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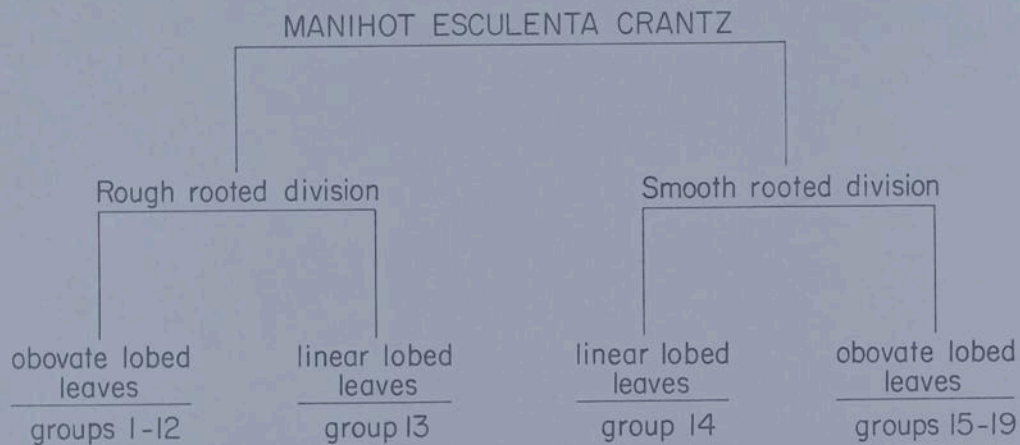
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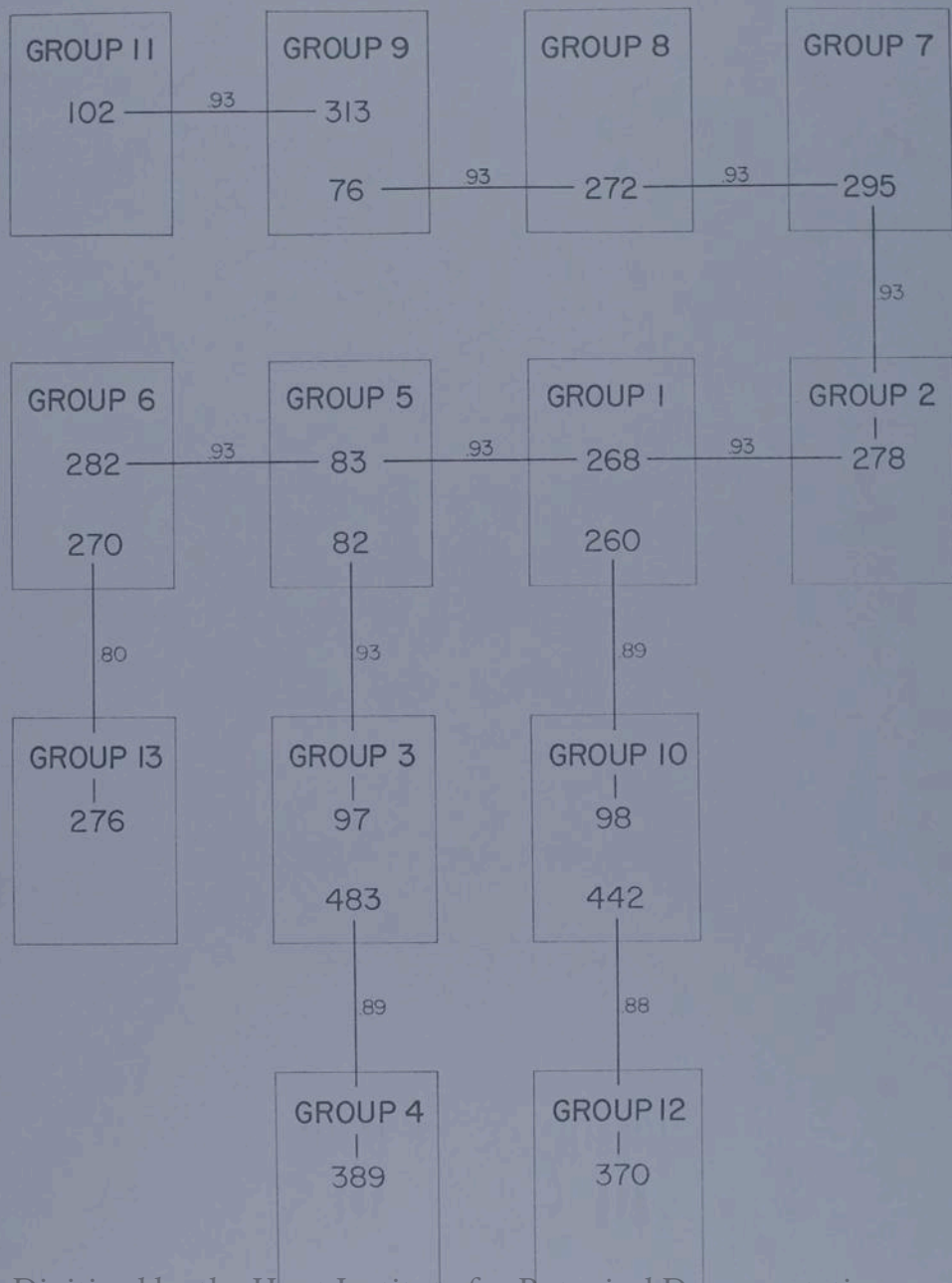
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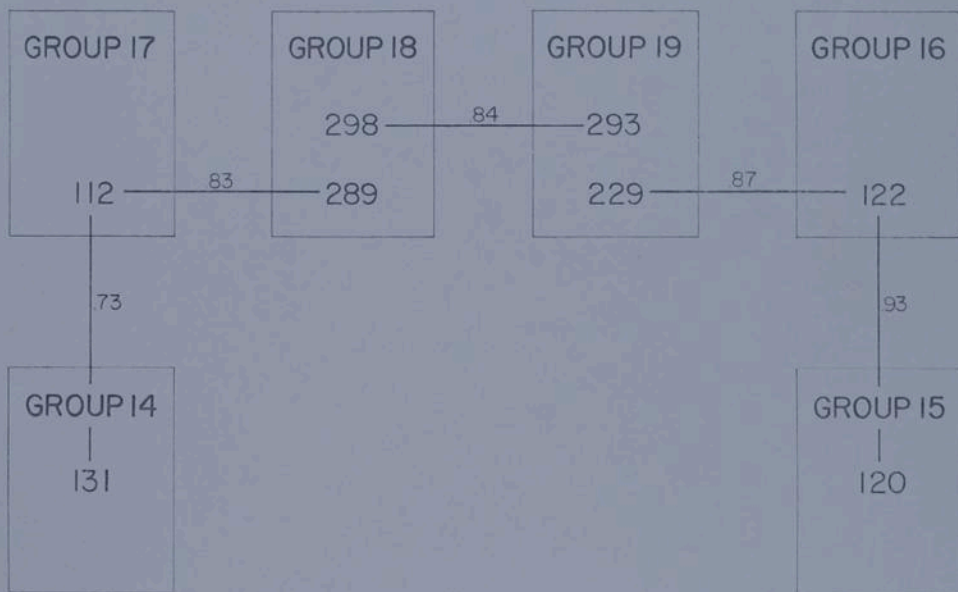
About the Institute

The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.







Description

Root externally rough and brown, dark brown or reddish brown; root flesh white to cream. Stem brown; storey length moderate (330, short); scars usually slightly or moderately raised, sometimes large. Branches usually more than two, sometimes moderate (state 2). Leaves most often seven-lobed, but also five or nine lobed; lobes obovate with smooth margins (90, sinuous); the median lobe of moderate length (330, short) and moderate width. Petiole mostly green, sometimes red. Young apical foliage either reddish blue or green.

Discussion

Two populations (260, 322) have identically coded characters, but may be distinguished on the basis of an additional character which was not used in the formal coding. Population 260 (Jamaica) has an internal stem color greenish-white; 322 (Belem, Brazil) has a brilliant greenish yellow internal stem color. Populations 268 and 281 coded identically also differ in respect to the internal stem color, the former being light yellow and the latter greenish white. The lobes of 281 also have a strong tendency towards being linear.

From the above very homogeneous section, a series of populations (93, 108, 284 and 320) is derived containing the populations characterized by nine-lobed leaves and with green young foliage. The pith of the stem of 108 is amber colored. Populations 90 and 264 have the young foliage reddish blue, and the section containing 330, 377, 486 and 487 is bluish green. Three of the latter populations have a variable leaf lobe number, between three and seven lobes. An amino acid analysis of the leaves of 320, 322 and 330 of this group are appended.

Table Morphological and Other Descriptive Information for Group I

No.	Character Number													Country +	Common Name	Color of Root Bark	Tree or Shrub	Height	Date Collected
	1	2	3	4	5	6	7	8	9	10	11	12	13						
90	2	2	3	2	4	3	5	1	4	2	2	2	4	1	Jamaica	Yellow Saunders	-	12 months	June 1954
93	2	2	3	2	3	3	6	1	4	3	2	2	4	3	Jamaica	Blue Bud	-	12 months	June 1954
108	2	2	2	2	4	2	6	1	4	3	2	2	4	3	Jamaica	Elmo Stick	pink	12 months	June 1954
260	2	2	3	2	3	3	5	1	4	3	2	2	4	3	Jamaica	-	light tan	12 months	June 1954
264	2	2	3	2	2	3	5	1	4	3	2	2	4	1	Jamaica	-	light tan	12 months	July 1955
268	2	2	3	2	2	3	5	1	4	3	2	2	4	3	Jamaica	-	light yellow	12 months	July 1955
281	2	2	3	2	2	3	5	1	4	3	2	2	4	3	Jamaica	-	light tan	12 months	July 1955
284	2	2	3	2	3	2	6	1	4	3	2	2	1	3	Jamaica	-	white	12 months	July 1955
*320	2	2	3	2	3	2	6	1	4	3	2	2	4	3	Jamaica	-	white	15 months	June 1960
*322	2	2	3	2	3	3	5	1	4	3	2	2	4	3	Brazil ⁵	Pretinha	light tan	10 months	June 1960
*330	2	2	3	1	2	3	2	1	4	3	1	2	1	1	Brazil ⁵	Amazonas	white	10 months	June 1960
377	2	2	3	2	4	3	5	1	4	3	2	2	1	1	Brazil ⁶	Macacheira Rosa	pink	24 months	Feb. 1961
486	2	2	3	2	3	3	2	1	4	3	2	2	1	1	Peru ²⁰	Pira Rica	white	? 6 months	Feb. 1962
487	2	2	3	2	3	3	2	1	4	3	2	2	4	1	Peru ²⁰	Machoa	white	6 months	Feb. 1962

^o Population and D. J. Rogers collection number

⁺ See Appendix for exact localities

^{*} Amino acid analysis follows

Table 2
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Population

320 Proximate Analysis of Leaves

Percent per 100 gm

	As received	Dry
Moisture	76.72	
Protein	4.81	20.66
Ether Extract ¹	1.30	5.93
Ash	2.03	8.72
Crude Fiber	1.92	8.25
Carbohydrates	13.77	59.15
Calories	86.7	372.6

¹ Considered as fat for the calculation of caloric values.

Amino Acid Determination

Percent (16 mg Nitrogen Basis)

Alanine	5.77	Lysine	7.86
Arginine	4.00	Methionine	1.74
Aspartic Acid	10.12	Phenylalanine	5.25
Cystine	1.04	Proline	4.12
Glutamic Acid	10.07	Serine	5.52
Glycine	5.28	Threonine	4.80
Histidine	3.05	Tryptoph	1.62
Isoleucine	4.91	Tyrosine	3.74
Leucine	8.82	Valine	6.22

ppm Cyanide in leaf = 33

Population

322 Proximate Analysis of Leaves

Percent per 100 gm

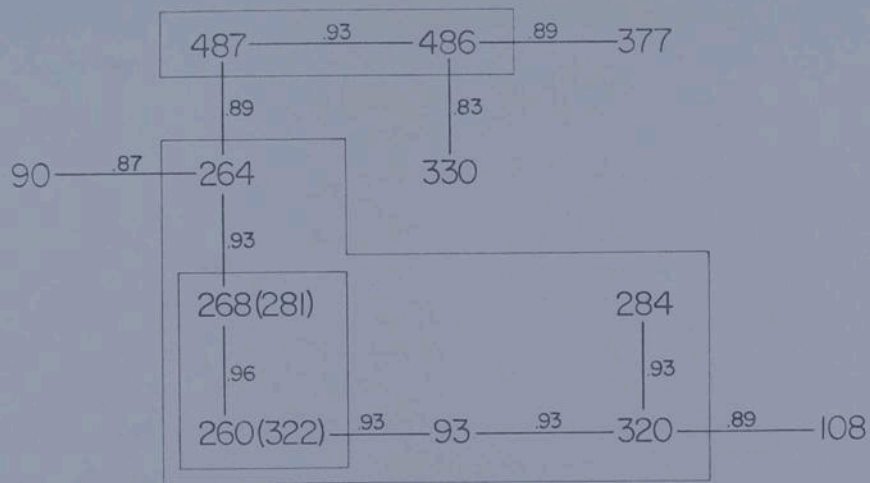
	As received	Dry
Moisture	69.83	
Protein	5.37	17.80
Ether Extract ¹	3.36	11.14
Ash	1.57	5.20
Crude Fiber	1.37	4.54
Carbohydrates	18.50	61.32
Calories	125.7	416.7

Amino Acid Determination

percent (16 gm Nitrogen Basis)

Alanine	6.66	Lysine	6.29
Arginine	5.69	Methionine	2.00
Aspartic Acid	10.53	Phenylalanine	5.48
Cystine	1.47	Proline	5.44
Glutamic Acid	11.02	Serine	5.56
Glycine	4.94	Threonine	4.74
Histidine	2.87	Tryptophane	1.56
Isoleucine	5.06	Tyrosine	4.08
Leucine	9.47	Valine	6.09

ppm Cyanide in leaf = 47



Description

Root externally rough and brown or dark brown; root flesh white to cream. Stem brown (440, silver brown); storey length usually moderate but also short; scars usually slightly raised, sometimes moderate or large. Branches, three or more. Leaves mostly seven-lobed but also nine-lobed; leaf lobes obovate with smooth margins (440, pandurate); median lobe long and usually of moderate width, but sometimes broad. Petiole red, greenish red or green. Young foliage commonly green, occasionally bluish green.

Discussion

Population 278 is closely related to 268 of Group 1 from which it differs in having longer leaf lobes. 278 is the radiating point for group 2. Populations 376, 94 and 440 form a cline differing in leaf scars, storey length of the stem and in color of petioles from 222, 267 and 280. Populations 278 and 285 are coded alike but differ in the internal stem color, respectively greenish white and light yellow green. The root surface of 285 is not as rough as 278. The lobes of the leaves of all populations are long and near the upper limit for moderate width except for population 94. Populations 267 and 280 form a small section of the group with nine-lobed leaves.

Population 440 from Bolivia is only distantly related to this group, but nonetheless, is most closely related to 94 from Jamaica which it resembles in having very large stem scars and short storey length. It is different from other populations in the group in having a silver-brown stem, red petioles, and pandurate lobed leaves. It is probably sufficiently different from other populations of Manihot esculenta to be distinguished as a separate group.

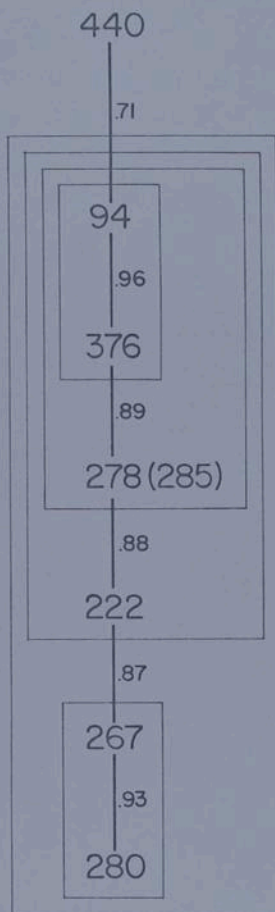
TABLE 3

Morphological and Other Descriptive Information for Group 2

Population Number ^o	Character Number															Country ⁺	Common Name	Color of Root Sub-epidermis	Age at Collection	Date of Collection
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
Character State																				
94	2	2	1	5	1	4	3	5	1	4	3	3	2	4	3	Jamaica ¹	Esther	light tan	12 months	June 1954
222	2	2	1	5	2	2	3	5	1	4	3	3	2	2	2	Costa Rica ²	Cubana	white	-	June 1955
267	2	2	1	5	2	2	3	6	1	4	3	3	3	2	2	Jamaica ¹	-	light tan	12 months	July 1955
278	2	2	1	5	2	2	3	5	1	4	3	3	2	4	3	Jamaica	-	"	"	July 1955
280	2	2	1	5	2	2	3	6	1	4	3	3	3	2	3	Jamaica	-	"	"	July 1955
285	2	2	1	5	2	2	3	5	1	4	3	3	2	4	3	Jamaica	-	"	"	July 1955
376	2	2	1	5	1	3	3	5	1	4	3	3	2	4	3	Brazil ⁶	Macacheira "Sabará"	"	24 months	Feb. 1961
440	2	2	0	2	1	4	3	6	1	4	1	3	2	1	3	Bolivia ³¹	Colla	"	15 months	Jan. 1962

⁺ See Appendix for exact localities

^o Population and D. J. Rogers Collection Number



Description

Root externally rough and brown, dark brown, or reddish brown (233, light brown yellow); root flesh white to cream. Stem brown, storey length moderate, rarely large (221); scars smooth or slightly raised, seldom moderately raised (312, 483). Branches two. Leaves seven-lobed; lobes obovate and margins usually smooth, sometimes sinuate; median lobes of moderate length, rarely long (233) and width usually moderate, seldom either narrow or wide. Petiole color, variable. Young foliage either reddish blue or green.

Discussion

In this study populations 97 and 103 begin a cline of similar populations. They are both closely related to populations 82 and 101, which are the beginning of group 5, and differ only in either branching and petiole color. The above populations are only a maximum of 8% different from each other, but develop into separate sequences of relationships. Populations 97 and 103 develop groups 3 and 4, while 82 and 101 are the base of Groups 5 and 6 (fig.).

Population 221 is quite unrelated to any other populations of Manihot esculenta, but its nearest relatives are in this group. It shows a more distant relationship to some populations in Groups 1, 5 and 7. (See table of nodal distance arrays.)

An interesting set of plants with quite distinct growth habits are found in eastern Brazil, in the states of Pernambuco and Para. These are represented by populations 393 (Group 3), 333, 388, 389, 392 (Group 4) and 390, 391 (Group 12). The growth habit is best described as having low, frequently branched, almost decumbent stems. The stems near the inflorescence are quite wiry, with a distinctive zig-zag appearance. This growth habit may occur in other localities (or geographic regions) but there are more of this type in the listed area than in any other known to us. Other characteristics of the plants cause them to be divided into the Groups

Discussion (continued)

3, 4, and 12, but if one wishes to examine these plants for the growth habits, then he will find interesting common features in the populations listed. While no precise statement on origins of the cultivars of M. esculenta can be made, it seems evident that one set of genes which contributed to the present diversity found in the cultivated species might be found in plants similar to populations 333, 388, 389, 390, 391, 392 and 393. The growth habits which appear to us as extremes in M. esculenta are those listed here as contrasted to those of completely unbranched plants. See Groups and

Table 5. Protein and Amino Acid Analyses

312 Proximate Analysis of Manioc Leaves

Percent per 100 g

	<u>As received</u>	<u>Dry</u>
Moisture	79.29	
Protein	6.41	30.95
Ether Extract ¹	1.17	5.65
Ash	1.72	8.31
Crude Fiber	1.48	7.15
Carbohydrates	9.93	47.95
Calories	75.9	366.5

1. Considered as fat for the calculation of caloric values.

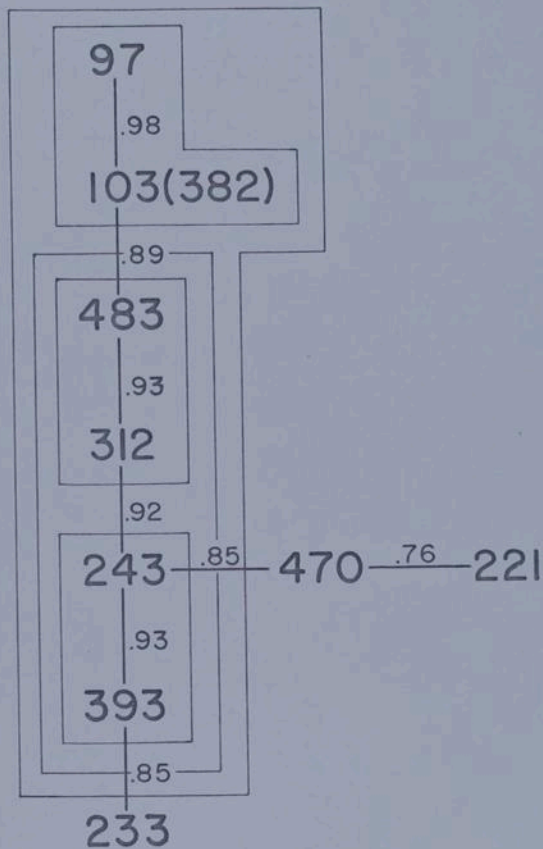
312 Amino Determination

Percent (16 g Nitrogen Basis)

Alanine	6.01	Lysine	7.73
Arginine	5.48	Methionine	1.65
Aspartic Acid	10.27	Phenylalanine	5.96
Cystine	1.41	Proline	4.82
Glutamic Acid	10.26	Serine	4.74
Glycine	5.42	Threonine	5.14
Histidine	2.04	Tryptophane	1.37
Isoleucine	4.86	Tyrosine	4.22
Leucine	8.76	Valine	5.70

ppm Cyanide in leaf 43

Analysis made by Food and Drug Research Labs., Inc., Maspeth
Queens, Long Island, N.Y.

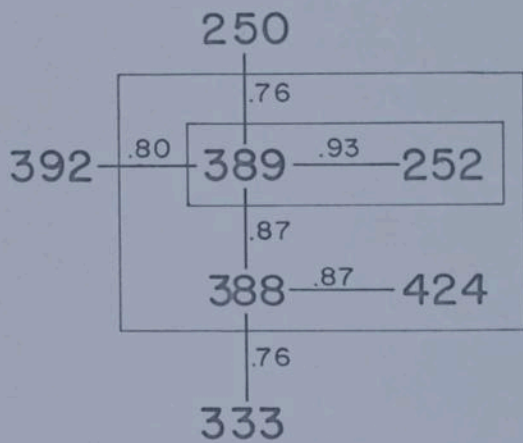


Description

Root externally rough and brown or dark brown (250, light brown); root flesh white. Stem brown (250, silver); storey length variable but rarely long; scar slightly raised, rarely smooth or moderately raised. Branches, two or more. Leaves five-lobed (see discussion 392); lobes obovate and margins smooth (see discussion, 333); median lobe of moderate length and usually median width, rarely narrow (392). Petiole either red or green. Young foliage reddish blue; rarely green (333).

Discussion

This group is composed of continental populations. Populations 392, 250 and 333 are only loosely related to this group, although the group provides their closest relationship. Population 392 may be more closely related to 389 than indicated by the graph because its leaf properties have been determined from leaves of the inflorescence which are most frequently different from mature vegetative leaves. Population 250 is unusual in having a silver stem and light brown root associated with a rough surfaced root. Most populations fall clearly into either rough or smooth-rooted groups, and it is seldom that silver-stemmed plants have rough-surfaced roots. However in these cultivated plants, it would be unusual to have an absolute, clear cut distinction in any character. Population 333 has pandurate lobes in an otherwise simple-lobed group. It is distinctive in being scandent and in having distally enlarged roots. The group is connected to group 3 by populations 389-483.



Group 5

Description

Root externally rough and brown or dark brown (387, pinkish brown); root flesh white, rarely creamy white. Stem brown; storey length moderate; scar commonly slightly raised but may be otherwise. Branches usually one at top or none, rarely three or more branches (two Peruvian populations 452, 464). Leaves seven-lobed; lobes obovate with smooth margins; median lobes moderate or long and medium or wide. Petioles commonly red or greenish red, but sometimes green. Young foliage green, rarely reddish blue (91).

Discussion

Populations 82 and 101 of group 5 are closely allied to 97 and 103 of group 3. Population 101 is distinctive in having an angular leaf base. Group 5 divides into two sections, one continental and the other insular with the exception of 231, a Costa Rican population which is also almost equally related to the continental sections by way of another Costa Rican population, 249. Population 249 and 479 from Peru were coded identically; however, the root subepidermis of 249 is white while the latter is a strong reddish purple. While both have broad lobed leaves, the Costa Rican population (249) is unusually broad.

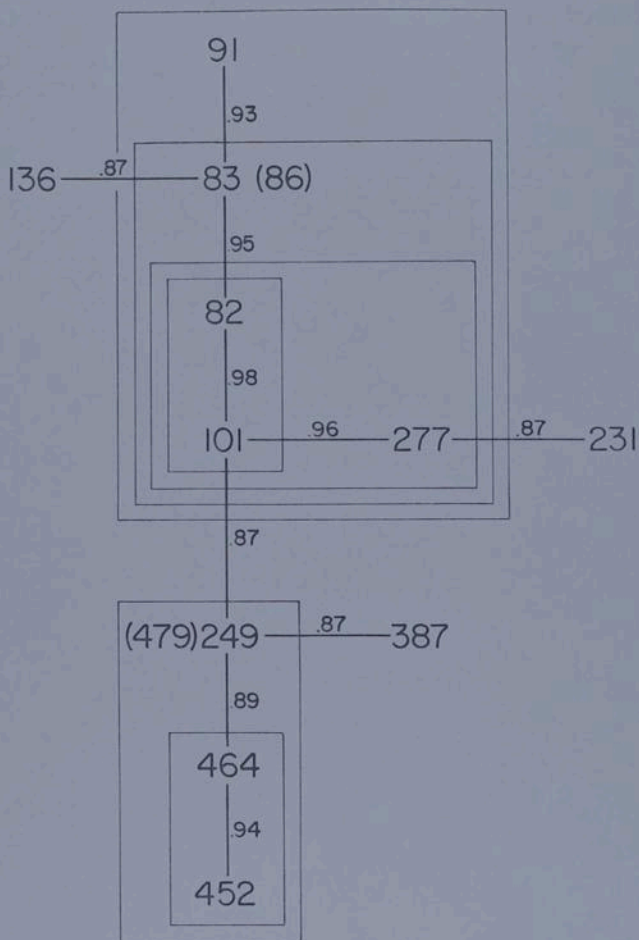
The continental populations have longer leaves than the Jamaican. The one Jamaican population, 136, with long leaves is a highly articulating population (see introductory discussion) and has equally close relatives in four other groups. Populations 83 and 86, coded as identical, differ in that 83 has a light yellow internal stem color instead of the cream color of 86. 86 is unbranched while 83 has one branch at the top.

Table 7 Morphological and Other Descriptive Information for Group 5

Popula- tion Number ^o	Character Number															Country +	Common Name	Color of Root Sub- epidermis	Age at Collection	Date of Collection
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
82	2	2	1	5	2	2	1	5	1	4	3	2	2	2	3	Jamaica ¹	Blue Bud	-	12 months	June 1954
83	2	2	1	5	2	2	1	5	1	4	3	2	2	4	3	Jamaica	Black Stick Buck Buck	-	12 months	June 1954
86	2	2	1	5	2	2	1	5	1	4	3	2	2	4	3	Jamaica	Gordon	-	12 months	June 1954
91	2	2	1	5	2	2	1	5	1	4	3	2	2	4	1	Jamaica	Blue Bitter	-	12 months	June 1954
101	2	2	1	5	2	2	1	5	1	4	3	2	2	1	3	Jamaica	Bullet Tree	pink	12 months	June 1954
136	2	2	1	5	2	4	1	5	1	4	3	3	2	4	3	Jamaica	Bobby Hanson	-	12 months	June 1954
231	2	2	1	2	2	1	1	5	1	4	3	2	3	1	3	Costa Rica ²	Nativa	white	-	June 1955
249	2	2	1	5	2	2	1	5	1	4	3	3	3	1	3	Costa Rica	Chilena	white	-	June 1955
277	2	2	1	5	2	1	1	5	1	4	3	2	2	1	3	Jamaica ¹	-	light pink	12 months	July 1955
387	2	4	1	5	2	2	1	5	1	4	3	3	2	1	3	Brazil ⁹	Pasarinha	deep pink	8 months	Feb. 1961
452	2	2	1	5	2	4	3	5	1	4	3	3	3	2	3	Peru ¹²	-	light reddish purple	10 months	Feb. 1962
464	2	2	1	5	2	3	3	5	1	4	3	3	3	1	3	Peru ¹¹	-	deep purplish pink	7 months	Feb. 1962
479	2	2	1	5	2	2	1	5	1	4	3	3	3	1	3	Peru ²³	-	strong reddish purple	7 months	Feb. 1962

+ See Appendix for exact localities.

^o Population and D. J. Rogers collection number



Description

Root externally rough and brown, dark brown or reddish brown, rarely pinkish brown (110); root flesh white to cream, rarely white grading to brilliant greenish yellow in center (439). Stem brown, rarely silver brown (110); storey length usually moderate but also short or long; scars usually slightly raised but sometimes moderate or large. Unbranched or one branch at top, seldom with two branches. Leaves nine-lobed, rarely three-, four-, or five-lobed (455, see discussion); lobes obovate and margins smooth, rarely with some sinuosity (110), the median lobe usually long, but occasionally moderate or short; lobes of moderate width, rarely wide (439). Petioles green, sometimes reddish green or greenish red. Young foliage color variable but mostly green.

Discussion

This group is related to group 5, differing principally in the number of leaf lobes. Populations 282 and 455 in particular are closely related to group 5. These populations have moderate length median lobes. Leaf characters of 455 are from leaves near the inflorescence, and are thus different from mature vegetative leaves. Population 88 has short lobes but is also very unrelated to any other cultivar of M. esculenta.

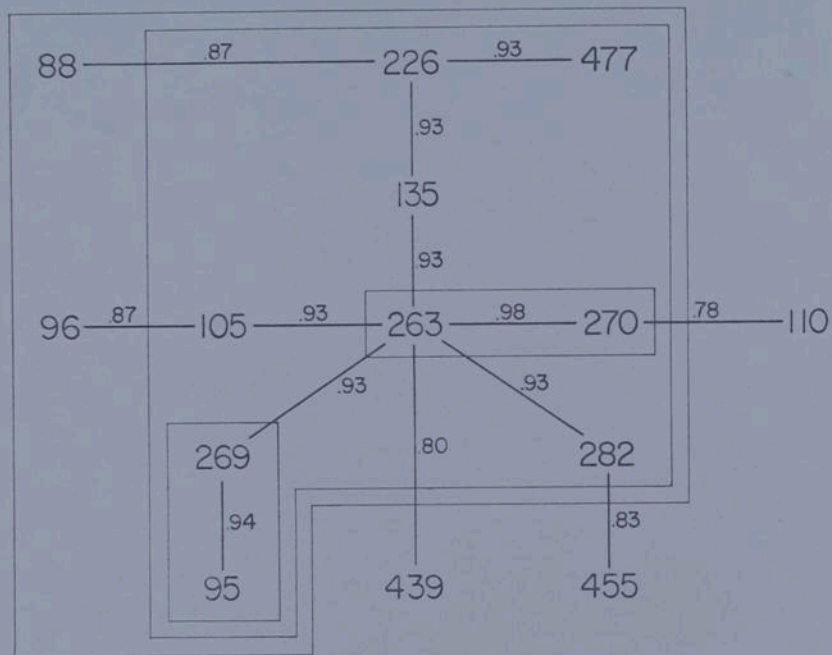
This is a homogeneous group. The two most unrelated specimens are 110 with a pinkish brown external colored root and 439 with the internal parts of the root white grading to brilliant greenish yellow in the center.

Table 8 Morphological and Other Descriptive Information for Group 6

Populatio Number ^o	Character Number												Country ⁺	Common Name	Color of epidermis	Time of Collection	Date of Collection			
	1	2	3	4	5	6	7	8	9	10	11	12								
88	2	2	1	5	1	2	1	6	1	4	3	1	2	4	1	Jamaica ¹	New Green	-	12 months	June 1954
95	2	2	1	5	2	3	1	6	1	4	3	3	2	3	2	Jamaica	Eye Water	-	"	June 1954
96	2	2	1	5	2	4	2	6	1	4	3	3	2	4	1	Jamaica	Agricultural Portland #3	-	"	June 1954
105	2	2	1	5	2	2	2	6	1	4	3	3	2	4	3	Jamaica	New Green	-	"	June 1954
110	2	4	1	2	2	2	1	6	1	4	2	3	2	2	3	Jamaica	Walters	-	"	June 1954
135	2	2	1	5	3	2	1	6	1	4	3	3	2	4	3	Jamaica	Bobby Hanson	-	"	June 1954
226	2	2	1	5	3	2	1	6	1	4	3	3	2	4	1	Costa Rica ²	#1	white	-	June 1955
263	2	2	1	5	2	2	1	6	1	4	3	3	2	4	3	Jamaica ¹	-	light tan	12 months	July 1955
269	2	2	1	5	2	2	1	6	1	4	3	3	2	4	2	Jamaica	-	light tan	"	July 1955
270	2	2	1	5	2	2	1	6	1	4	3	3	2	3	3	Jamaica	-	light tan	"	July 1955
282	2	2	1	5	2	2	1	6	1	4	3	2	2	4	3	Jamaica	-	light tan	"	July 1955
439	2	2	3	5	2	4	1	6	1	4	3	3	3	4	1	Bolivia ³¹	-	light tan	15 months	Jan. 1962
455	2	2	1	5	1	3	1	2	1	4	3	2	2	4	3	Peru ¹⁴	-	light purplish pink	11 months	Feb. 1962
477	2	2	1	5	3	2	2	6	1	4	3	3	2	4	1	Peru ¹⁹	-	light reddish purple	6 months	Feb. 1962

⁺ See Appendix for exact localities.

^o Population and D. J. Rogers collection number



Description

Root externally rough and usually brown, dark brown or reddish brown, sometimes light brown yellow (239, 417, 447) or light brown (104, 234, 238); root flesh white to cream, rarely cream yellow (241) or light yellowish pink (417). Stem usually brown, seldom silver (234, 417) or yellow (238, 481); storey length moderate, seldom long; scars commonly slightly raised, sometimes moderately raised, seldom either large or smooth. Branches usually moderate (state 2), seldom more (cline 227, 239, 447), rarely unbranched (417). Leaf usually seven-lobed, rarely nine-lobed (447) or three-, four-, or five-lobed (481); lobes obovate with smooth margins; the median lobes long, rarely short (315) and of either moderate or wide width. Petiole either green or red, sometimes reddish green, rarely green-red (106). Young foliage either reddish blue or green, seldom bluish green (227, 236).

Discussion

Related to groups 4 and 6 but differs from them in the number of leaf lobes. The group as a whole is inhomogeneous but, nonetheless, contains populations that are closely related. The Jamaican populations are quite similar to one another, while the continental populations contain several closely related populations and a number of quite different single populations. Population 481 could probably have been coded as state 3 (5- or 6-lobed) as well as state 2 (3-, 4-, or 5-lobed) but is, nonetheless, unusual for the size and number of its inflorescence leaves. Population 238 from Costa Rica is equally similar to both 457 and 469 from Peru and almost as similar to 241 from Costa Rica.

Table 9 Morphological and Other Descriptive Information for Group 7

Popula- tion Number	Character Number															Country†	Common Name	Color of Root Sub- epidermis	Age at Collection	Date of Collection
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
	Character State																			
92	2	2	1	5	2	3	2	5	1	4	3	3	2	1	3	Jamaica ¹	Mullings	-	12 months	June 1954
104	2	3	1	5	2	2	2	5	1	4	3	3	2	4	3	Jamaica	Smalling	-	12 months	June 1954
106	2	2	1	5	2	3	2	5	1	4	3	3	2	2	3	Jamaica	Cashew Long Leaf	-	12 months	June 1954
227	2	2	1	5	2	1	3	5	1	4	3	3	3	4	2	Costa Rica ²	Camota	white	-	June 1955
234	2	3	1	1	2	2	2	5	1	4	3	3	2	1	3	Costa Rica	Sra. Esta in La Mesa	light pink	-	June 1955
236	2	2	1	5	2	2	2	5	1	4	3	3	3	4	2	Costa Rica	#2	white	-	June 1955
238	2	3	1	6	3	2	2	5	1	4	3	3	3	3	1	Costa Rica	Amarillo Correinte	light yellow brown	-	June 1955
239	2	1	1	5	2	2	3	5	1	4	3	3	3	4	1	Costa Rica	Zopilota	white	-	June 1955
241	2	2	3	5	2	2	2	5	1	4	3	3	3	3	1	Costa Rica	Camote Corriente	white yellow	-	June 1955
274	2	2	1	5	2	2	2	5	1	4	3	3	2	4	1	Jamaica ¹	-	light tan	12 months	July 1955
275	2	2	1	5	2	2	2	5	1	4	3	3	2	4	1	Jamaica	-	light tan	12 months	July 1955
295	2	2	1	5	2	2	2	5	1	4	3	3	2	4	3	Jamaica	-	pink	12 months	July 1955
*315	2	2	1	5	2	2	2	5	1	4	3	1	2	4	3	Jamaica	-	light tan	12 months	June 1960
379	2	2	1	5	2	4	2	5	1	4	3	3	2	1	3	Brazil ⁶	Pacarú	tan	24 months	Feb. 1961
417	2	1	4	2	3	2	1	5	1	4	3	3	2	1	1	Bolivia ²⁹	-	white	5 months	Jan. 1962
447	2	1	1	5	2	3	3	6	1	4	3	3	3	3	1	Bolivia ²⁷	-	light tan	9 months	Jan. 1962
457	2	2	1	5	3	2	2	5	1	4	3	3	2	1	1	Peru ¹⁷	-	mod. purplish red	ca. 5 mo.	Feb. 1962
465	2	1	1	5	2	2	2	5	1	4	3	3	3	1	3	Peru ¹¹	Negro	" " "	5 months	Feb. 1962
469	2	2	1	5	2	2	2	5	1	4	3	3	3	1	1	Peru ²¹	-	deep purplish- pink	5 months	Feb. 1962
481	2	2	1	6	2	4	2	2	1	4	3	3	3	1	3	Peru ²³	-	light tan	12 months	Feb. 1962

Table 10. Protein and Amino Acid Analyses

Population
315 Proximate Analysis of Manioc Leaves
percent per 100 grams

	As Received	Dry
Moisture	79.86	5.96
Protein	3.73	5.96
Ether Extract ¹	1.20	5.96
Ash	2.23	11.07
Crude Fiber	1.90	9.43
Carbohydrates	11.08	55.01
Calories	70.04	347.8

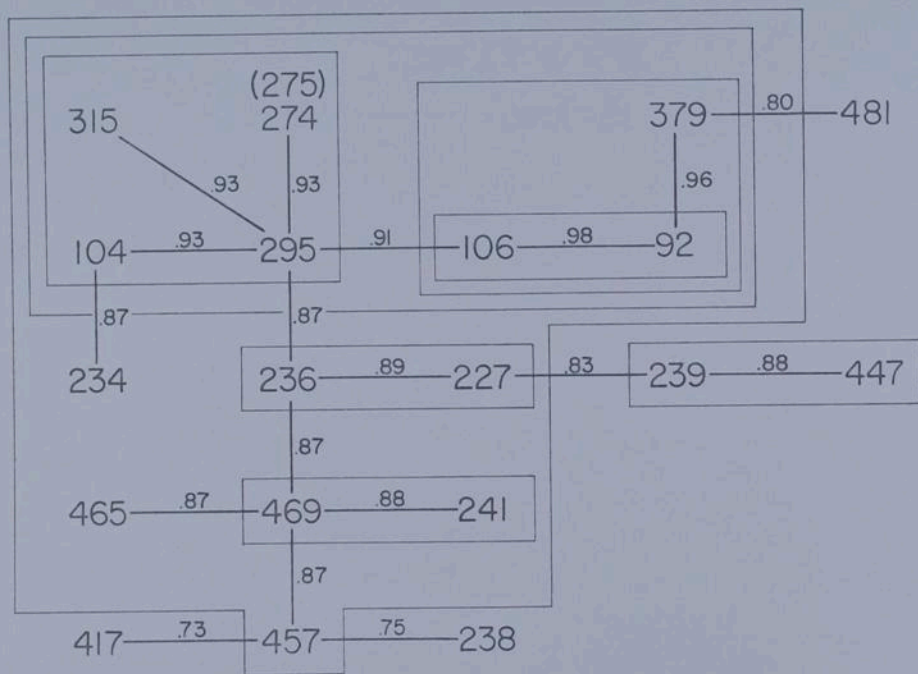
1. Considered as fat for the calculation of caloric values.

Population
315 Amino Acid Determination
percent (16 gm Nitrogen basis)

Alanine	6.11	Lysine	6.65
Arginine	5.20	Methionine	1.56
Aspartic Acid	10.20	Phenylalanine	6.39
Cystine	1.56	Proline	4.95
Glutamic Acid	11.83	Serine	5.24
Glycine	5.25	Threonine	4.91
Histidine	3.28	Tryptophane	1.45
Isoleucine	4.95	Tyrosine	4.82
Leucine	9.32	Valine	5.89

Cyanide in leaf 39 ppm

Analysis made by Food and Drug Research Lab., Inc.,
Maspeth, Queens, Long Island



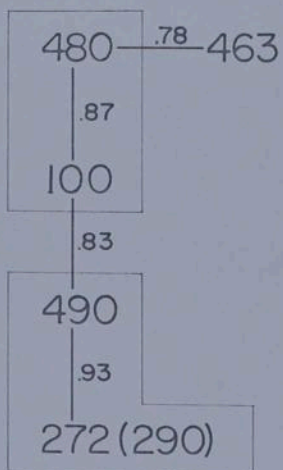
Group 8

Description

Root externally rough and brown, dark brown or reddish brown; root flesh light yellow. Stems usually brown but also silver-brown (480) or yellow (463); storey length medium or long; scars variable from smooth to very large. Branches, two. Leaves usually seven-lobed, seldom with 4, 5- or 6-lobes (463, 480); lobes obovate with smooth margins; the median lobes mostly long but also medium length, all of medium width. Petioles usually green, rarely reddish green (463). Young apical foliage either reddish blue or green.

Discussion

This is a small group of populations unified by the light yellow flesh of the root and moderate branching. Two sections are evident, one with reddish blue young foliage (100, 480, and 463) and the other with green young foliage. Two populations 272 and 290 are coded identically but 290 is a taller plant with more branching occurring in the middle region of the stem and the internal stem color light yellow green rather than light yellow.



Description

Root externally rough, usually dark brown, occasionally brown; root flesh yellow. Stem yellow, rarely brown (492); storey length, moderate, rarely short (78); scars either slightly or moderately raised. Branches, variable but mostly two-branched. Leaves usually seven-lobed, seldom nine-lobed (78, 279); leaves obovate with smooth margins (492, slightly sinuous); median lobes usually long, sometimes moderate, rarely short (314) and usually of medium width, rarely wide (488) or narrow (314). Petiole usually green, seldom reddish green (77, 492), rarely red (488). Young foliage usually green but sometimes reddish blue or bluish green.

Discussion

This a homogeneous group of populations mostly from Jamaica, which may be characterized by their yellow pigments in stems and roots. Population 492 from Manaus, Brazil, is the most dissimilar member of this group but its closest affinity is with 256 and then with 266. 492 is also related to population 100 of Group 8, another group characterized by yellow pigments in the root.

Population 488 from Peru is distinctive in that the proximal inner margin of the basal lobes of the leaf are straight rather than evenly curved.

Table 12 Morphological and Other descriptive Information for Group 9

Population Number ^o	Character Number															Country	Common Name	Color of Root Sub-epidermis	Age at Collection	Date of Collection
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
73	2	2	3	6	2	2	1	5	1	4	3	3	2	4	3	Jamaica ¹	Foul Fat	-	12 months	June 1954
74	2	2	3	6	2	2	2	5	1	4	3	3	2	4	2	Jamaica	Smalling	-	"	June 1954
76	2	2	3	6	2	2	2	5	1	4	3	3	2	4	3	Jamaica	Yellow Heart	-	"	June 1954
77	2	2	3	6	2	3	2	5	1	4	3	3	2	3	3	Jamaica	White Heart	-	"	June 1954
78	2	2	3	6	1	3	2	6	1	4	3	3	2	4	3	Jamaica	Yellow Belly	-	"	June 1954
255	2	2	3	6	2	2	1	5	1	4	3	3	2	4	3	Jamaica	-	white	"	July 1955
256	2	2	3	6	2	2	1	5	1	4	3	3	2	4	1	Jamaica	-	yellow	"	July 1955
266	2	2	3	6	2	3	3	5	1	4	3	3	2	4	1	Jamaica	-	light yellow	"	July 1955
279	2	2	3	6	2	3	3	6	1	4	3	2	2	4	3	Jamaica	-	light pink	"	July 1955
*313	2	2	3	6	2	3	2	5	1	4	3	2	2	4	3	Jamaica	-	yellow	15 months	June 1960
*314	2	2	3	6	2	2	2	5	1	4	3	1	1	4	3	Jamaica	-	pinkish tan	15 months	June 1960
488	2	2	3	6	2	3	2	5	1	4	3	2	3	1	3	Peru ²⁰	Senorita	orange yellow	6 months	Feb. 1962
492	2	2	3	5	2	3	1	5	1	4	2	3	2	3	1	Brazil ³	Mandioca	light purplish pink	?	Feb. 1962

+ See Appendix for exact localities

* Amino-acid analysis follows discussion

^o Population and D. J. Rogers's collection number

Table 13. Protein and Amino Acid Analyses

Population

313 Proximate Analysis of Manioc Leaves
Percent per 100 gm

	<u>As received</u>	<u>Dry</u>
Moisture	80.50	
Protein	5.69	29.18
Ether Extract ¹	.77	3.95
Ash	1.47	7.54
Crude Fiber	1.34	6.87
Carbohydrates	10.23	52.46
Calories	70.6	362.1

1. Considered as fat for the calculation of caloric values.

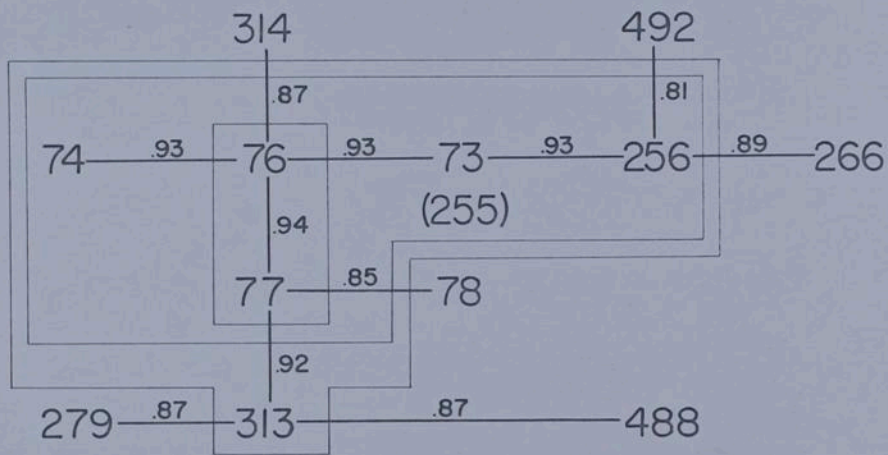
Population

313 Amino Acid Determinations
Percent (16 gm Nitrogen basis)

Alanine	6.18	Lysine	6.18
Arginine	5.70	Methionine	1.78
Aspartic Acid	10.22	Phenylalanine	5.68
Cystine	1.35	Proline	4.47
Glutamic Acid	10.50	Serine	5.11
Glycine	5.44	Threonine	4.76
Histidine	1.95	Tryptophane	1.29
Isoleucine	5.23	Tyrosine	3.98
Leucine	8.98	Valine	5.30

Cyanide in leaf 47 ppm

Analysis made by Food and Drug Research Labs., Inc.
Maspoth, Queens, Long Island, N.Y.



Description

Root externally rough and brown, dark brown or reddish brown; root flesh usually cream yellow to yellow, rarely white (438, and color unknown for 436, 482, 485). Stems brown or yellow; storey length most often moderate, sometimes short, rarely long (265); scars usually moderately raised or large, sometimes smooth or slightly raised. Branches, more than two. Leaves usually 7-lobed, seldom with fewer lobes (325, 482, 485); leaves obovate with smooth margins; median lobes usually short, sometimes of medium length; width, medium. Petiole either red or green. Young foliage usually green, rarely reddish blue (109).

Discussion

The petiole color of the Jamaican populations is green, the South American populations, red (except 325, green). The petiole color of 325 is light yellow green which differentiates it from the green of the Jamaican material. Populations 98 and 107 were coded as identical, but although both 98 and 107 branch near the base, 107 sometimes has three or four branches rather than the more usual two. Population 107 has a faint silver cast to the stem and the root flesh is light yellow rather than yellow. The external color of the root of 98 is dark brown rather than simply brown. The two Peruvian populations 482 and 485 were also coded identically but the upper branches of 482 form a zig-zag pattern, giving the bulk of the plant a much greater spread than 485 and a much less dense appearance. The leaves of 482 are dark green while the leaves of 485 are yellowish green. The mid vein of the leaf of 482 is light brown while that of 485 is purple. The tepals of the latter population are deep pink.

In general this group is homogeneous, particularly the South American members. The Jamaican material can be thought of as peripheral. Groups 8, 9, and 10 are the only groups with rough roots that have yellow root flesh.

Table 14 Morphological and Other descriptive Information for Group 10

Population Number	Character Number															Country	Common Name	Color of Root Sub-epidermis	Age at Collection	Date of Collection
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
80	2	2	3	6	2	4	3	5	1	4	3	1	2	4	3	Jamaica ¹	Norsuck, Portland #2	-	12 months	June 1954
89	2	2	3	5	1	3	3	5	1	4	3	1	2	4	3	Jamaica	Bygrave	-	"	June 1954
98	2	2	3	5	2	4	3	5	1	4	3	2	2	4	3	Jamaica	Blue Bud	-	"	June 1954
107	2	2	3	5	2	4	3	5	1	4	3	2	2	4	3	Jamaica	White Stick	-	"	June 1954
109	2	2	3	5	2	4	3	5	1	4	3	1	2	4	1	Jamaica	Catch Thief	-	"	June 1954
265	2	2	3	5	3	1	3	5	1	4	3	1	2	4	3	Jamaica	-	light tan	"	July 1955
*323	2	2	3	6	2	3	3	5	1	4	3	1	2	1	3	Brazil ⁵	Cachimbo	brilliant yellow	10 months	June 1960
*325	2	2	3	6	1	4	3	3	1	4	3	1	2	4	3	Brazil ⁵	Mameluca	light tan	10 months	June 1960
433	2	2	3	6	2	2	3	5	1	4	3	2	2	1	3	Bolivia ³³	Amarilla	pale pink	12 months	Jan. 1962
436	2	2	0	5	2	2	3	5	1	4	3	1	2	1	3	Bolivia ³⁴	Gancho	pale orange-yellow	18 months	Jan. 1962
438	2	2	1	5	1	3	3	5	1	4	3	2	2	1	3	Bolivia ³¹	Chaparalosa	light tan	15 months	Jan. 1962
442	2	2	3	5	2	3	3	5	1	4	3	1	2	1	3	Bolivia ³²	Moja Blanca	light tan	12 months	Jan. 1962
482	2	2	0	6	2	3	3	2	1	4	3	1	2	1	3	Peru ²³	-	strong reddish purple	7 months	Feb. 1962
485	2	2	0	6	2	3	3	2	1	4	3	1	2	1	3	Peru ²²	Paloma Rumo	moderate purplish pink	6 months	Feb. 1962

+ See Appendix for exact localities

* Amino acid analysis follows discussion.

o Population and D. J. Rogers collection number

Table 15. Protein and Amino Acid Analyses

323 Proximate Analysis of Manioc Leaves
Percent per 100 gm.

	<u>As received</u>	<u>Dry</u>
Moisture	67.01	
Protein	10.74	32.56
Ether Extract ¹	2.82	8.55
Crude Fiber	1.56	4.73
Carbohydrates	16.51	51.43
Calories	134.4	412.9

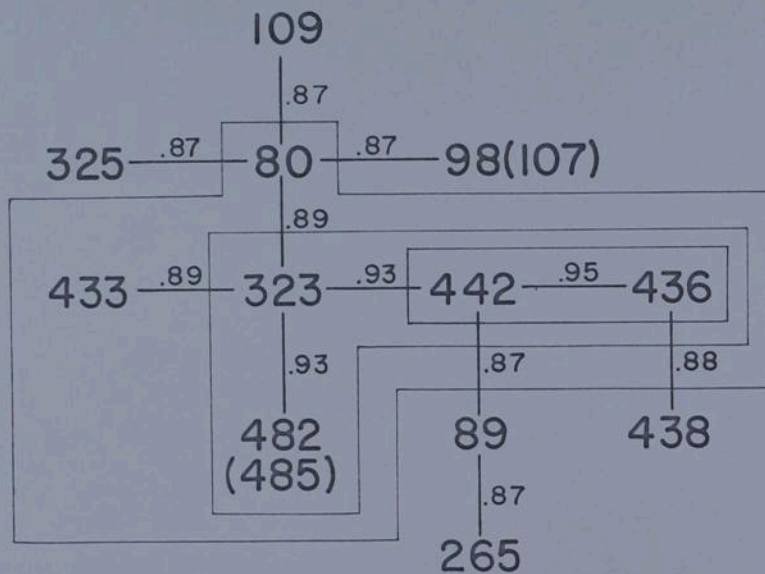
1. Considered as fat for the calculation of caloric values.

323 Amino Acid Determination

Percent (16 gm Nitrogen Basis)

Alanine	6.60	Lysine	5.60
Arginine	6.00	Methionine	1.54
Aspartic Acid	9.81	Phenylalanine	6.65
Cystine	1.45	Proline	5.48
Glutamic Acid	10.14	Serine	4.44
Glycine	5.45	Threonine	4.71
Histidine	3.01	Tryptophane	2.03
Isoleucine	4.78	Tyrosine	3.96
Leucine	8.81	Valine	5.48
ppm Cyanide in leaf	46		

Analysis made by Food and Drug Research Labs, Inc.
Maspeth, Queens, Long Island



Description

Root externally rough and brown or dark brown; root flesh white to cream. Stem usually yellow, seldom silver brown; storey length moderate; scars moderately raised to large, sometimes slightly raised. Branches, two or more. Leaves seven-lobed, rarely nine-lobed (81); leaves obovate with simple margins; length of median lobe variable but mostly moderate; width moderate. Petioles usually green, sometimes reddish green. Young foliage usually green, seldom reddish blue (79, 258).

Discussion

A group of closely allied populations, mostly Jamaican, composed of yellow and two silver-brown stemmed populations with a white or cream colored root cortex. Population 420 is similar to 102 in having very rough roots and almost as similar to 472 with which it agrees in branching pattern. The stem pith of 118 is light amber.

Table 17. Protein and Amino Acid Analyses

Population
321 Proximate Analysis of Manioc Leaves
Percent per 100 gm

	<u>As received</u>	<u>Dry</u>
Moisture	78.17	
Protein	6.50	29.78
Ether Extract ¹	1.59	7.28
Ash	1.69	7.74
Crude Fiber	1.40	6.41
Carbohydrates	10.65	48.79
Calories	82.9	379.8

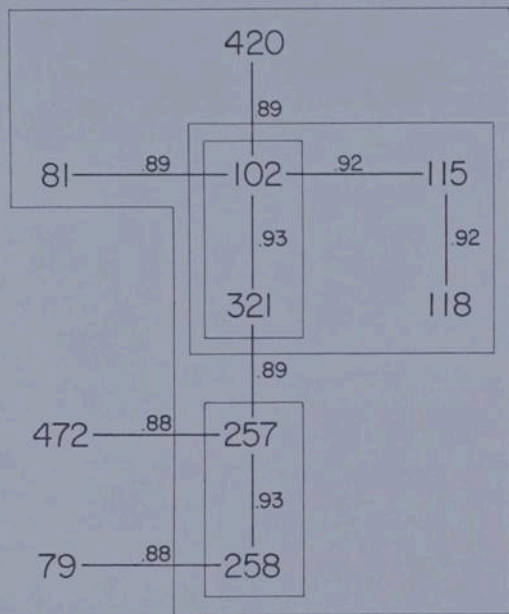
1. Considered as fat for the calculation of caloric values

Population
321 Amino Acid Determination
Percent (16 gm Nitrogen Basis)

Alanine	6.39	Lysine	6.00
Arginine	6.80	Methionine	1.84
Aspartic Acid	9.49	Phenylalanine	6.23
Cystine	1.39	Proline	4.38
Glutamic Acid	9.37	Serine	5.12
Glycine	5.23	Threonine	4.96
Histidine	5.32	Tryptophane	1.59
Isoleucine	4.85	Tyrosine	4.47
Leucine	9.67	Valine	5.82

Cyanide in Leaf 65 ppm

Analysis made by Food and Drug Research Labs., Inc.,
Maspeth, Queens, Long Island

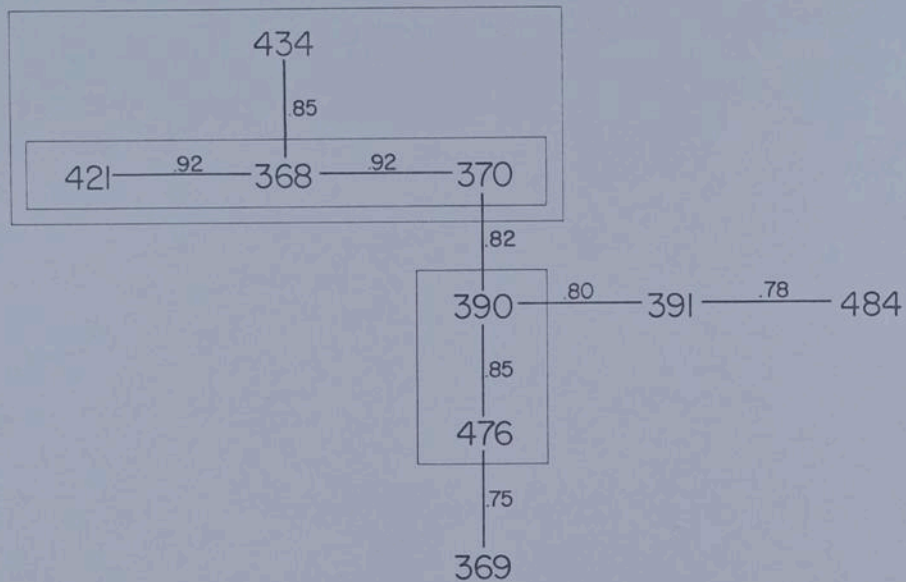


Description

Root externally rough and yellow brown, brown or dark brown; root flesh white, rarely white with pink stripes (434). Stem usually brown, sometimes yellow, rarely silver brown (421); storey length commonly of moderate length, sometimes long, rarely short (391); scars variable from smooth to large. Branches three or more, rarely two branched (369). Leaves with six or fewer lobes, often variable within a population; leaves obovate with smooth margins; the median lobe length most frequently moderate, infrequently short; width most frequently moderate, infrequently narrow. Petiole color mostly red, but sometimes mixed with green. Young foliage green.

Discussion

These populations, though all South American and characterized by having leaves with five or fewer lobes, are on the whole quite variable. Population 484, while most closely related to this group, is quite distinct. It is notable for having a very glaucous leaf undersurface, and for the large number of vascular strands in the roots. Population 369, which is the least similar member of this group, lacks information on external root and root cortex color. 369 is associated with populations in this group because of the low leaf lobe number and, though coded as having five-lobed leaves, has occasional leaves with fewer lobes. Populations 390 and 391 have been discussed with some related populations in Group 3.



Description

Root externally rough and brown, dark brown or yellow brown; root flesh white to cream, rarely brilliant greenish yellow (328, 331). Stems brown, sometimes yellow; storey length commonly moderate, sometimes short rarely long (478); scars variable, rarely smooth (478). Branches variable, often more than two branches. Leaves mostly seven-lobed, sometimes nine-lobed, seldom with five or fewer lobes (419, 462); leaves linear, margins usually sinuate, often simple, rarely pandurate (446); median lobes either long or moderate length, rarely short (451); width narrow, sometimes moderate. Petiole color variable but most often either green or red. Young foliage commonly green, but also bluish green or reddish blue.

Discussion

The linear-lobed rough-rooted populations divide into five sections. The most closely related populations are represented by specimens 99, 276, and 247; the first two populations are from Jamaica and only differ in the size of the scars on the stem and the last specimen is from Costa Rica, differing from the Jamaican populations in the color of the young foliage and petioles. The plants are very similar, even to habit, being tall and slender with few leaves clustered at the top. The Costa Rican population has somewhat shorter leaf lobes. All have very long acuminate lobe apices. The closest relatives to this section are nine-lobed populations in Group 6, an obovate-leaved group. Within the linear-lobed rough-rooted populations they are related directly to another nine-lobed section. This latter section is composed of two relatively unrelated Jamaican populations, 84 and 273, though more similar to one another than to any other population in the study. The above two sections contain all the linear-lobed rough-rooted populations with nine lobes.

Table 19. Morphological and other Descriptive Information for Group 13

Population Number	Character Number															Country ⁺	Common Name	Color of Root Sub-epidermis	Age at Collection	Date of Collection
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
84	2	2	1	5	2	2	2	6	2	2	4	2	1	3	1	Jamaica ¹	Government	-	12 months	June 1954
99	2	2	1	5	2	3	1	6	2	2	4	3	2	3	3	Jamaica	Long Leaf Black Stem	-	"	June 1954
246	2	2	1	5	2	2	1	5	2	3	4	2	1	4	3	Costa Rica ²	Colorado (2)	white	-	June 1955
247	2	2	1	5	2	2	1	6	2	2	4	3	2	4	2	Costa Rica	Blanco	white	-	June 1955
261	2	2	1	5	2	2	3	5	2	2	4	2	1	3	2	Jamaica ¹	-	light tan	12 months	July 1955
273	2	2	1	5	1	3	2	6	2	2	4	2	1	4	3	Jamaica	-	light pink	"	July 1955
276	2	2	1	5	2	2	1	6	2	2	4	3	2	3	3	Jamaica	-	white	"	July 1955
*326	2	2	1	6	1	4	3	5	2	2	4	3	1	4	1	Brazil ^{5a}	Abaete	light tan	10 months	June 1960
*328	2	2	3	5	1	3	3	5	2	2	4	2	1	1	1	Brazil ^{5b}	Wapchuna (Uapichuna)	orange yellow	10 months	June 1960
*331	2	2	3	5	2	2	3	5	2	2	4	2	1	1	3	Brazil ^{5c}	Paica	light tan	10 months	June 1960
380	2	2	1	5	1	3	3	5	2	2	4	2	2	4	3	Brazil ⁶	Macacheira "Picui"	white	24 months	Feb. 1961
419	2	2	1	5	2	4	3	3	2	2	4	2	1	4	3	Bolivia ³⁰	Yuca Blanca	light tan	14 months	Jan. 1962
446	2	1	1	6	1	4	3	5	2	1	4	3	2	3	3	Bolivia ²⁷	-	light tan-white	9 months	Jan. 1962
451	2	2	1	5	2	4	3	5	2	2	4	1	1	4	1	Bolivia ²⁸	-	light tan	16 months	Jan. 1962
460	2	1	1	6	2	2	1	5	2	3	4	3	1	1	3	Peru ¹⁶	-	white	8 months	Feb. 1962
462	2	1	1	5	2	2	2	2	2	3	4	2	1	1	1	Peru ¹⁰	Negro	white	6 months	Feb. 1962
475	2	2	1	6	2	4	3	5	2	3	4	3	1	1	3	Peru ¹⁹	-	light tan	6 months	Feb. 1962
478	2	2	1	6	3	1	2	5	2	3	4	3	1	4	3	Peru ¹⁹	-	reddish purple	6 months	Feb. 1962

⁺ See Appendix for exact localities.

^o Population and D. J. Rogers collection number

* Amino acid analyses follow discussion

^o Variety originally from San Rafael del Sur, Nicaragua.

Table 20. Protein and Amino Acid Analyses

326 Proximate Analysis of Leaves
Percent per 100 gm

	<u>As received</u>	<u>Dry</u>
Moisture	73.78	
Protein	6.63	24.26
Ether Extract ¹	2.00	7.63
Ash	1.56	5.95
Crude Fiber	1.78	6.79
Carbohydrates	14.52	55.38
Calories	101.5	387.2

1. Considered as fat for the calculation of caloric values.

326 Amino Acid Determination
Percent (16 gm. Nitrogen Basis)

Alanine	5.88	Lysine	7.25
Arginine	7.35	Methionine	1.68
Aspartic Acid	9.33	Phenylalanine	5.11
Cystine	0.79	Proline	6.22
Glutamic Acid	10.13	Serine	4.50
Glycine	5.58	Threonine	4.83
Histidine	2.65	Tryptophane	2.50
Isoleucine	4.64	Tyrosine	4.00
Leucine	9.29	Valine	5.40

Cyanide in leaf 74 ppm

Analysis made by Food and Drug Research Labs., Inc.
Maspeth, Queens, Long Island, N. Y.

Table 20. Protein and Amino Acid Analyses

328 Proximate Analysis of Leaves
Percent per 100 gm

	<u>As received</u>	<u>Dry</u>
Moisture	74.82	
Protein	6.60	26.21
Ether Extract ¹	3.35	13.30
Ash	1.40	5.56
Crude Fiber	1.55	6.16
Carbohydrates	12.28	48.77
Calories	105.7	419.6

1. Considered as fat for the calculation of caloric values

328 Amino Acid Determination
Percent (16 gm Nitrogen Basis)

Alanine	5.98	Lysine	5.91
Arginine	5.80	Methionine	1.51
Aspartic Acid	9.10	Phenylalanine	6.06
Cystine	0.95	Proline	4.97
Glutamic Acid	11.00	Serine	4.65
Glycine	5.27	Threonine	4.66
Histidine	2.97	Tryptophane	2.20
Isoleucine	6.31	Tyrosine	3.75
Leucine	8.55	Valine	5.65

Cyanine in leaf 43 ppm

Analysis made by Food and Drug Research Labs.
Maspeth, Queens, Long Island, N.Y.

Table 20. Protein and Amino Acid Analyses

331 Proximate Analysis of Leaves
Percent per 100 gm

	<u>As received</u>	<u>Dry</u>
Moisture	72.58	
Protein	8.80	32.09
Ether Extract ¹	4.18	15.24
Ash	1.81	6.60
Crude Fiber	1.40	5.11
Carbohydrates	11.23	40.96
Calories	117.7	429.4

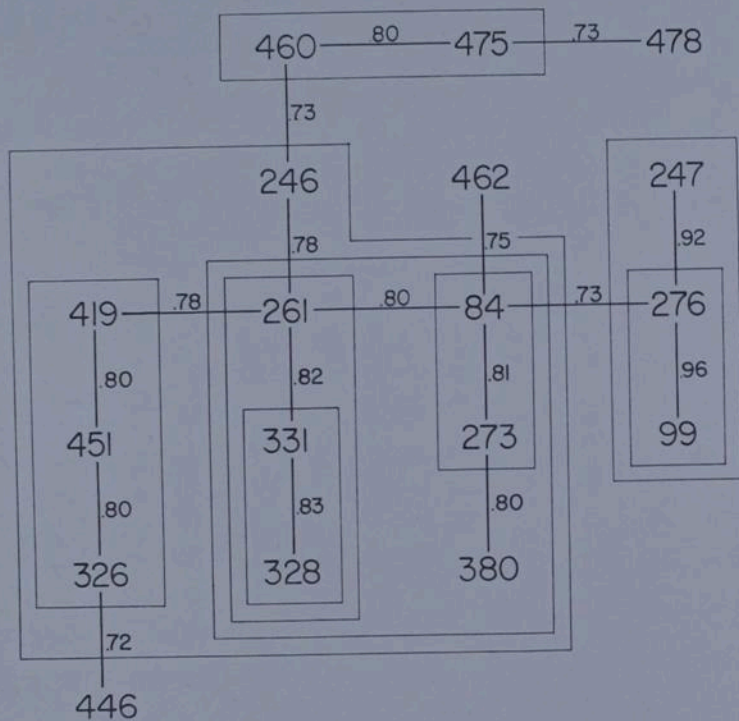
1. Considered as fat for the calculation of caloric values.

331 Amino Acid Determination
Percent (16 gm Nitrogen Basis)

Alanine	6.16	Lysine	4.78
Arginine	6.00	Methionine	1.75
Aspartic Acid	9.50	Phenylalanine	5.89
Cystine	0.97	Proline	4.91
Glutamic Acid	10.13	Serine	4.52
Glycine	5.42	Threonine	5.08
Histidine	3.40	Tryptophane	2.33
Isoleucine	4.70	Tyrosine	4.21
Leucine	8.86	Valine	5.55

Cyanide in leaf 48 ppm

Analysis made by Food and Drug Research Labs.
Maspeth, Queens, Long Island, N.Y.



Discussion

This group can be conveniently divided into three sections represented by the larger enclosed areas (Fig.). The peripheral populations outside the enclosed areas are attached to the closest respective relatives inside.

The first section contains populations 303 and 300 which act as the "nucleus" or node for a series of clines of relationship. Population 303 arrays all the nine-lobed-leaved populations (114, 131, 123, 242, 303) and population 300 is the "nucleus" for all the seven-lobed-leaved populations except populations 319 and 416.

Populations 131 and 416 make up the second section. The two populations of the second section are relatively unrelated but are brought together by the external root color pink, and are similar in having wider leaf-lobes than other linear-lobed populations. Population 416, seven-lobed, is almost as closely related to 288, seven-lobed, (.78) as it is to population 131, nine-lobed, (see nodal distance array, table). Similarly, population 319, seven-lobed, is nearly as closely related (.80) to a seven-lobed leaf population, 225, as it is to 114 and 132. Populations 114 and 131 are the most closely related of Group 14 (.73) to the obovate lobed populations and specifically to population 124 in Group 16.

The third section (111, 224, 288, 450, 456) contains two populations (111, 288) whose affinities to this (or any other smooth-rooted group) is doubtful, as they have very sinuous leaf lobes and it is difficult to determine whether the lobes should be considered as linear or obovate. But, if obovate, the lobes are very narrow for obovate lobes and are therefore most reasonably allied with the other members of group 14.

The peripheral populations of the group are sufficiently unrelated so that they individually could be considered as separate groups. However, since the present arrangement indicates their closest relatives and affinities, it is considered more useful to include them within a single group.

Description

Root externally smooth and light brown to light tan, sometimes pinkish tan to pinkish white; root flesh white to cream, in one population uniquely light orange, 5YR 8/7 (454). Stems silver; storey length commonly moderate, occasionally short or large; scars usually slightly raised, sometimes moderately raised, uniquely large (130). Branching varied, frequently with none or one branch at top, sometimes two-branched, rarely three or more (225, 242). Leaves usually seven-lobed, sometimes nine-lobed; leaf lobes linear with sinuate margins, except Costa Rican populations usually smooth (225, 242, 244); the length of median lobes at least 14-17 cm. long and usually longer, and usually narrow but sometimes narrow-medium in width. Petiole color usually green, sometimes reddish green, rarely red (224, 256). Young foliage green or bluish green, rarely reddish blue (224, 256).

Table 21. Morphological and other Descriptive Information for Group 14

Population Number	Character Number															Country ⁺	Common Name	Color of Root Sub-epidermis	Age at Collection	Date of Collection
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
	Character State																			
111	1	3	1	1	1	2	1	5	2	2	4	2	1	3	2	Jamaica ¹	Blue Top	-	12 months	June 1954
114	1	4	1	1	2	3	2	6	2	2	4	2	1	4	3	Jamaica	Tall Leaf Cotton Tree	white	"	June 1954
130	1	5	1	1	2	4	1	5	2	2	4	3	2	4	2	Jamaica	Long Leaf White Tuber	light pink	"	June 1954
131	1	5	1	1	2	3	2	6	2	2	4	3	2	4	3	Jamaica	Marlie Hill Big Yard	pink	"	June 1954
132	1	3	1	1	2	3	1	6	2	2	4	2	1	4	3	Jamaica	Richmond Stick	light tan	"	June 1954
224	1	3	1	1	2	2	1	5	2	2	4	3	2	1	1	Costa Rica ²	Flor de Lis	white	-	June 1955
225	1	3	1	1	2	2	3	5	2	3	4	2	1	4	2	Costa Rica	-	white	-	June 1955
242	1	3	1	1	2	2	3	6	2	3	4	3	1	3	3	Costa Rica	Vainilla	white	-	June 1955
244	1	3	1	1	2	2	1	5	2	3	4	3	1	3	2	Costa Rica	Mangi	pink	-	June 1955
288	1	3	1	1	1	2	2	5	2	2	4	3	2	3	2	Jamaica ¹	-	white	12 months	July 1955
300	1	3	1	1	2	3	1	5	2	2	4	3	1	4	2	Jamaica	-	white	"	July 1955
303	1	3	1	1	2	3	1	6	2	2	4	3	1	4	3	Jamaica	-	white	"	July 1955
*319	1	3	1	1	2	2	2	5	2	2	4	2	1	4	3	Jamaica	-	light pink	15 months	June 1960
416	1	5	1	1	3	2	2	5	2	2	4	3	2	4	3	Bolivia ²⁹	-	light pink to light tan	5 months	Jan. 1962
450	1	3	1	1	1	2	1	5	2	2	4	3	1	3	3	Bolivia ²⁶	Mojito	tan	4 months	Jan. 1962
454	1	3	3	1	2	2	2	5	2	2	4	3	1	4	2	Peru ¹³	-	light brown to tan	10 months	Feb. 1962
456	1	3	1	1	3	2	1	5	2	2	4	3	1	1	1	Peru ¹⁴	-	white	11 months	Feb. 1962

* Amino acid analysis follows

⁺ See Appendix for exact localities^o Population and D. L. Rogers collection number

Table 22. Protein and Amino Acid Analysis

319 Proximate Analysis of Manioc Leaves
Percent per 100 gm

	<u>As received</u>	<u>Dry</u>
Moisture	79.83	
Protein	6.54	32.42
Ether Extract ¹	1.92	9.52
Ash	1.88	9.32
Crude Fiber	1.66	8.23
Carbohydrates	8.17	40.51
Calories	76.1	377.4

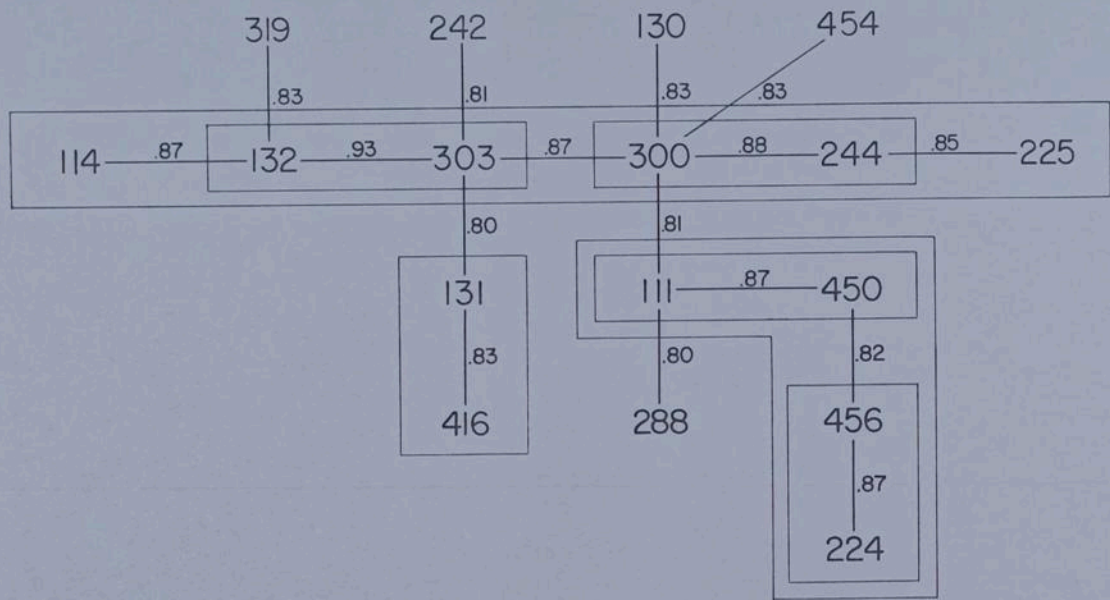
1. Considered as fat for the calculation of caloric values.

319 Amino Acid Determinations
Percent (16 gm Nitrogen basis)

Alanine	5.86	Lysine	7.83
Arginine	5.53	Methionine	1.44
Aspartic Acid	9.80	Phenylalanine	5.79
Cystine	1.29	Proline	4.33
Glutamic Acid	9.50	Serine	5.32
Glycine	5.58	Threonine	5.01
Histidine	1.66	Tryptophane	1.40
Isoleucine	5.26	Tyrosine	4.11
Leucine	8.95	Valine	5.83

Cyanide in leaf 39 ppm

Analysis made by Food and Drug Research Labs., Inc.,
Maspoth, Queens, Long Island, N.Y.



Description

Root externally smooth and light tan (235, light brown) root flesh usually white rarely orange-yellow (444, 461). Stems usually silver, rarely silver-brown (286, 294); storey length usually of moderate length, occasionally long; scars either slightly or moderately raised, rarely smooth (237). Branches usually one or none, rarely two (232, 254). Leaves of most populations nine-lobed, but some are seven-lobed; leaf lobes obovate, with smooth margins; the median lobe usually long, occasionally of moderate length, and either of moderate width or wide. Petiole frequently red, commonly with some red pigment, occasionally only green. Young foliage most frequently green, but often either bluish green or reddish blue.

Discussion

The central population of this group is 120 from Jamaica. The most unrelated section contains populations 232 and 254 from Turrialba, Costa Rica. These are the only two populations of Group 15 that are moderately branched rather than unbranched or with a single branch at the apex of the stem. The populations are closely related to one another and differ only in the color of the young leaves and degree of red in the petiole.

All five Costa Rican populations are seven-lobed and the lower epidermis of the leaves is glaucous. The lower surface of the epidermal cells of population 235 is farinose, of 237 and 240, smooth, and of 232 and 254, slightly tuberculate. Neither the glaucosity nor the nature of the surface of epidermal cells of the underside of the leaves have been used in the analysis since both conditions require further study. Populations 235 and 240 show a suggestion of variability in leaf lobe number as each population has some eight-lobed leaves.

The nine-lobed specimens of group 15, six in number (129, 287, 291, 294, 415, 466), are connected as nearest neighbors except for population 291 which nonetheless shows a close relation to 129 (.87).

The section with populations 466, 444, 461, and 286 has cream yellow to yellow colored root flesh.

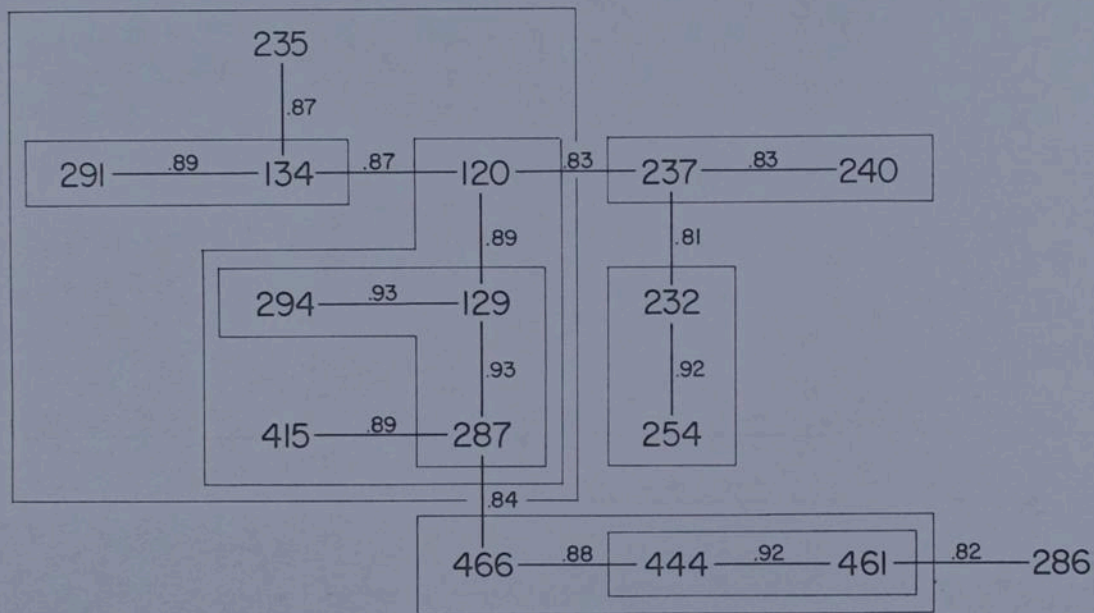
Populations 286 and 294 are atypical in having a silver-brown stem color. These are the only smooth-rooted *M. esculenta* that have any brown tinting in the color of the stem. Population 286 is relatively unrelated (see Table nodal distance array) to other populations. Other than population 461, its closest relative is the other silver-brown stemmed population 294.

Table 23. Morphological and other Descriptive Information for Group 15.

Population Number	Character Number															Country ⁺	Common Name	Color of Root Sub-epidermis	Age at Collection	Date of Collection
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
	Character State																			
120	1	3	1	1	2	2	1	5	1	4	3	3	2	1	3	Jamaica ¹	Agricultural (A.G.R.)	light pink	12 months	June 1954
129	1	3	1	1	2	3	1	6	1	4	3	3	2	1	3	Jamaica	White Margaret	white	"	June 1954
134	1	3	1	1	2	2	1	5	1	4	3	3	2	4	2	Jamaica	Short Leaf Cotton Tree	light tan	"	June 1954
232	1	3	1	1	3	2	2	5	1	4	3	3	3	2	1	Costa Rica ²	Camote Blanca ²	white	-	June 1955
235	1	3	1	1	2	2	1	5	1	4	3	2	2	4	1	Costa Rica	Crema	white	-	June 1955
237	1	3	1	1	2	1	1	5	1	4	3	3	3	1	1	Costa Rica	Higuerilla	white	-	June 1955
240	1	3	1	1	2	2	1	5	1	4	3	2	3	1	2	Costa Rica	Rosada - Jorge Leon	pink	-	June 1955
254	1	3	1	1	3	2	2	5	1	4	3	3	3	3	2	Costa Rica	Cubana Blanca	white	-	June 1955
286	1	3	3	2	2	3	1	5	1	4	3	2	2	1	3	Jamaica	-	white	12 months	July 1955
287	1	3	1	1	2	3	1	6	1	4	3	3	3	1	3	Jamaica	-	light tan	"	July 1955
291	1	3	1	1	2	3	1	6	1	4	3	3	2	4	2	Jamaica	-	light tan	"	July 1955
294	1	3	1	2	2	3	1	6	1	4	3	3	2	1	3	Jamaica	-	pink tan	"	July 1955
415	1	3	1	1	3	2	1	6	1	4	3	3	3	1	3	Bolivia ²⁹	-	light tan	5 months	Jan. 1962
444	1	3	3	1	2	3	1	5	1	4	3	3	3	4	3	Bolivia ²⁴	Amarilla	light tan	8 months	Jan. 1962
461	1	3	3	1	2	3	1	5	1	4	3	3	2	3	3	Peru ¹⁰	Amarilla	brilliant greenish yellow	6 months	Feb. 1962
466	1	3	3	1	2	2	1	6	1	4	3	3	3	3	3	Peru ¹¹	-	light tan	4 months	Feb. 1962

* Amino acid analysis follows

⁺ See Appendix for exact localities^o Population and D. J. Roders collection number



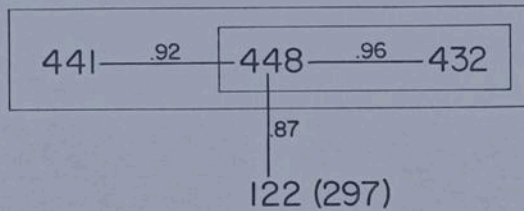
Description

Root externally smooth and light tan; root flesh white (441, white with pink stripes). Stems silver; storey length moderate; scars slightly raised, rarely moderately raised (432). Branches moderate (state 2). Leaves seven-lobed; leaf lobes obovate with some sinuosity or with smooth margins. Median lobe long and of median width. Petioles red. Young foliage variable, reddish blue, bluish green or green.

Discussion

Population 122 differs from 120, the base articulator of group 15, by having more branches. The coding of 297 is identical to 122. Population 297 is a more vigorous plant, erect rather than inclined stems, and with more and larger leaves. The root subepidermis of 112 is light pink whereas 297 is light tan; the latter has a slight yellowing of the silver colored stem.

The remainder of the populations are Bolivian and form a homogeneous unit among themselves. The lobes of the leaves of the three populations as in group 16, are long-obovate and the margins are sinuous.



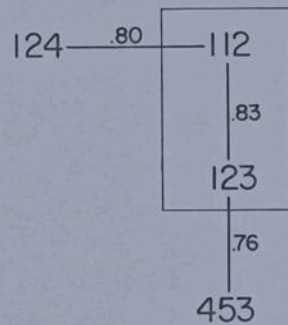
Description

Root externally smooth and pink, pinkish brown, or purplish pink (453); root flesh white. Stem silver, storey length moderate, except 453 long; scars moderately or slightly raised. Branches: one or two, but not one if near top of stem. Leaves five- to nine-lobed; leaf lobes obovate with simple margins or some sinuosity; median lobe of variable length but medium wide. Petiole green. Young foliage green.

Discussion

This group of four populations is not a very homogeneous group, particularly 453 which is one of the four most distinct populations of the smooth-rooted division. The three Jamaican populations are very interesting in respect to their leaf-lobe shape which is best described as long-obovate. Significantly, though for reasons not understood by us at the moment, 112 and 124 are the first populations that articulate with the linear-lobed, smooth-rooted group (populations 114 and 131 of Group 14). Population 112 also articulates with another long-obovate population, 289 of Group 18.

The lobe-width of the Peruvian population 453 was coded as medium (2.6-4.8 cm), but the width is at the upper limit of this state. Another specimen of this population might indicate a wider lobe. The margins of the lobes towards the base appear to diverge at a greater angle and are less curved than usual. This last population is unusual in having the external color of the root and sub-epidermis pink mixed with purple. All four populations have a pinkish cast to the external root color.



Description

Root externally smooth and light brown, except 121 pink brown, and 493 dark orange yellow; root flesh usually white to cream, occasionally yellow. Stems silver; storey length most frequently short but often moderate in length; scars commonly either slightly or moderately raised by occasionally smooth or very large. Branching, more than two branches except 366 branched at midpoint of plant and near base and 445 only at top. Leaves seven-lobed; leaf lobes obovate with smooth margins (289, 327 somewhat sinuous); the median lobes of variable length and commonly of medium width, but may be narrow or wide. Petiole usually green but also red. Young foliage usually green, but sometimes reddish blue (296, 443) or bluish green (332, 406).

Discussion

The group as a whole is rather well characterized by being essentially many branched and with seven-, obovate-, lobed-leaves. The group may be divided into three sections (Fig. 13). The subset originating from 127 have either small or medium length leaf lobes and short stem stories except for 298 with moderate sized storey lengths. The populations in the last subset, originating with 296 usually have moderate sized leaf lobes and the storey lengths are short. The petioles of this last set are red; whereas all the other populations except 121 are green. Population 121 is also distinguished by an unusually large root. There is a distinct broadening of the leaf lobes relative to the length of the leaf in the subgroup articulating with 296. This is true of 296 from Jamaica though by no means as distinctly as with the South American populations which comprise the remainder of the subgroup. The width of the lobe blade of 296 is wide relative to other Jamaican populations.

Table 26. Morphological and Other Descriptive Information for Group 18

Popula- tion Number	Character Number															Country +	Common Name	Color of Root Sub- epidermis	Age at Collection	Date of Collection
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
	Character State																			
121	1	4	1	1	2	3	3	5	1	4	3	3	2	1	3	Jamaica	Agricultural White Stick	-	12 months	June 1954
126	1	3	1	1	1	3	3	5	1	4	3	1	1	4	3	Jamaica	Cotton Tree (Portland #4)	-	"	June 1954
127	1	3	1	1	1	4	3	5	1	4	3	1	2	4	3	Jamaica	White Stick Portland #1	-	"	June 1954
128	1	3	1	1	2	3	3	5	1	4	3	3	2	4	3	Jamaica	Laura	-	"	June 1954
271	1	3	1	1	1	4	3	5	1	4	3	2	2	4	3	Jamaica	-	white	"	July 1955
289	1	3	1	1	2	2	3	5	1	4	2	3	2	4	3	Jamaica	-	pink	"	July 1955
296	1	3	1	1	1	3	3	5	1	4	3	2	2	1	1	Jamaica	-	light tan	"	July 1955
298	1	3	1	1	2	4	3	5	1	4	3	2	2	4	3	Jamaica	-	light pink	"	July 1955
299	1	3	1	1	2	1	3	5	1	4	3	3	2	4	3	Jamaica	-	white	"	July 1955
*318	1	3	1	1	1	3	3	5	1	4	3	1	1	4	3	Jamaica	-	light tan	15 months	June 1960
*327	1	3	3	1	1	3	3	5	1	4	2	2	1	4	3	Brazil ⁵	Xingu	pale orange- yellow	10 months	June 1960
332	1	3	1	1	1	3	3	5	1	4	3	1	2	4	2	Brazil ⁵	Mata Negra	white	10 months	June 1960
366	1	3	0	1	1	3	2	5	1	4	3	2	2	1	3	Brazil ⁴	Manteiga	-	24 months	Feb. 1961
378	1	3	1	1	2	3	3	5	1	4	3	3	3	4	3	Brazil ⁶	Mandioca - Vira Barco	light tan	24 months	Feb. 1961
406	1	3	1	1	1	3	3	5	1	4	3	2	3	1	2	Brazil ⁷	Maniêba branca	light pink	36 months	Mar. 1961
443	1	3	3	1	1	4	3	5	1	4	3	2	2	1	1	Bolivia ²⁴	Blanca	light tan	13 months	Jan. 1962
445	1	3	3	1	1	2	1	5	1	4	3	1	2	1	3	Bolivia ²⁵	Blanca	light tan	12 months	Jan. 1962
493	1	1	1	1	2	2	3	5	1	4	3	3	3	4	3	Brazil ³	Mamacheira	white	?	Feb. 1962

* Amino acid analysis follows

+ See Appendix for exact local titles.

o Population and D. J. Rogers collection number

Table 27. Protein and Amino Acid Analyses

318 Proximate Analysis of Manioc Leaves
Percent per 100 gm

	<u>As received</u>	<u>Dry</u>
Moisture	79.15	
Protein	5.10	24.46
Ether Extract ¹	1.75	8.39
Ash	1.89	9.06
Crude Fiber	1.47	7.05
Carbohydrates	10.64	51.03
Calories	78.7	377.5

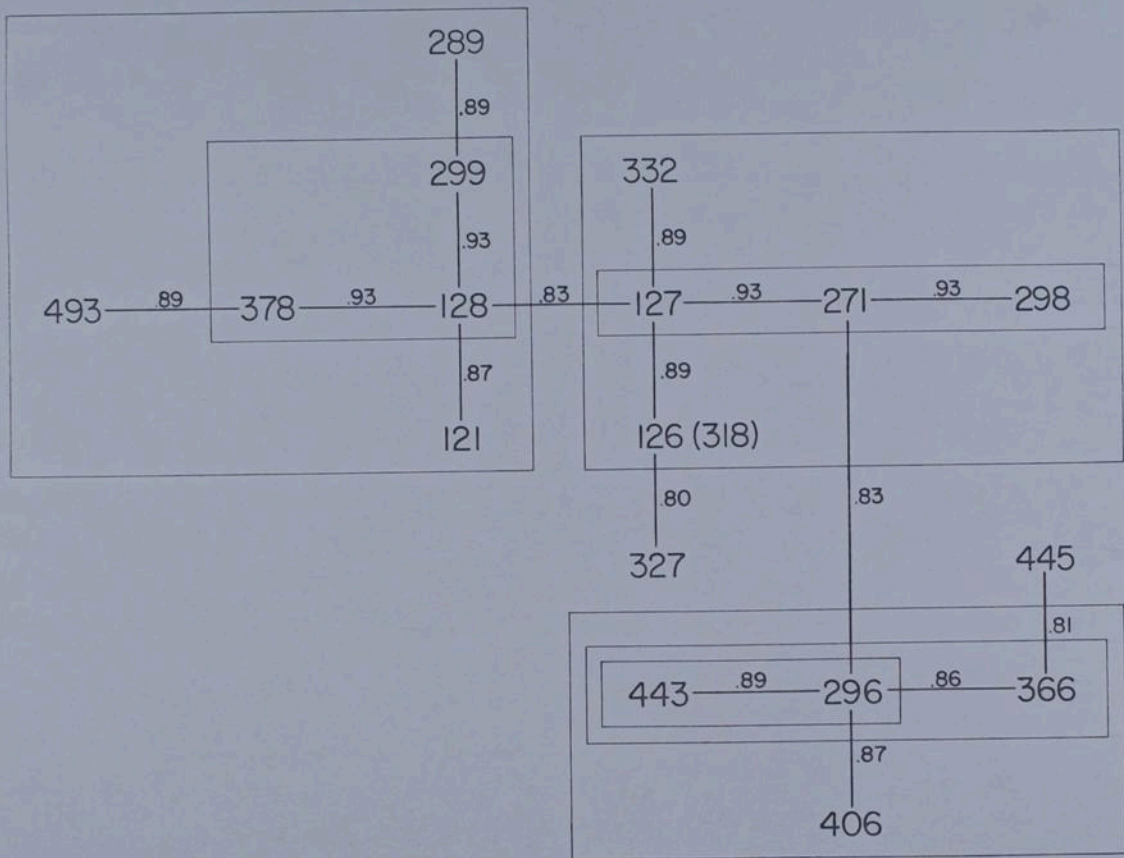
1. Considered as fat for the calculation of caloric values.

318 Amino Acid Determinations
Percent (16 gm Nitrogen basis)

Alanine	5.68	Lysine	8.14
Arginine	5.04	Methionine	1.39
Aspartic Acid	10.10	Phenylalanine	5.79
Cystine	1.99	Proline	6.14
Glutamic Acid	10.10	Serine	4.96
Glycine	5.76	Threonine	4.71
Histidine	2.30	Tryptophane	1.69
Isoleucine	4.92	Tyrosine	4.25
Leucine	8.66	Valine	5.65

Cyanide in leaf 39 ppm

Analysis made by Food and Drug Research Labs., Inc.
Maspeth, Queens, Long Island, N.Y.



Description

Root externally smooth and light tan or light brown, rarely light pink (116); root flesh white, except 329, vivid yellow. Stem silver; storey length moderate; seldom short (316, 405), scars variable. Branching variable, mostly more than two branches, rarely unbranched (316). Leaves commonly five-lobed, seldom seven-lobed or nine-lobed (316); leaf-lobes obovate with smooth margins, seldom with some sinuosity (316, 329); the median lobe short or moderate in length and usually of moderate width, but narrow in 316 and 329 and wide in 405. Petiole color usually with some red color but occasionally green. Young foliage usually reddish blue or bluish green but also green.

Discussion

The upper subset of Group 19, which has no population that can be really considered as a center of radiation unless we elect 458 to that role, has the lobes of the leaves of medium length rather than short as in the lower subset with 125 as the articulation point. The set containing 458 is much more homogeneous than the second set which contains 329 and 405, the two populations which are very dissimilar to other populations of M. esculenta. 329 from Para, Brazil, has obovate inflorescent leaves and both broad-linear and narrow-obovate vegetative leaf-lobes. 405 has very short, very broad obovate leaf-lobes that are dark green, glossy above and light green glaucous below. Its closest relative is 125 from Jamaica that similarly has the underside glaucous colored and the upper side dark green. A note on 405 relates the leaf appearance to M. piauhyensis Ule, indigenous in the same region as the cultivar.

Population 229 from Costa Rica has the underside of the leaves glaucous as frequently occurs in Costa Rican populations. In the same subset, 116, 301 and 302 have the light bluish gray colored undersides of the leaves sometimes found in the Jamaican populations.

Table 29. Protein and Amino Acid Analyses

316 Proximate Analysis of Manioc Leaves
Percent per 100 gm

	<u>As received</u>	<u>Dry</u>
Moisture	79.10	
Protein	5.36	25.65
Ether Extract ¹	2.67	12.78
Ash	1.56	7.46
Crude Fiber	1.57	7.51
Carbohydrates	9.74	46.60
Calories	84.43	404.0

1. Considered as fat for the calculation of caloric values.

316 Amino Acid Determinations
Percent (16 gm Nitrogen basis)

Alanine	5.66	Lysine	5.94
Arginine	4.29	Methionine	1.79
Aspartic Acid	10.64	Phenylalanine	5.85
Cystine	1.24	Proline	4.67
Glutamic Acid	10.43	Serine	4.80
Glycine	5.66	Threonine	5.01
Histidine	2.05	Tryptophane	1.50
Isoleucine	5.08	Tyrosine	4.30
Leucine	7.66	Valine	5.99

Cyanide in leaf 34 ppm

Analysis made by Food and Drug Research Labs., Inc.
Maspeth, Queens, Long Island, N.Y.

Table 29. Protein and Amino Acid Analyses

329 Proximate Analysis of Manioc Leaves
Percent per 100 gm

	<u>As received</u>	<u>Dry</u>
Moisture	72.13	
Protein	7.74	27.77
Ether Extract ¹	4.16	14.93
Ash	1.44	5.17
Crude Fiber	1.11	3.98
Carbohydrates	13.42	48.15
Calories	122.1	438.1

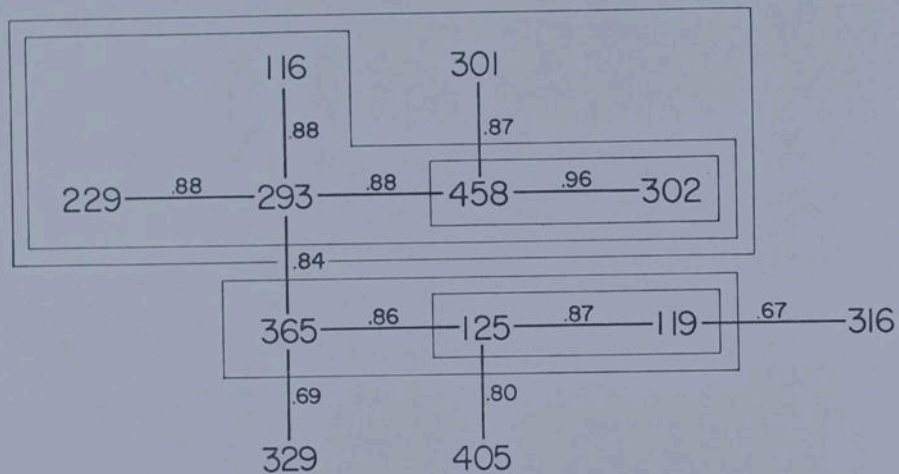
1. Considered as fat for the calculation of caloric values.

329 Amino Acid Determinations
Percent (16 gm Nitrogen basis)

Alanine	6.37	Lysine	6.07
Arginine	5.70	Methionine	1.54
Aspartic Acid	9.48	Phenylalanine	5.45
Cystine	1.02	Proline	6.40
Glutamic Acid	10.80	Serine	5.05
Glycine	5.10	Threonine	4.85
Histidine	3.22	Tryptophane	2.18
Isoleucine	4.54	Tyrosine	3.68
Leucine	8.72	Valine	5.46

Cyanide in leaf 60 ppm

Analysis made by Food and Drug Research Labs., Inc.
Maspeth, Queens, Long Island, N.Y.



		NAME			
1	Uses	NAME		A	If no use, then just place two commas together ,,
2	Vernacular name	NAME		A	If no vernacular name, place two commas ,,
3	Most recent identification, or identification comment	NAME	8	A & B	If in genus <u>Manihot</u> = <u>M.</u> If other genus, write it out. If genus only = <u>M. sp.</u> If sp. corrected but not given, Then <u>M. notangustiloba</u> as three words. Authority (ies) to be included and brackets instead of parentheses. If none, unident. Leave one space between species name and authority.
4	Most recent identifier	NAME	7	A & B	Name space initials with periods. Rogers D.J. If not signed, then ,, no identifier.
5	Other identifications	NAME		B	Name, slash identifier or if no identifier - followed by semicolon if additional identifications.
6	Rogers and Appan Identification	NAME		A & B	At present time two commas ,,
7	Type designation	NAME		B	Leave off -type. Thus; holo, iso, lecto, neo, para, etc. SP = not a type. If not sure if type, then "possible".
8	Author	NAME		B	At all times author of name; If author did not in some acceptable manner designate type of species, then a (;) and designator if known. na = not applicable.
9	Original name of type	NAME		B	Jatropha _____ Manihot _____
10	Collector	NAME		B	
11	Collector Number	NAME		B	
12	Duplicate specimens	NAME	9	A	Use one number, an item number, giving preference to the lowest item number in the duplicated or equivalence set. If no duplicate, write None.
13	Year of collection	ORDERED NAME	8	A	1753 to X written out in numerical form.
14	Month of collection	CODE	5	A	1 thru 12 for each month and 12 additional as follows: 13. Jan. & Feb. 19. July & Aug. 14. Feb. & Mar. 20. Aug. & Sept. 15. Mar. & Apr. 21. Sept. & Oct. 16. Apr. & May 22. Oct. & Nov. 17. May & June 23. Nov. & Dec. 18. June & July 24. Dec. & Jan ,, = month not known
15	Day of Collection	CODE	6	A	32 = varians and is used when monthly descriptor coding is in states 13 thru 24 or variable dates within month - we may with some collections for the latter wish to divide the month into halves, thirds or fourths in which case additional states would have to be created. 1 - 31 + 32 ,, = day not known

K				MODE	COMMENTS
16	Country of collection	NAME	5	A & B	If not known ,,
17	Province/State of Collection	NAME	6	A & B	If not known ,, Unknown either because of inability to determine, or truly unknown.
18.	Precise Locality of Collection	NAME		B	
19.	Herbarium	NAME	6	A & B	Use accepted abbreviations in Index Herbarium. Abbreviate in letters.
20	Herbarium accession #	NAME		B	Accession number in whatever form. No accession number = ,,
21	Condition of flowers	CODE	2	A	0 = no information 1 = absent 2 = present
22	Condition of fruit	CODE	3	A	0 = no information 1 = absent 2 = immature 3 = damaged 4 = mature
23	Condition of roots	CODE	2	A	0 = no information 1 = absent 2 = present
24	Mature seeds	CODE	2	A	0 = no information 1 = absent 2 = present
25	Condition of specimen	CODE	2	A & B	0 = no information 1 = poor 2 = fair 3 = good
26	Additional comments	CODE	2	A	0 = no information 1 = absent 2 = present
27	Comments	NAME		D	

29 August 1967

Mr. Tom Whitfield
1041 Ponderosa Drive, #8
Fort Collins, Colo. 80521

Dear Tom,

I noticed on the table this morning the chart for Group 15. This replaces the one you have already done. One S_{ij} was incorrect and that was sufficient to change the figure.

I have some notes that I made in regard to the figures:

On Fig. 10 (Group I, Linear-lobed foliage, between 450 and 546 add (.82)

On Fig. 13 - Group IIC, insert 332 with an S_{ij} of (.89) to
127 Thus

332				293 (DELETE)	
(.89)		(.93)	291	(.93)	(.84)
127	-----				298
(.89)					
126 [318]		etc.			

On Fig. 12, OMIT II_a and II_d ; also II_c . Omit words Group I both times after Linear-Lobed Foliage.

I hope this is all. Have a good year at school this session.

Sincerely,

Henry S. Fleming