No. 6 (1981), published by The Palm Oil Research Institute of Malaysia, Kuala Lumpur, Malaysia.
5. Khor, H. T. and Tan, H. L. (1981) *J. Sci. Food Agric.* **32**, 399.
6. Oo, K. C. and Stumpf, P. K., *Plant Physiol.* (in press).
7. Turner, P. D. and Gillbank, R. A. (eds) (1974) *Oil Palm Cultivation and Management*, pp. 36. Incorporated Society of Planters, Kuala Lumpur, Malaysia.
8. Folch, J., Lees, M. and Sloane-Stanley, G. H. (1957) *J. Biol. Chem.* **226**, 497.
9. Carroll, K. K. and Khor, H. T. (1971) *Lipids* **6**, 415.
10. Carroll, K. K. (1961) *Nature (London)* **192**, 965.
11. Marsh, J. B. and Weinstein, O. B. (1966) *J. Lipid Res.* **7**, 574.