Lipid, Fatty Acid, Amino Acid, and Mineral Compositions of Five Edible Plant Leaves

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The moisture, lipids, fatty acids, proteins, amino acids, ash, and minerals (Ca, Mg, Fe, Zn, and Cu) of edible plant leaves of *Hibiscus manihot*, *Ipomoea aquatica*, *Brassica juncea*, *Cucurbita maxima*, and *Sechium edule* were determined. The leaves of *H. manihot*, *I. aquatica* *B. juncea*, *C. maxima*, and *S. edule* contained (as-is basis) 1.77, 2.09, 1.75, 1.27, and 2.32% lipids, 2.20, 3.64, 4.58, 2.83, and 2.69% proteins, and 1.61, 1.53, 1.82, 1.0 and 2.16% ash, respectively. Lipid classes were separated by silicic acid column chromatography and quantified. Among the constituent fatty acids, determined by gas–liquid chromatography, the major ones were linolenic (18:3) and palmitic (16:0) acids. Amino acid analysis showed that the proteins contained nutritionally useful quantities of most of the essential amino acids except for those containing sulfur. The mineral contents were appreciable.

INTRODUCTION

Hisbiscus manihot Linn. syn. *Abelmoschus manihot* (L.) Medik of Malvaceae, *Ipomoea aquatica* Forsk of Convolvulaceae, *Brassica juncea* (L.) Czern & Cass of Cruciferae, *Cucurbita maxima* Duch. of Cucurbitaceae, and *Sechium edule* Jacaq. of Cucurbitaceae are widely cultivated plants. The leaves of these plants are used in culinary preparation by Papua New Guineans and are considered of economic and nutritional importance. This paper reports the lipid, fatty acid, protein, amino acid, ash, and mineral compositions of the leaves.

MATERIALS AND METHODS

Materials. Young fresh plants normally used in culinary preparations were purchased in a local vegetable market. The leaves were separated, pooled to form composite samples, and processed immediately.

Methods. Standard methods were used to determine moisture, protein, and ash contents (AOCS, 1973). The experimental procedures for extraction of total lipids with chloroform–methanol and their purification and separation into nonpolar lipids, glycolipids, and phospholipids by silicic acid column chromatography were described in detail (Lakshminarayana et al., 1984). The lipid classes were quantified by gravimetry. Acyl lipids were converted into fatty acid methyl esters (Luddy et al., 1960) and analyzed by using a Hewlett-Packard 5890 A gas chromatograph fitted with a flame ionization detector and a data processor. Helium was used as a carrier gas, and the column, injection port, and detector were maintained at 200, 220, and 240 °C, respectively. A polar (BP-20) capillary column (12.0 m × 0.25 mm, SGE Scientific; Melbourne, Australia) was used to separate the esters. The peaks were identified by comparison with standard fatty acid methyl esters.

The amino acid analysis procedure was described in detail in an earlier paper (Sundar Rao et al., 1989). Samples were ashed and analyzed for component minerals by the AOAC method (AOAC, 1975) using a Varian Model AA-175 atomic absorption spectrophotometer.

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Table I. Compositions of Edible Plant Leaves

plant name	moisture,[b] %	lipid,[a,b] %	protein,[a,b] %	ash,[a,b] %
H. manihot	88.4	1.77	2.20	1.61
I. aquatica	86.6	2.09	3.64	1.53
C. maxima	85.9	1.75	4.58	1.82
B. juncea	90.8	1.27	2.83	1.0
S. edule	82.3	2.32	2.69	2.16

[a] Moisture basis. [b] Expressed as mean of duplicated values.

Table II. Lipid Class Compositions (Weight Percent) of Edible Plant Leaves[a]

plant name	nonpolar lipids	glycolipids	phospholipids
H. manihot	38.9	31.1	30.0
I. aquatica	34.2	37.9	27.9
C. maxima	45.1	24.4	30.5
B. juncea	30.6	25.4	44.0
S. edule	40.2	30.8	29.0

[a] Overall recovery of total lipids after column chromatography was 92.5–90.0%.

RESULTS AND DISCUSSION

The moisture, lipid, protein, and ash contents are presented in Table I. The moisture content in different vegetables ranged between 82.3 and 90.8%, while ash content ranged between 1.53 and 2.16%. The lipid and protein contents were appreciable, compared with those of other green leafy vegetables. The lipids were quantitatively fractionated into nonpolar lipids, glycolipids, and phospholipids by column chromatography. The lipid class compositions are shown in Table II. The leaves contained significant quantities of nonpolar lipids as do the leaves of *Peucedanum graveolens*, *Mentha arvensis*, *Colocasia esculenta* (Sundar Rao and Lakshminarayana, 1988), spinach, barley (Zill and Harmon, 1962), and red clover (Weenink, 1962). The glycolipid and phospholipid contents ranged from 24.4 to 37.9% and from 27.9 to 44.0%, respectively. *B. juncea* contained the highest phospholipid content.

The fatty acid compositions are shown in Table III. The predominant fatty acids of leaves in general were linolenic, linoleic, and palmitic (Hitchcock and Nichols, 1971; Sundar Rao and Lakshminarayana, 1988) and were found to be present in varying proportions among different lipid

0021-8561/90/1438-2137$02.50/0

Table III. Fatty Acid Composition of Lipid Classes of Edible Plant Leaves

		fatty acid,[a] area %												
plant name	lipid class	12:0	14:0	16:0	16:1	16:2	16:3	18:0	18:1	18:2	18:3	20:0	22:0	others
H. manihot	nonpolar lipids	10.3	3.0	38.0	0.3	0.2	0.3	9.2	5.0	18.1	14.7	0.5	0.3	0.0
	glycolipids	1.4	0.9	8.4	0.0	0.0	0.6	0.9	1.2	12.2	74.1	0.0	0.3	0.0
	phospholipids	0.0	0.5	28.0	0.2	0.3	0.0	1.7	5.2	24.3	39.3	0.2	0.1	0.2
I. aquatica	nonpolar lipids	0.0	1.1	19.4	0.1	0.0	0.0	3.4	2.8	14.2	57.5	1.0	0.1	0.4
	glycolipids	0.0	0.0	13.6	0.0	0.0	0.0	1.7	2.6	4.1	78.0	0.0	0.0	0.0
	phospholipids	0.0	1.0	13.9	0.1	0.0	0.2	0.8	2.0	6.0	73.3	1.8	0.5	0.4
C. maxima	nonpolar lipids	0.0	1.6	19.8	0.1	0.1	0.4	2.8	3.0	9.0	62.7	0.3	0.2	0.0
	glycolipids	0.0	1.2	24.5	3.2	0.0	0.0	2.4	1.8	10.6	56.3	0.0	0.0	0.0
	phospholipids	0.0	0.0	17.4	0.8	0.0	0.0	1.8	2.3	12.1	63.4	2.2	0.0	0.0
B. juncea	nonpolar lipids	2.2	0.1	4.4	0.9	0.0	0.0	31.4	0.5	4.4	55.6	0.1	0.3	0.1
	glycolipids	0.0	1.1	19.3	0.6	0.0	0.0	14.6	3.0	7.9	53.4	0.1	0.0	0.0
	phospolipids	0.0	2.0	24.4	0.0	0.0	0.0	3.5	3.2	10.2	54.3	0.3	0.0	2.1
S. edule	nonpolar lipids	0.0	0.0	38.5	0.2	0.3	0.6	3.2	1.8	11.2	43.7	0.5	0.0	0.0
	glycolipids	0.0	0.5	13.7	0.0	0.0	0.0	1.4	1.7	5.7	76.7	0.2	0.1	0.0
	phospholipids	0.0	0.0	33.8	1.9	0.3	0.0	3.0	3.1	15.3	42.1	0.5	0.0	0.0

[a] Duplicate values for methyl esters in standard mixtures by GLC analysis varied within 10% for minor components (<5%) and within 3% for others.

Table IV. Amino Acid Composition (Mole Percent) of Proteins in Edible Plant Leaves

amino acid	sample name				
	H. manihot	*I. aquatica*	*C. maxima*	*B. juncea*	*S. edule*
CySO$_3$H	0.61	0.0	0.0	0.13	0.51
Asp	11.12	10.0	13.13	10.82	9.90
Thr	3.02	2.64	2.40	2.51	2.78
Ser	1.35	0.88	1.28	1.10	1.03
Glu	11.83	11.70	12.26	11.50	12.15
Pro	6.05	6.30	5.56	6.15	6.00
Gly	10.86	11.24	10.73	11.26	11.01
Ala	10.22	10.98	9.78	9.88	11.36
Val	8.00	8.47	8.10	8.43	8.34
$^1/_2$Cys	0.0	0.0	0.22	0.08	0.0
Met	0.66	0.59	0.50	0.58	0.60
Ile	5.60	5.74	5.65	5.86	5.25
Leu	10.19	10.67	9.57	10.23	9.89
Tyr	2.63	2.83	2.28	2.35	2.61
Phe	5.26	5.28	4.66	5.04	5.10
Lys	5.64	5.78	6.54	6.65	5.93
His	2.03	2.00	2.17	2.32	2.20
Asp	0.90	0.55	0.50	0.78	1.24
Arg	4.03	4.35	4.58	4.33	4.10

Table V. Mineral Composition of Edible Plant Leaves (Milligrams per 100 g)[a]

sample name	minerals[b]				
	Ca	Mg	Fe	Zn	Cu
H. manihot	72.45	56.42	3.32	1.25	0.25
I. aquatica	27.56	51.07	4.43	1.23	0.26
C. maxima	36.38	38.80	2.04	0.76	0.42
B. juncea	51.18	35.31	1.59	0.56	0.13
S. edule	59.19	67.01	4.63	1.29	0.18

[a] Fresh weight basis. [b] Expressed as mean of duplicated values.

classes of leaves of the five plants. Linolenic acid was predominant (39.3–78.0%) in all lipid classes except in nonpolar lipids of *H. manihot*, in which palmitic acid (38.9%) was the major component.

The amino acid composition values are summarized in Table IV. The leaves of all of the samples contained adequate quantities of most of the essential amino acids. Compared with the WHO recommended pattern for an ideal dietary protein (WHO, 1973), the five plant leaves are good sources of most essential amino acids with the exception of cystine and methionine. The values obtained for cystine and methionine are perhaps lower than the actual content since a small proportion of these acids could have been oxidized during acid hydrolysis and not shown in the chromatographic analysis. Except for cystine and methionine, all the leaves contain appreciable concentrations of essential amino acids compared to conventional food crops such as soybeans or whole egg, indicating their potential for future utilization as feed supplements.

The composition of mineral elements is listed in Table V. Copper availability was low, calcium and magnesium showed high availability, and iron and zinc were moderately available. The levels of trace minerals, in particular copper, would appear to be low in leafy vegetables. One of the major factors influencing trace mineral uptake in plants is the composition of the soil (Nielson, 1980). The contents of calcium, magnesium, iron, zinc, and copper showed that these leaves were an excellent source of bioelements. Further work is needed on the vitamin content, the quality of carbohydrates, and the availability of dietary fiber as these leafy vegetables occupy an important position in the diets of many persons in developing countries.

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Received for review March 2, 1990. Revised manuscript received May 29, 1990. Accepted June 12, 1990.

Registry No. Ca, 7440-70-2; Mg, 7439-95-4; Fe, 7439-89-6; Zn, 7440-66-6; Cu, 7440-50-8; linolenic acid, 463-40-1; palmitic acid, 57-10-3.