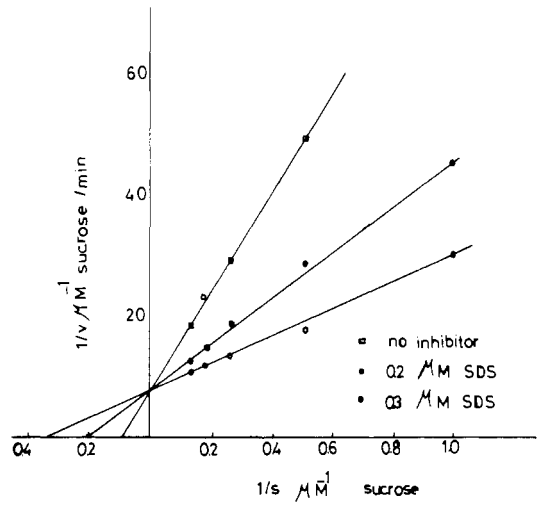

Figure 7. Double-reciprocal plots of velocity against sucrose concentrations in the presence of $NaDodSO_4$ (SDS in the figure) (insoluble invertase).

tryptophan oxygenase (Koike et al., 1969), and asperate transcarbamylase (Colman and Markus, 1972). However, some enzymes were resistant to $NaDodSO_4$ and showed no loss of activity even after 4 h of treatment with high concentrations of (Nelson, 1971).

Webb (1963) proposed an uncompetitive mechanism for the inhibition of enzymic activities by $NaDodSO_4$. Others aslo reported uncompetitive inhibition of acid and neutral invertases from sugar cane (Rosario and Santisopasri, 1977) and bovin liver glutamate dehydrogenase (Rogers and Yusko, 1972) by $NaDodSO_4$. Our data indicate $NaDodSO_4$ acted as a competitive inhibitor for the soluble enzyme and a noncompetitive inhibitor for the insoluble enzyme. In spite of our extensive review of literature we were unable to locate similar competitive inhibition by $NaDodSO_4$ to other enzymes.

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Composition of Lipids in *Dioscorea* Tubers

Lipids extracted from *Dioscorea* tubers were analyzed, and the fatty acid composition of the various lipid types was determined. Total lipid content of the four different species varied from 0.4% to 1.5%, but the percentage composition of the lipid classes was nearly the same. The quantitative composition of these lipids was in general very similar to that in many other nonphotosynthetic plant storage tissues.

The bulky storage tissue of *Dioscorea* species, commonly called yams, is important in human nutrition throughout West Africa. Environmental conditions that influence the yield and storage of this crop have been studied extensively (Coursey, 1967; Onwueme, 1978). However, the gross chemical composition of these tubers has received little attention (Oyenuga, 1968; Kay, 1971). In particular, these reports merely stated the amount of crude fat in the tuber.

With a lipid content of less than 2% of dry weight, the contribution of these tubers to total dietary fat intake may be considered negligible. However, polar lipids are essential part of the tuber tissue membranes where they form a lipoprotein complex responsible for the transport of material and permeability processes involving diffusion and active transport against a prevailing electrochemical gradient (Hitchcock and Nichols, 1971). Tubers with a higher lipid content have recently been shown to be less susceptible to damage following bruising and less susceptible to discoloration (Mondy and Koch, 1978; Klein et al., 1981). Furthermore, fat composition and changes are now included among possible quality factors in food prepared from these tubers (Grosch, 1972). This communication reports on the composition of polar lipid classes in tubers of four *Dioscorea* species. The information will provide

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Table I. Lipid Analysis and Fatty Acid Composition of *D. cayenensis* Lipids[a]

lipid	% by wt	fatty acids, % by wt[b] 14:0	16:0	18:0	18:1	18:2	18:3
total lipid	100	t	31.6	2.0	3.0	54.2	7.1
neutral lipids	61.4	0.7	33.6	1.9	2.7	53.9	4.8
glycolipids							
esterified steryl glycoside	1.5		59.8	2.3	5.5	28.1	3.4
monogalactosyldiaclglycerol	5.4		10.7	2.1	4.5	59.5	23.1
steryl glycoside	2.8						
cerebrosides[c]	4.2	1.2	42.2	1.9	2.7	39.0	6.4
digalactosyldiacylglycerol	3.5		32.2	7.4	2.1	50.6	7.7
trigalactosyldiacylglycerol	1.3	t	58.2	1.5	5.0	29.8	4.0
tetragalactosyldiacylglycerol	1.0	t	60.4	3.2	7.5	24.6	2.4
phospholipids							
phosphatidylglycerol	1.5	1.1	42.2	2.4	8.4	38.4	4.8
phostphatidylethanolamine	2.7	0.7	37.0	2.2	6.9	47.5	5.3
phosphatidylinositol	1.7	t	50.4	1.8	4.2	34.9	6.8
unidentified phospholipid[d]	0.9	0.9	39.0	3.4	5.2	38.5	11.1
phosphatidylserine	0.8	t	45.2	1.9	5.0	39.8	2.5
phosphatidylcholine	5.5	0.8	38.1	1.4	4.4	45.9	8.3

[a] The figures are mean values of three replicate extractions, at harvest. [b] Trace amounts of 15:0, 16:1, and a long-chain fatty acid (possibly 20:0) were also detected. t = trace amounts: <0.5% total fatty acids. [c] May contain hydroxy fatty acids. Significant amounts of a long-chain fatty acid. [d] Tentatively bis(phosphatidic acid).

Table II. Lipid Analysis and Fatty Acid Composition of *D. alata* Lipids[a]

lipid	% by wt	fatty acids, % by wt[b] 14:0	16:0	18:0	18:1	18:2	18:3
total lipid	100	t	34.4	3.2	8.1	48.5	5.7
neutral lipids	43	0.9	37.7	2.1	4.0	47.4	4.9
glycolipids							
esterified steryl glycosides	1.5		79.4	1.8	2.7	12.8	2.2
monogalactosyldiacylglycerol	6.8		12.7	1.2	3.9	49.5	29.9
steryl glycoside	4.7						
cerebrosides[c]	4.6	0.6	45.6	1.7	5.2	41.6	2.7
digalactosyldiacylglycerol	6.2	t	38.6	2.7	3.9	40.5	12.2
trigalactosyldiacylglycerol	0.6	t	62.4	1.3	4.2	25.8	3.6
tetragalactosyldiacylglycerol	0.4	t	68.9	3.5	8.5	17.4	1.6
phospholipids							
phosphatidylglycerol	4.5	0.7	47.0	4.9	5.9	38.0	3.9
phosphatidylethanolamine	6.0	0.6	40.0	2.4	8.8	42.9	5.0
phosphatidylinositol	5.0	1.0	58.0	1.1	2.7	31.2	5.8
unidentified phospholipid[d]	2.8	0.8	31.9	4.5	6.4	46.6	9.1
phosphatidylserine	10.1	1.2	37.2	0.9	5.1	52.1	1.5
phosphatidylcholine	2.5	t	40.6	1.5	4.5	46.8	5.6

[a-d] See footnotes *a-d* of Table I.

a basis for monitoring changes in the tuber lipids during growth, maturation, and storage and the relationship of these changes to the keeping quality of food prepared from these tubers.

MATERIALS AND METHODS

Dioscorea alata, *Dioscorea bulbifera*, *Dioscorea rotundata*, and *Dioscorea cayenesis* tubers were grown by local farmers and were collected immediately after harvest. Healthy, mature tubers were selected and only varieties of unequivocal identity were utilized.

Lipids were extracted from about 500 g of plant material by a modified Folch procedure (Opute and Osagie, 1978). Separation of the lipid classes was achieved by chromatography on a column of silicic acid that was eluted with chloroform (neutral lipids), acetone (glycolipids), and methanol (phospholipids) (Kates, 1975). Each fraction was further separated by thin-layer chromatography (TLC) on silica gel plates with chloroform–methanol–28% ammonia (65:35:5 v/v) for phospholipids and chloroform–methanol–acetic acid–water (170:25:25:4 v/v) for glycolipids. The components were identified by comparison of their mobilities with those of authentic lipid standards (Supelco) and by use of specific staining reagents (Skipiski and Barclay, 1969; Dittmer and Lester, 1964; Christie, 1976). Preparative TLC was used to isolate pure phospholipids and glycolipids. Lipids were eluted from the silica gel with chloroform–methanol (1:1), the eluates were taken to dryness under N_2, and the residues were dissolved in chloroform. Duplicate aliquots were taken for quantification. The different fractions were methylated with 3% H_2SO_4 in methanol plus benzene (Feldman et al., 1962).

The quantity of each glycolipid was estimated by assaying for the sugar moiety with anthrone reagent (Hansen and Møller, 1975) while phospholipids were estimated by assaying for phosphorus (Morrison, 1964). Fatty acid methyl esters from individual lipids separated by TLC were analyzed by gas chromatography on a column of 20% diethylene glycol succinate on HMDS Chromsorb W 80/100 (1.7 m × 4 mm) at 180 °C, using a flame ionization detector. Methyl esters were identified by comparison of retention times to those of authentic standards and were quantified by an Infratronics CRS 309 integrator.

RESULTS AND DISCUSSION

The nature, quantity, and fatty acid composition of the *Dioscorea* tuber lipids are shown in Tables I–IV. The total lipid content on dry weight basis was 0.4% for *D. rotundata*, 0.7% for *D. alata*, 0.8% for *D. cayenesis*, and 1.5% for *D. bulbifera*. The value recorded for *D. bulbifera* is

Table III. Lipid Analysis and Fatty Acid Composition of *D. bulbifera* Lipids[a]

lipid	% by wt	fatty acids, % by wt[b] 14:0	16:0	18:0	18:1	18:2	18:3
total lipid	100	0.4	33.5	t	11.4	42.2	10.0
neutral lipids	51.3	1.0	35.4	t	11.2	42.8	7.6
glycolipids							
esterified steryl glycoside	2.8		57.6	2.5	4.5	27.2	3.5
monogalactosyldiacylglycerol	8.7		19.0	1.0	1.9	35.0	43.2
steryl glycoside	5.2						
cerebrosides[c]	5.6	1.1	32.3	1.2	4.2	42.5	15.2
digalactosyldiacylglycerol	6.6	t	32.1	1.9	4.2	44.2	15.8
trigalactosyldiacylglycerol	2.8	t	60.8	2.1	3.2	28.9	4.0
tetragalactosyldiacylglycerol	1.4		45.1	3.4	7.2	35.2	6.2
phospholipids							
phosphatidylglycerol	1.8	0.9	40.7	4.2	9.7	37.8	4.2
phosphatidylethanolamine	3.1	1.2	36.3	t	10.2	45.2	5.4
phosphatidylinositol	2.0	1.7	60.2	1.2	5.7	24.9	4.8
unidentified phospholipid[d]	1.0	0.6	56.6	3.4	2.7	25.8	6.8
phosphatidylserine	1.0	t	36.9	t	5.0	53.6	1.9
phosphatidylcholine	6.5	0.7	38.7	1.9	5.9	44.6	5.8

[a-d] See footnotes *a-d* of Table I.

Table IV. Lipid Analysis and Fatty Acid Composition of *D. rotundata* Lipids[a]

lipid	% by wt	fatty acids, % by wt[b] 14:0	16:0	18:0	18:1	18:2	18:3
total lipid	100	t	31.2	1.9	3.5	47.5	13.8
neutral lipids	62	t	31.8	1.9	3.7	47.7	13.0
glycolipids							
esterified steryl glycoside	2.1		61.9	4.1	3.2	20.8	5.4
monogalactosyldiacylglycerol	7.3		7.4	0.7	1.8	34.6	55.2
steryl glycoside	5.4						
cerebrosides[c]	6.5	1.1	26.0	2.0	4.6	57.7	3.9
digalactosyldiacylglycerol	4.9		38.1	3.3	3.2	37.5	16.9
trigalactosyldiacylglycerol	1.8	t	63.2	2.5	4.0	21.6	2.4
tetragalactosyldiacylglycerol	1.5	t	45.0	1.4	2.7	41.7	7.8
phospholipids							
phosphatidylglycerol	1.0	1.3	24.3	9.0	7.7	44.7	1.2
phosphatidylethanolamine	1.7	1.6	40.9	t	1.4	49.3	4.6
phosphatidylinositol	1.1	1.1	24.6	1.0	3.5	61.1	5.0
unidentified phospholipid[d]	0.6	0.6	49.3	t	t	49.5	
phosphatidylserine	0.5	1.0	45.9	0.7	1.9	40.5	t
phosphatidylcholine	3.5	t	28.7	1.8	3.9	58.1	5.9

[a-d] See footnotes *a-d* of Table I.

relatively higher than those for the other three. It is not clear whether this is related to the fact that *D. bulbifera* tuber is aerial while the others are underground. Although the lipid contents for other storage organs are equally low, the proportions of polar to nonpolar lipids are generally lower than those previously found in other tubers of temperate habitat (Nichols and James, 1964; Lepage, 1968; Galliard, 1968; Opute and Osagie, 1978).

TLC analysis showed that triacylglycerol was the major component of the neutral lipid fraction. Results also showed that monogalactosyldiacylglycerol and digalactosyldiacylglycerol were the two major glycolipids. The presence of trigalactosyldiacylglycerol and tetragalactosyldiacylglycerol is notable. These glycolipids seem to be accumulated in significant amounts in these carbohydrate-rich storage organs (Galliard, 1969; Opute and Osagie, 1978). Phosphatidylcholine and phosphatidylethanolamine were the major phospholipids.

Palmitic acid (16:0) and linoleic acid (18:2) were the predominant fatty acids. The glycolipids exhibited a relatively high proportion of linolenic acid (18:3). The yams are usually boiled and made into soft dough, and large quantities are eaten by West Africans. Since the diet is virtually carbohydrate based, the amount of essential fatty acid supplied from yam sources may be critical (Sonderhjelm et al., 1971). Similarly the fatty acids contribute to the flavor and aroma in foods prepared from these tubers as a result of lipoxygenase action (Galliard, 1975; Nwanze, 1982).

The lipid composition in *Dioscorea* tubers appears in general very similar to that in many nonphotosynthetic plant storage tissues containing little fat such as sugar beet (Beiss, 1969), sweet potato (Walter et al., 1971), the Irish potato (Galliard, 1968), and *Alocasia macrorrhiza* tubers (Opute and Osagie, 1978). No major qualitative differences between the different *Dioscorea* species have been found.

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