ORIGINAL ARTICLE

Chemical Characterization and Nutritional Evaluation of Mountain's yam (*Dioscorea remotiflora* Kunth) Tubers

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ABSTRACT

The objective of this study was to provide information on the chemical composition and nutritional value of the mountain's yam (Dioscorea remotiflora Kunth) tubers and compare this with other national popular consumer tubers like potato (Solanum tuberosum) and the sweet potato (Ipomoea batatas). Mountain's yam tubers provide 21.82 ± 0.4 % dry matter which is integrated by $8.75\pm0.1\%$ protein, $2.15\pm0.09\%$ lipids, $3.91\pm0.04\%$ ashes, $5.59\pm0.09\%$ crude fiber, and 79.60±0.9% carbohydrates; are also a good source of minerals, especially potassium, iron and phosphorus; although its fatty acid content is very poor. Its calorie intake is 81.35 ± 1.06 Kcal/100g_{WB}, similar to having potato tubers. Comparatively, in the mountain's yam tubers oily extract excels its content of palmitoleic acid (380.4 mg/100 g_{DB}), oleic acid (637.3 mg/100 g_{DB}), α -linolenic acid (261.2 mg/100 g_{DB}) and lignoseric acid (105.4 mg/100 g_{DB}), while in sweet potato oily extract excels its content of palmitic acid (400 mg/100 g_{DB}) and octadecanoic acid (220 mg/100 g_{DB}). The content of each one of the fatty acids quantified were less in potato tubers oily extract than on the other. The proteins of the mountain's yam tubers are rich in aspartic acid, glutamic acid, arginine and leucine; its content in mg/100 g tuber in wet basis was: 266 ± 4.0 , 305 ± 4.3 , 185 ± 4.5 , 158 ± 3.2 , respectively. These result suggested that the mountain's yam tubers can be used as a good alternative source of food to alleviate hunger and malnutrition that affects a large part of the population living in rural areas of Mexico.

Key words: Nutritional value, ñame, mountain's yam, Dioscorea remotiflora Kunth

Received 13/02/2014 Accepted 19/05/2014

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How to cite this article:

José L M S., José V G, Aurea B N, Leopoldo G C, Jorge Y F. Chemical Characterization and Nutritional Evaluation of Mountain's yam (*Dioscorea remotiflora* Kunth) Tubers . Adv. Biores., Vol 5 [2] June 2014: 153-160. DOI: 10.15515/abr.0976-4585.5.2.153160

INTRODUCTION

Millions of people worldwide are fed daily with tubers produced by certain plants, because they provide the necessary nutrients for the body, being the starch its main constituent [1, 2]. In spite of the wide variety of tubers grown in all the world, only five species account for 99% of total world production, between them we have: potato (*Solanum tuberosum*, 46%), yucca (*Manihot esculenta*, 28%), sweet potato (*Ipomea batatas*, 18%), ñame (*Dioscorea spp.* 6%) and taro (*Colocassia, Cytosperma, Xanthosoma* spp., 1%) [3].

In several countries it is known as "ñame" to edible tubers produced by plants Dioscoreaceae family, which integrates about 650 species, of which at least 40 of them are grown worldwide, among them are: *Discorea batatas* or chinese ñame, *Discorea cayenensis* or yellow ñame which is native to Africa, *Discorea rotundata* or white ñame and *Discorea alata* or great yam, which is native from Southeast Asia. In the 2012, the ñame global production was 57.3 million tonnes, 96% of which were obtained in Africa, mainly in Nigeria, Ghana and Ivory Coast; where per capita ñame consumption stands around 65 kg per year [4];

The remaining 4% is produced in some countries of Latin America among them Brazil, Costa Rica, Colombia and Panama; and in some countries of Asia (India, the Philippines and Japan) and Oceania [5]. The ñame tubers are the main source of food, employment and income of small and medium producers in rural areas have a high caloric content, are rich in potassium and phosphorus and they have a taste like sweet potato [6]. The main uses of ñames have been as cooked vegetable for human consumption, in making flour for preparing porridges, purees, soups or pasta, but is also being used in the development of a substitute for chips and French-fries, so as to obtain alkaloid or steroid sapogenins; compounds from which anti-inflammatory drugs, and oral contraceptives are produced [7].

In the western area of Mexico two species of Dioscorea are collected, they are: *Dioscorea remotiflora* Kunth [8] and *Dioscorea sparsiflora* [9], whose tubers are called "mountain's yam" and they are prized as food by the inhabitants of the region, who consume it as cooked vegetable. Its collection and marketing is done during the months of September to May, giving employment to rural families who supplement their income with this activity [8]. Depending on the Mexico region, this resource has many names; in the states of Colima, Jalisco, Nayarit and Michoacán is known as "hualacamote" or "mountain's yam", in Oaxaca is known as "ñame" or "iguana's tail", in Guerrero it is known as "tlacocamote" and in all the country it is known with different regional names [10].

The "mountain's yam" (*Dioscorea remotiflora* Kunth) is a climbing plant with heart shaped leaves and seeds in axillary racemes, it is present in the dry tropical deciduous forests (Figure 1), the tubers are collected and consumed either as entree or mixed with other vegetables and usually after to be cooking, in several parts of rural areas from México. The collected of the mountain's yam tubers has been intensified as a response to its increased demand, so it is becoming less common to find wild populations of this natural resource, because the mountain's yam tubers are extracted from the soil without replenishing the material for its preservation [11].

These wild tubers hold an important place in the diets of local people, especially people living in the hillsides or in mountainous areas, however, exist a minimal knowledge about nutritive value of these tubers, either raw or cooked [8].Currently people show a higher interest by to know the nutritional value of food that they consume. It is therefore of great importance to determine the specific composition of a food product in their energy intake and its vitamins, minerals, amino acids and essential fatty acids content, so that consumers have accurate information on specific nutritional quality that allows you to make the best choice of food that they consume.

That is why the objective of this study was to provide information on the chemical composition and nutritional value of the "mountain's yam" (*Dioscorea remotiflora* Kunth), and compared this with other national popular consumer tubers, such as potato (*Solanum tuberosum*) and the sweet potato (*Ipomoea batatas*).

MATERIALS Y METHODS

Materials

Fresh tubers of mountain's yam (*Dioscorea remotiflora* Kunth) (Figure 2), free from harm whether physical, microbial or insect attack, were collected during the month of October 2012, in five different sampling points in the region Cienega of Chapala, Mexico. Immediately the tubers were placed in closed container at 12°C and transported to the laboratory for further analysis. On the other hand, in the local market town of Jiquilpan, Mich., Mexico, were acquired potato tubers (*Solanum tuberosum* cv. Alpha) and tubers of sweet potato (*Ipomoea batatas* cv. Nylon), which were also analyzed for comparison at the same time than the mountain's yams with the same methodology.



Figure 1. Mountain's yam plant (Dioscorea remotiflora Kunth)



Figure 2: Mountain's yam tubers (Dioscorea remotiflora Kunth)

Conditioning raw material

Initially the tubers were washed, drained and the surface moisture was removed using paper towels. The physical characterization of tubers was carried out and then the respective flours were obtained as follows. The tubers were cut into slices of about 2 mm thickness using a meat slicer and ham (Denim, USA). The slices were scattered uniformly on the trays of a dryer which is at a temperature of 50°C. The drying process was maintained for 48 hours, after which, dried flakes were ground with a hammer mill (IKA, Germany) and the powder obtained was sieved through a sieve with an opening of 200 microns (Montinox, Mexico). The respective flours thus obtained were packed in amber glass bottles, which were properly identified and stored in a dry place at room temperature for further analysis.

Physical characterization

Physical characteristics such as morphology, size, weight and color as well as the edible portion of mountain's yams (*Dioscorea remotiflora* Kunth) tubers, were evaluated and compared with potato (*Solanum tuberosum* cv. Alpha) tubers and with sweet potato (*Ipomoea batatas* cv. Nylon) tubers. Within morphology, the external appearance and shape of tubers are described. The length and average diameter of the tubers were evaluated by using a vernier caliper (Mitutoyo, Japan), while their average weight was obtained with a balance Ohaus model BD- 6000, series number 11555 (Ohaus, USA). External color of tubers, ie, the shell coloration was determined visually and the edible portion of the tubers was determined as follows. For the purposes of this study, it was considered edible portion to the fraction after washing and removing the skin of the tubers with a commercial peeler manual. The yield of the edible portion was estimated as the ratio of the weight of tubers peeled and divided by the weight of the whole tubers and multiplied by one hundred.

Chemical characterization

Chemical determinations were performed on dry samples (< 8% moisture). The proximal chemical composition of tubers was determined according to the official methods of analysis [12]. The parameters and the method used in its determination were: moisture (method 925.09), crude protein (method 954.01), crude fat (method 920.39), crude fiber (method 962.09), ash (method 923.03) and the content of total carbohydrates were obtained by complement to 100%. The dry matter content in tubers was determined as the difference between the total weight of the test sample and its moisture content. A factor of 6.25 was used to the conversion of specific content of nitrogen to protein. The calorie content of tubers was obtained as the sum of their calories from carbohydrates, fats and proteins, assuming that it is 4, 9 and 4 Kcal/g respectively [13].

Minerals content

The content of some minerals such as calcium, sodium, potassium, magnesium, iron, copper, manganese and zinc were evaluated with an atomic absorption spectrophotometer Perkin Elmer 3100 (Perkin Elmer Ins, USA) after digestion with $HNO_3/HCLO_4$ of the ashes obtained from flours samples [14]. The phosphorus content was determined colorimetrically with a UV-visible spectrophotometer model U-2001 (Hitachi Co., Tokyo, Japan), using dihydrogen phosphate as the standard test [12].

Fatty acids content

To determine the fatty acid content in the tubers, initially the oily extracts of these tubers was obtained by placing the respective flours refluxing with hexane and subsequently removing the hexane by heating in grill. Then the fatty acids contained in these extracts were quantified by gas chromatography using a Perkin Elmer model Autosystem GC fitted with a flame ionization detector and integrator (PerkinElmer Inc., USA). Before being injected into the chromatograph, the extracts were subjected to a methylation process to form the methyl esters of the corresponding fatty acids [15]. Fatty acid standards (Sigma, USA) were used for its identification and quantification in the test samples, which was quantified by percentage of area. One column model ZB-FFAP-7HG-G009-11 with 30m of length, 0.25mm of internal diameter and 0.25 μ film thickness was used. The chromatograph working conditions were: detector temperature 250°C, injector temperature 220°C , column temperature 150°C (2 min), followed by a temperature ramp of 5°C/min until reaching 220°C (8 min) and a second temperature ramp of 8°C/min until reaching 230°C and maintained for 12 min.

Amino acids content

Initially 1 g of each one of the dry and defatted flours was hydrolyzed with 10 mL of 6N HCl at $100^{\circ}C/22$ hours. Then the hydrolyzates were brought to a volume of 100 mL with citrate buffer 0.2 N. A 10 mL aliquot was filtered through millipore membrane with 0.5 µm diameter [16]. The hydrolyzed and clarified sample was injected into an amino acids analyzer Beckman Model 6300 System (Beckman Co. USA), using a buffer solution of sodium citrate as mobile phase to achieve the separation of amino acids by ion exchange chromatography and the derivatization post column of such amino acids by its reaction with ninhydrin. The detection is performed by measuring the absorbance of the column effluent stream in two simultaneous wavelengths (570 and 410 nm) [17]. The content of each of the amino acids that make up proteins present in the different flours were reported as mg amino acid / 100 g tuber in wet basis.

Statistical Analysis

All determinations were performed in triplicate and the data shown are the average of three determinations \pm standard deviation of the series. The data were analyzed with ANOVA and a posteriori tests (Tukey) in order to determine statistically significant differences (p<0.05) among the samples, using the SPSS ver. 12.0 statistical software.

RESULTS AND DISCUSSION

Physical characteristics and edible portion

Mountain's yam tubers (*Dioscorea remotiflora* Kunth) have smooth or rough surfaces and are cylindrical and irregular shapes, its deck or skin is very thin and light brown coloration (Figure 2), similar to that presented potato tubers (*Solanum tuberosum*) [18] and tubers of *Dioscorea alata* and *Dioscorea esculenta* [3]. The irregular shape and the rough surface of the tubers makes difficult the removal of the shell, which is normally removed by rubbing or simply the tubers are washed, cooked and consumed entirely, by that, its edible portion becomes 100 %, similar to the edible portion of the sweet potato tubers (*Ipomoea batatas*), but higher than the edible portion of the chayote tubers (*Sechium edule*) and potato tubers (*Solanum tuberosum*), whose edible portion is 86 and 90 % respectively [18].

Physical characteristics such as weight, length, diameter and edible portion of the mountain's yam tubers (*Dioscorea remotiflora* Kunth), were compared with other popular consumer tubers such as potato (*Solanum tuberosum*), chayote (Sechium edule), yams (*Dioscorea bulbifera*) and sweet potato (*Ipomoea batatas*) (Table 1). The *Dioscorea bulbifera* tubers are shorter and thinner and therefore lighter weight compared to the mountain's yam (*Dioscorea remotiflora* Kunth) and the edible portion of such tubers is lower because its cover or skin should be removed before consuming, since it is very thick and fibrous [19].

It is important to say that because the mountain's yam tubers were not cultivated, but they were collected, it is not known the actual age of the plants from which these tubers were obtained and the conditions under which they were grown, therefore, the physical characteristics reported here do not necessarily correspond to those that would have the tubers obtained under optimal growing conditions, since it is known that mountain's yam tubers can weigh up to 3 kg [9].

	Parameter			
Tubers	Lenght	Diameter	Weight	Edible portion (%)
	cm	cm	g	
Dioscorea remotiflora	15 - 60	3 - 8	350 - 1000	100
Solanum tuberosum ¹	7 - 30	4 - 10	50 - 250	86
Sechium edule ¹	28 - 43	4 - 10	480 - 930	86
Ipomoea batatas ²	13 - 31	8 - 15	370 - 2200	100
Dioscorea bulbifera ³	2.7 - 9.4	2.6 - 7.8	97 - 281	85

Table 1: Physical characteristics of several popular consumer tubers

1. Jiménez et al. (2007); 2. Medina et al. (2013); 3. Rincón et al. (2000)

Chemical characterization

Table 2 shows the chemical composition of mountain's yam tubers (*Dioscorea remotiflora* Kunth), compared with those that have the potato tubers (*Solanum tuberosum*) and the sweet potato tubers (*Ipomoea batatas*).

The chemical composition of the mountain's yam tubers is very similar to those having the potato tubers in their moisture content, carbohydrates, protein, ash, and even in your caloric intake, and there is only a statistically significant difference (p<0.05) in their lipid content and crude fiber, the lipid content was higher in the mountain's yam tubers while the crude fiber content was higher in potato tubers. The tubers of mountain's yam have 36% more protein than the sweet potato tubers. The protein content in the three types of tubers, although it is lower than provided by animal foods, it is higher than have the most grains, roots and others tubers. Moreover, in all aspects evaluated, the chemical composition of mountain's yam tubers and the potato tubers, differ significantly (p<0.05) with the sweet potato tubers chemical composition. Although the mountain's yam tubers provide greater amount of lipids (0.47 $\%_{BH}$) and protein (1.91 $\%_{BH}$) than the sweet potato, the higher carbohydrates content (20.50 $\%_{BH}$) that provides the sweet potato (*Ipomoea batatas*) makes your energy intake also is greater (91.20 ± 1.27 Kcal/100g). According with Treche and Agbor, (1996), the dry matter and a plant's starch content constitute important indicators for the evaluation of the relative "quality" of plant-derived starchy food products [20].

The results obtained on the chemical composition of potato tubers are similar to those reported by Jiménez *et al.*, [18], but differs from the values reported by Wolfgang *et al.*, [21]. It has been reported further that the chemical composition of the tubers is clearly affected by factors such as tuber origin, genetic variations, climate and fertilizer type and the development period of tubers [17].

If we consider that the catabolism of carbohydrates and proteins provide 4 kcal/g of each one of them, and the catabolism of fat provides 9 kcal/g [12], energy intake derived from the catabolism of these nutrients contained in the mountain's yam tubers is 81.35 Kcal/100g of fresh tubers consumed, equivalent to 4.07% and 3.25% of the recommended diet (2000-2500 calories per day). The mountain's yam tubers also has a considerable amount of dietary fiber, which has been found to accelerate intestinal transit prevents colon cancer, controls the level of glucose, reduce cholesterol and feeling of fullness in the body [22].

We should note that in general, the composition of the tubers can be modified by factors such as the variety, soil type, climate and growing conditions, as well as diseases, pests and duration of production cycles. Similarly, the composition of the tubers can also be affected by the shape of their preparation within households, as well as by the type of processing that they undergo industrial level.

Mineral Content

The mineral content in the tubers directly dependent on the nature and composition of the soil where they were grown, for that reason the mineral content is variable. The mineral content in the different analyzed tubers are shown in Table 3. In the mountain's yam tubers protrudes its high content of K, Fe, Zn, and P and its lower content of Ca and Na, compared with the other tubers. We also note that the content of Mg and Mg in mountain's yam tubers are similar to those found in the potato tubers as there is no statistically significant difference (p<0.05) between them.

The content of the different minerals in the mountain's yam tubers were similar than those found in others different varieties of Dioscoreas *as D. deltoidea, D. versicola, D. triphylla and D. alata* [23]. These also were higher than those reported by Huang *et al.*, [22] when they analyzed the *Dioscorea alata* tubers, and those reported by Zhou *et al.*, [24] when they analyzed the *Dioscorea opposita* tubers. Furthermore, the results obtained on the mineral content in the sweet potato tubers are similar to those reported by Montes *et al.*, [25]

Most minerals are required by the body in very small amounts in those metabolic processes to produce energy or, in those processes aimed at the synthesis of other substances that our body requires. In all three types of tubers analyzed protrudes their high potassium and phosphorus contents and their low content of other minerals including sodium; aspects that must be considered in the design of the diet for those people hypertenses in which the sodium intake in the diets it is restricted. In general terms we can say that all the three studied tuber types are a rich and important source of minerals needed for the good nutrition human, which largely fulfill the daily intake recommended for each of them [26].

taber obami j and on over potato (ipomova batatas)				
Parameter (% _{WB})	D. remotiflora	S. tuberosum	Ipomoea batatas	
Moisture	78.18 ± 0.40^{a}	77.33 ± 0.30 ^a	75.00 ±0.40 ^b	
Carbohydrates	17.37 ± 0.20^{a}	17.97 ± 0.20^{a}	20.50 ± 0.22^{b}	
Protein	1.91 ± 0.02^{a}	2.01 ± 0.03^{a}	1.40 ± 0.03^{b}	
Lipids	$0.47 \pm 0.02^{\circ}$	0.12 ± 0.02^{a}	0.40 ± 0.03^{b}	
Ash	0.85 ± 0.01^{a}	0.81 ± 0.02^{a}	1.60 ± 0.05^{b}	
Crude fiber	1.22 ± 0.02^{b}	1.76 ± 0.02°	1.10 ± 0.02^{a}	
Caloric intake Kcal/100g	81.35 ± 1.06^{a}	81.00 ± 1.10^{a}	91.20 ± 1.27^{b}	

Table 2. Tubers chemical composition of mountain's yam (*Dioscorea remotiflora* Kunth), potato (*Solanum tuberosum*) and sweet potato (*Ipomoea batatas*)

Different letters in the same row indicate statistically significant differences (p>0.05).

Table 3. Mineral content in tubers of mountain's yam (Dioscorea remotiflora Kunth), potato (Solanum
<i>tuberosum</i>) and sweet potato (<i>Ipomoea batatas</i>).

Mineral content	Dioscorea remotiflora	Solanum	Іротоеа
(mg/100g) _{WB}		tuberosum	batatas
Ca	242 ± 14^{a}	320 ± 15^{b}	380 ± 12°
Mg	250 ± 10^{b}	230 ± 15^{b}	160 ± 5^{a}
Na	79 ± 6^{a}	170 ± 13^{b}	410 ± 25^{a}
К	4891 ± 25 ^b	4300 ± 25°	2530 ± 50^{a}
Fe	12.4 ± 0.5^{b}	8.9 ± 0.5^{a}	10.0 ± 0.4^{a}
Cu	3.3 ± 0.2^{b}	5.4 ± 0.2°	1.3 ± 0.1^{a}
Zn	7.1 ± 0.3^{b}	2.9 ± 0.1°	1.6 ± 0.1^{a}
Mn	4.1 ± 0.2^{b}	4.2 ± 0.2^{b}	1.2 ± 0.2^{a}
Р	720 ± 20 ^b	570 ± 15ª	550 ± 15^{a}

Different letters in the same row indicate statistically significant differences (p>0.05).

Fatty acids content

In general, the fatty acid contribution by the three types of tubers is very low. The oily extract of the mountain's yam tubers consists mainly of the fatty acids oleic, palmitoleic, palmitic, octadecanoic and α -linolenic, but also contains minor amounts of other fatty acids like lignoseric, lauric, stearic, margaric and others (Table 4).

Comparatively the sweet potato tubers provide greater amounts of palmitic acids (400 mg/100 g_{DB}) and octadecanoic acid (220 mg/100 g_{DB}) than the potato tubers and the mountain's yam tubers. By other hand, in the mountain's yam tubers oily extract excels its content of palmitoleic acid (380.4 mg/100 g_{DB}), oleic acid (637.3 mg/100 g_{DB}), α -linolenic acid (261.2 mg/100 g_{DB}) and lignoseric acid (105.4 mg/100 g_{DB}). The content of each one of the fatty acids quantified in the different oiled extracts were less in the potato tubers than on the other studied tubers. We did not find reports in the literature on the content of the different fatty acids making up the oiled extracts from any of the tubers studied here, possibly by the low fat content in them and hence its minimal impact on energy intake and on the human nutrition.

Table 4. Fatty acids content in tubers of mountain's yam (*Dioscorea remotiflora* Kunth), potato (*Solanum tuberosum*) and sweet potato (*Ipomoea batatas*).

Fatty acid	Іротоеа	Solanum	Dioscorea
(mg/100 g) _{WB}	batatas	Tuberosum	remotiflora
Lauric (12:0)	7	ND	12
Myristic (14:0)	2	ND	4
Palmitic (16:0)	100	22	66
Palmitoleic (16:1)	2	ND	83
Margaric (17:0)	2	ND	6
Stearic (18:0)	16	6	10
Oleic (18:1)	5	3	139
Linoleic (18:2)	7	ND	ND
Octadecadienoic (18:2n6)	205	61	62
α -Linolenic (18:3n3)	47	25	57
Arachidonic (20:0)	4	ND	4
Eicosapentaenoic (20:5n3)	4	2	2
Behenic 22:0	2	2	2
Lignoseric (24:0)	ND	ND	23

ND: Not detected

Amino acids content

The proteins present in all three samples tubers were integrated by an amino-acids considerable diversity (Table 5). Amongst the amino acids analyzed herein, the content of aspartic acid ($266 \pm 4.0 \text{ mg}/100\text{g}$ wet basis), glutamic acid ($305 \pm 4.3 \text{ mg}/100\text{g}$ wet basis), arginine ($185 \pm 4.5 \text{ mg}/100\text{g}$ wet basis) and leucine ($158 \pm 3.2 \text{ mg}/100\text{g}$ wet basis) in the mountain's yam tubers tended to predominate over the other tubers.

Table 5. Amino acid content in tubers of mountain's yam (Dioscorea remotiflora Kunth), p	potato (<i>Solanum</i>
tuberosum) and sweet notato (Inomore batatas)	

Fatty acid	Іротоеа	Solanum	Dioscorea remotiflora
(mg/100 g) _{WB}	batatas	Tuberosum	
Phenylalanine	58 ± 2.1ª	88 ±3.0 ^b	118 ± 4.1°
Tryptophan	21 ± 1.5^{a}	35 ± 1.8 ^b	32 ± 1.8^{b}
Methionine	24 ± 1.2^{a}	29 ± 1.5 ^b	$40 \pm 1.9^{\circ}$
Cysteine	16 ± 0.8^{a}	14 ± 0.7^{a}	25 ± 1.1 ^b
Leucine	75 ± 2.5^{a}	131 ± 3.1 ^b	158 ± 3.2°
Isoleucine	55 ± 1.6^{a}	80 ± 1.8^{b}	93 ± 2.2°
Valine	61 ± 2.6^{a}	96 ± 2.8 ^b	115 ± 3.2°
Lysine	50 ± 1.5^{a}	97 ± 2.8 ^b	100 ± 2.5^{b}
Threonine	56 ± 1.4^{a}	78 ± 2.2^{b}	90 ± 2.3°
Arginine	63 ± 2.0^{a}	102 ± 3.2^{b}	185± 4.5°
Histidine	22 ± 0.5^{a}	33 ± 1.0^{b}	48 ± 1.1°
Aspartic acid	185 ± 3.1^{a}	241 ± 3.5 ^b	266 ± 4.0°
Serine	56 ± 2.1^{a}	88 ± 2.4^{b}	128 ± 2.8°
Glutamic acid	115 ± 3.1^{a}	198 ± 3.5^{b}	305 ± 4.3°
Proline	48 ± 1.5^{a}	75 ± 1.9 ^b	98 ± 2.5°
Glycine	53 ± 1.2^{a}	82 ± 2.1 ^b	85 ± 2.5^{b}
Alanine	65 ± 1.1^{a}	94 ± 1.8^{b}	98 ± 2.2^{b}
Tyrosine	35 ± 1.0^{a}	52 ± 1.8^{b}	$82 \pm 2.5^{\circ}$

Different letters in the same row indicate statistically significant differences (p>0.05).

The mountain's yam tubers provide higher quantities of most amino acids, except tryptophan, lysine, glycine and alanine, whose contribution is similar to potato tubers, as there is not a statistically significant difference (p<0.05) between them. The reports on the amino acid composition of yam tubers are limited, however similar results to those presented here were found in *Dioscorea alata* L. tubers (17), as well as in the tubers of others *Dioscoreas's* varieties as *Dioscorea bulbifera*, *Dioscorea deltoidea*, *Dioscorea versicolor and Dioscorea triphylla* (23).

Mountain's yam tubers studied herein contained remarkably substantial amounts of essential amino acids, all of which appeared to be superior to the FAO reference pattern [27], except the sulfur-containing amino acids and lysine. Sweet potato tubers (*Ipomoea batatas*) provide smaller quantities as proteins (Table 2) as each and every one of the amino acids with they are integrated, compared with the contributed quantities as proteins as amino acids by the potato tubers (*Solanum tuberosum*) and the mountain's yam tubers (*Dioscorea remotiflora Kunth*) [28].

CONCLUSIONS

The results obtained here revealed that from a nutritional view point, mountain's yam tubers (*Dioscorea remotiflor*a Kunth) may be considered as a good mineral source, especially potassium, iron and phosphorus, also, its high carbohydrates content and their reasonably substantial content of both protein and fat, makes mountain's yam tubers an excellent source of energy.

In general terms, chemical composition and nutritional value the mountain's yam tubers (*Dioscorea remotiflora* Kunth) are very similar to that presented by potato tubers (*Solanum tuberosum*) and the sweet potato tubers (*Ipomoea batatas*), two of the main tubers integrating the Mexican diet.

These result suggested that the mountain's yam tubers can be used as a good alternative source of food to alleviate hunger and malnutrition that affects a large part of the population living in rural areas of Mexico. Domestication studies are needed of the mountain yam in order to find the optimal conditions for its "*exsitu*" cultivation.

ACKNOWLEDGMENT

The authors thank to SIP-IPN, EDI-IPN and COFAA-IPN; by the financial support granted to carry out this research.

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