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Chemical composition of *Lepidium meyenii*

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Lepidium meyenii Walpers, a tuber of Andine origin still cultivated in Peru for local preparation, was studied. The carbohydrate, lipid, protein, fibre and also the amino-acid, fatty acid, mineral and sterol fractions were determined. The results show that the tuber is nutritionally interesting. Alkaloid-like compounds were also found. It is concluded that this tuber can be a food source in countries, where economic and technological conditions are inadequate to combat malnutrition.

INTRODUCTION

This investigation was initiated to evaluate the composition of 'maca' (*Lepidium meyenii*), a crucifera. The tuber of this plant, common in the Andine diet, is not used by old world agriculture, unlike other South American crops such as potatoes (*Solanum tuberosum*), tomatoes (*Lycopersicum esculentum*) and maize (*Zea mais*). It is the purpose of this paper to assess the nutritional value of a food—produced in a part of the world that is lacking in technological resources and has unfavourable climatic and agronomic conditions—which is an inexpensive alimentary resource and also can be nutritionally effective in combating malnutrition.

To our knowledge there are no data available in literature about the chemical composition of maca. This paper deals with the relative amounts of carbohydrates, lipids and proteins and also the amino acid, fatty acid and sterol composition of the maca tuber to establish its potential as a food. The plant is used by the Andine people boiled or roasted as a food and also in ethnological medicine as an antidepressive and injury cicatrizing drug. We also assayed the tuber for alkaloid-like compounds to relate these to taste and pharmacological properties. Other studies on the composition of maca are in progress.

MATERIALS AND METHODS

The dried samples, analysed in triplicate (results later reported as means), were supplied by Ce Pe Ser (Central Peruviane de Servicios) collected in Ayakawa, Peru in 1990. A voucher specimen is deposited in the Herbario de Museo de Historia Natural 'J. Prado' Un. H. S. Lima (Peru).

Moisture content was determined by slicing and powdering the tubers in a blender and drying them in an oven at 130°C to constant weight by the AOAC 925.10 method (AOAC, 1990). Fat was determined by weighing the dichloromethane extracts. The nitrogen content was established in a Kjeldahl apparatus, following the 920·87 AOAC method; the factor N × 6·25 was used to convert nitrogen into crude protein. Amino acid contents were determined after hydrolysis with 6N HCl for 4 h at 145°C in vacuum hydrolysis tubes from Pierce (Product N. 29560) (Gehrke *et al.*, 1985).

The analyses were done by reverse-phase HPLC using a system of Hewlett-Packard HP 1050 series modules with quaternary pump, an autosampler provided with injector programme, a variable wavelength detector, an HP 3396A integrator and a Spherisorb ODS-2, 5 μm 250 mm × 4 mm column. The derivatization procedure was automated, withdrawing from different vials suitable amounts of sample and reagents OPA from Sigma (50 mg) in CH_3OH (1 ml), FMOC from Aldrich and buffer, mixing for a minute and injecting into the column (Schuster, 1988). The eluents were MeOH(A) and a 50 mM AcONa solution (B) (flow rate 1·0ml/min; Gradients: 18–23% A (10 min linear); 23–27·2% A (12 min linear) held at 27·2% A for 4 min; 27·2–50% A (12 min linear), held at 50% A for 10 min: 50–80% A (10 min linear), held at 80% A for 10 min).

Fatty acids were analysed as methyl esters after hydrolysis in 2N KOH by using a Hewlett-Packard 5890 apparatus and an HP-5 column, a gas chromatograph fitted with an HP 5970B mass detector (helium was used as a carrier gas, flow 6·845 kPa (10 psi) and

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Table 1. Analytical composition of maca and other edible tubers.[a]

	Maca	Potato	Carrot
Water(%)	10·4		
Proteins(%)	10·2	1·9	8·8
Lipids(%)	2·2	2·5	1·7
Hydrolyzable carbohydrates(%)	59·0	61·4	79·8
Whole fibre(%)	8·5	1·8	8·8
Ash(%)	4·9		

[a] The composition of maca refers to an air-dried tuber; the composition of other tubers are from Documenta Geigy (1963), calculated on a dry matter basis.

an HP 59970 MS Chemstation. Conditions here as in Table 3. (see later).

Sterols were examined after purification on a silica-gel column (eluent: CH_2Cl_2) of the insaponifiable matter by gas chromatography using the same apparatus as the methyl ester; conditions as in Table 4 (see later).

Mineral ions were examined using a Varian AA-475 flame photometer and a Varian AA-475 atomic adsorption spectrophotometer.

Starch and hydrolysable carbohydrates were examined by the AOAC 948.02 method (AOAC, 1990).

Ash was determined by the AOAC 923.03 method (AOAC, 1990), and the crude fiber content by the Bellucci method (Bellucci, 1932): 3 g of powder were boiled for 25 min with 50 ml of AcOH (80%) and conc. HNO_3 (45/5, v/v), filtered and, after a wash with boiling water (10 ml), ethanol (20 ml), ethyl ether (20) and boiling water to neutralize, the precipitate was dried in an oven for 3 h at 105°C, weighed, burned on flame in a crucible and re-weighed.

Table 2. Amino acid composition of maca.

R_t	Aminoacid	(mg concentration/ g protein)	Essential amino acid pattern (FAO-WHO, 1973)	Chemical index
2·83	Aspartic acid[a]	91·7	—	—
3·98	Glutamic acid[a]	156·5	—	—
9·81	Serine[a]	50·4	—	—
14·16	Histidine[a]	21·9	—	—
15·10	Glycine[a]	68·3	—	—
15·58	Threonine[a]	33·1	40	83
	Cystine	nd		
24·51	Alanine[a]	63·1	—	—
22·45	Arginine[a]	99·4		
25·05	Tyrosine[a]	30·6		
37·82	Phenylalanine[a]	55·3	>85·9 60	143
31·16	Valine[a]	79·3	50	158
30·80	Methionine[a]	28	35	80[c]
35·79	Isoleucine[a]	47·4	40	118
37·95	Leucine[a]	91	70	130
46·89	Lysine[a]	54·5	55	99
	Tryptophan	nd[d]	10	—
33·78	HO-Proline[b]	26		
42·92	Proline[b]	0·5		
44·80	Sarcosine[b]	0·7		

[a] As OPA derivatives—detector: Ultraviolet radiation at λ=340 nm.
[b] As FMOC derivatives—detector: Ultraviolet radiation at λ=270 nm.
[c] Chemical score: as in materials and methods.
[d] nd, not determined.

The alkaloid-like compounds were detected by TLC chromatography: a specimen, from the extraction of a tuber powder sample with CH_2Cl_2 in alkaline conditions, after chromatography shows three yellow-orange spots obtained by spraying with Dragendorff reagent on a TLC silica-gel plate (Merck 60 F-254, 5 × 10 cm^2; eluent: CH_2Cl_2:MeOH: conc. NH_4OH 9 : 0·9 : 0·1).

RESULTS AND DISCUSSION

The maca tuber, the edible part of the plant, is nutritionally very interesting in comparison with other roots such as potatoes, carrots (*Daucus carota*) and turnips (*Brassica campestris*).

Due to its high water content (>80%), these parts of plants generally display a very low energy and nutritional density. In the maca tuber, dried and preserved, the other nutritional constituents resemble those of other plants such as seeds and cereals (corn, maize and rice).

The carbohydrates constitute 59%, the lipids 2·2% and the proteins 10·2%. The composition of major nutrients appears very advantageous by comparison of the dry matter with the potato (Table 1), containing about 80% of water and a minor percentage of protein and lipids. Very interesting also is the content (8·5%) of fibre, the compositional and structural examination of which are to be further investigated.

Table 3. Fatty acids as methyl ester derivatives, present in *L. meyenii*.

Fatty acids	Percent of methyl ester mixture	Retention time (min)
$C_{12:0}$ dodecanoic (lauric)	0·8	17·4
$C_{13:1}$ 7-tridecenoic	0·3	18·3
$C_{13:0}$ tridecanoic	0·1	18·6
$C_{14:0}$ tetradecanoic (myristic)	1·4	19·9
$C_{15:1}$ 7-pentadecenoic	0·5	20·8
$C_{15:0}$ pentadecanoic	1·1	21·1
$C_{16:1}$ 9-esadecenoic (palmitoleic)	2·7	22·0
$C_{16:0}$ esadecanoic (palmitic)	23·8	22·4
$C_{17:1}$ 9-heptadecenoic	1·5	23·2
$C_{17:0}$ heptadecanoic	1·8	23·5
$C_{18:2}$ 9, 12-octadecadienoic (linoleic)	32·6	24·8
$C_{18:1}$ 9-octadecenoic (oleic)	11·1	24·8
$C_{18:0}$ octadecanoic (stearic)	6·7	25·1
$C_{19:1}$ 11-nonadecenoic	1·3	26·1
$C_{19:0}$ nonadecanoic	0·4	26·2
$C_{20:1}$ 15-eicosenoic	2·3	26·5
$C_{20:0}$ eicosanoic (arachidic)	1·6	27·1
$C_{22:0}$ docosanoic (behenic)	2·0	29·1
$C_{24:1}$ 15-tetracosenoic (nervonic)	0·4	31·2
$C_{24:0}$ tetracosanoic (lignoceric)	0·4	31·5
Fatty acids: saturated (%) 40·1		
unsaturated (%) 52·7		
Saturated/unsaturated ratio 0·76		

Column HP-5; 25 m × 0·2 mm; i.d., 0·33 μm film; temperature 180°C for 3 min, then to 290°C at 6°C/min; injection temperature, 290°C; transfer line temperature 290°C; carrier gas He (6·845 kPa (10 psi)).

The compounds were characterized by comparison with retention times of a reference mixture and the MS-spectra.

Table 4. Sterols as steryl acetate derivatives, present in *Lepidium meyenii*

Sterol	Percent of sterol mixture	Retention time (min)
Brassicasteryl acetate	9·1	22·4
Ergosteryl acetate	13·6	23·8
Campesteryl acetate	27·3	25·0
$\Delta^{7,22}$-Ergostadienyl acetate	4·5	27·5
Sitosteryl acetate	45·5	29·5

Column: HP-5, 25m × 0·2 mm; i.d., 0·33 μm film; temperature, 290°C; injection temperature, 290°C; transfer line temperature, 290°C; carrier gas, He (6·845 kPa (10 psi)).

The amino acid composition (Table 2) shows an excellent profile, confirmed by the high content in essential amino acids when compared with potatoes and carrots (Documenta Geigy, 1963).

The fat density is higher than that found in other roots. Moreover, the fatty acids fraction (Table 3) after alkaline hydrolysis, with the presence of linoleic acid (32·6%) as the main component followed by palmitic (23·8%) and oleic acid (11·1%), shows a good composition in unsaturated compounds.

The sterol fraction (Table 4), which is very useful in characterising the source of vegetable oils, shows sitosterol (45·5%) as the main component, followed by campesterol (27·3%), ergosterol (13·6), brassicasterol (9·1%) and $\Delta^{7,22}$-ergostadienol (4·5%) (Table 4). Also the mineral fraction appears interesting for its content of Fe, Ca and Cu (Table 5). The presence of minor components such as alkaloids are important because of their influence on taste and may justify the use of this plant in Andine medicine. More studies on the isolation and characterization of this fraction are in progress.

Table 5. Mineral composition of *Lepidium meyenii* (mg/100 g dry matter)

	Maca	Potato	Carrot
Fe	16·6	3·6	7·4
Mn	0·8	0·8	2·0
Cu	5·9	0·7	0·9
Zn	3·8	—	—
Na	18·7	3·6	387
K	2 050	1 850	2 504
Ca	150	63	330

The composition of maca refers to the air-dried tuber; the composition of other tubers are from Documenta Geigy (1963), calculated on a dry matter basis.

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REFERENCES

AOAC (1990). *Official Methods of Analysis*, 15th edn. *Association of Official Analytical Chemists*, Washington, DC.

Bellucci, C. (1932). La determinazione della cellulosa nelle farine di frumento e dei sottoprodotti. *Ann. Chim. Appl.*, **22**, 25.

Documenta Geigy (1963). *Tables Scientifiques* 16th edn. Dep. Pharmaceutique Basel, Switzerland, pp. 515–20.

Gehrke, C. W., Wall, L. L., Sr, Absheer, J. S., Kaiser, E. F. & Zumwalt, R. W. (1985). Sample preparation for chromatography of aminoacids; acid hydrolysis of proteins. *J. Assoc. Off. Anal. Chem.*, **68**(5), 811–21.

Schuster, R. (1988). Determination of aminoacids in biological, pharmaceuticals, plant and food samples by automated precolumn derivatization and high performance liquid chromatography. *J. Chromatography*, **431**, 27.