Classification of Japanese Cultivars of Taro (*Colocasia esculenta* (L.) SCHOTT) Based on Electrophoretic Pattern of the Tuber Proteins and Morphological Characters

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Both biochemical and morphological characters were examined in 85 Japanese cultivars of taro (*Colocasia esculenta*) to analyze the phylogenetic relationships. Acrylamide gel electrophoresis of the tuber proteins revealed five patterns, designated as E, I, D, T, and A, for the major cultivars. Additional three patterns were found in the minor cultivars. Cluster analysis of taro cultivars based on 40 morphological characters was also performed. The results which were in agreement with those of the above-mentioned biochemical analyses, enabled to identify seven groups, *i.e.* Eguimo, Dodare (Dotare), Hasubaimo, Ishikawa-wase, Kurojiku, Akame, and Tonoimo groups, for the non-fasciculated taro cultivars, while two, Yatsugashira and Shogaimo groups for the fasciculated ones. The Yatsugashira group showed electrophoretic patterns common to the non-fasciculated Tonoimo group. Similarly the Shogaimo and Dodare groups exhibited a common electrophoretic pattern. The fasciculated cultivars are, therefore, assumed to be derived from the corresponding non-fasciculated cultivars by bud mutation. The Kurojiku group may be at the origin of the Ishikawa-wase group, since these two groups showed a common electrophoretic pattern. The phylogenetic and morphological relationships between the Hasubaimo and Dodare groups were also discussed.

KEY WORDS: *Colocasia esculenta*, Taro, storage protein, phylogeny, cluster analysis, isozyme.

Introduction

Taro, which is native to Southeast Asia, is presently being cultivated widely in the Southeast Asian countries as well as China, Japan and some of the Oceanian countries such as Papua New Guinea and Fiji. The cultivation of taro is considered to have reached Japan during the late Jomon era (B.C. 10 c.), far earlier than the beginning of rice cultivation (NAKAO 1966, SASAKI 1971). The distribution pathway is, however, still obscure. The Japanese cultivars may have some phylogenetic relationship with the cultivars in neighboring countries. Therefore, the analysis of the phylogenetic relationships of the taro cultivars in Japan and the other countries may provide basic information on the development and distribution of agriculture before rice cultivation in Asia, and also valuable information on the breeding of taro cultivars.

The taro cultivars and wild plants in Asia and Oceania are classified into two varieties, *var. esculenta* and *var. antiquorum* by the length of the appendage in the flower (PURSEGLOVE 1972). Although more than one hundred cultivars are known in Japan, the classification of the Japanese cultivars remains difficult, because the flowering of taro is very rare in Japan. KUMAZAWA *et al.* (1956) classified the Japanese cultivars into four varieties consisting of 14 groups based on the morphology of the flower and vegetative organs. HOTTA (1970) recog-

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nized two varieties, *var. antiquorm* and *var. esculenta*, and the latter was classified further into five groups. Recently TANIMOTO and MATSUMOTO (1986) have examined both the morphological characters and isozyme patterns, and they pointed out the discrepancy in the classifications based on the two systems.

In the present report, we attempted to classify the taro cultivars in Japan by analyzing the morphological characters and the electrophoretic patterns of the tuber proteins.

Table 1. Electrophoretic pattern of corm proteins of taro (*Colocasia esculenta*) cultivars in Japan

Identifi- cation No.	Name	Origin	Pattern of corm protein	Classification based on morpho- logical criteria
1	Eguimo	NIVOT ¹⁾	E	Eguimo (E)
2	Eguimo	NIVOT	E	E
3	Eguimo	Mie	E	E
4	Eguimo	Oosaka	E	E
5	Eguimo	Tottori	E	E
6	Eguimo	Ehime	E	E
7	Eguimo	Ehime	E	E
87	Eguimo	Ehime	E	-
8	O-dodare	Gumma	E	-
9	O-dodare	Kanagawa	D	Hasubaimo (H)
10	Wase-hasubaimo	Kanagawa	D	H
11	Wase-kohasubaimo	Kanagawa	D	Dodare (D)
76	Hasubaimo	Kumamoto	D	H
12	Yaichi	Kanagawa	D	H
13	Onna-wase	Ehime	D	D
99	Onna-wase	Ehime	D	H
102	Onna-wase	Gifu	D	H
14	Ishikawa-wase	Saitama	I	Ishikawa-wase (I)
15	Ishikawa-wase-maru	Chiba	I	I
16	Ishikawa-wase	Kanagawa	I	I
17	Ishikawa-wase-Gumma	Kanagawa	I	I
18	Ishikawa-wase-Mikata	Kanagawa	I	I
19	Ishikawa-wase-Fujikata	Kanagawa	I	I
21	Ishikawa-wase	Tottori	I	I
23	Ishikawa-wase-maru	Kagoshima	I	I
75	Ishikawa-wase	Kumamoto	I	-
94	Ishikawa-wase	Ehime	I	I
50	Ishikawa	Oosaka	I	I
20	Bunkyu-wase	Tottori	I	I
22	Ehime-wase	Ehime	I	I
88	Ehime-wase	Ehime	I	I
24	Kohime	Yamagata	D	D
25	Dodare	Gumma	D	D

Table 1. Continued

Identifi- cation No.	Name	Origin	Pattern of corm protein	Classification based on morpho- logical criteria
26	Dodare-maru	Gumma	D	D
29	Dodare	Chiba	D	D
30	Dodare	Kanagawa	I	I
31	Dodare-maru	Kanagawa	D	H
53	Dodare	Oosaka	E	E
58	Dodare	Gumma	D	D
100	Dodare	Gifu	D	D
101	Dodare	Gifu	D	D
27	Aichi-wase	Gumma	D	D
28	Sanshu	Gumma	D	D
32	Waseimo	Ehime	D	D
97	Waseimo	Ehime	D	D
34	Uhan	Tottori	I	Kurojiku (K)
90	Uhan	Ehime	I	K
37	Serebesu	NIVOT	A	Akame (A)
83	Serebesu	Mie	A	A
38	Daikichi	Tottori	T	Tonoimo (T)
74	Daikichi	Kumamoto	A	A
84	Daikichi	Ehime	A	A
85	Akame	Ehime	T	A
78	Akame-amami	Kagoshima	A	A
39	Ebiimo-akakuki	Gumma	T	T
40	Ebiimo-shirokuki	Gumma	D	D
41	Ebiimo	Saitama	T	T
42	Ebiimo	Kanagawa	T	T
43	Tonoimo	Oosaka	T	T
44	Meimo	Tottori	D	H
45	Yatsugashira	Ehime	T	Yatsugashira (Y)
95	Yatsugashira	Ehime	T	Y
47	Takenokoimo	Tottori	C	-
51	Souma	Gumma	D	H
52	Hamakita	Oosaka	I	K
54	Taiwan-otome	Tottori	D	D
55	Shogaimo	Ehime	D	Shogaimo (S)
73	Shogaimo	Kumamoto	T	Y
86	Shogaimo	Ehime	D	S
57	Yamato	Toyama	D	D
79	Kirin-amami	Kagoshima	D	S
80	Shogatsuman-amami	Kagoshima	A	-
81	Ooshimakuro-amami	Kagoshima	A	A
82	Taiwan-shiro	Mie	D	D
89	Niimo	Ehime	T	-
91	Taiwan-imo	Ehime	A	-

Table 1. Continued

Identification No.	Name	Origin	Pattern of corm protein	Classification based on morphological criteria
92	Migashiki	Ehime	M	-
103	Migashiki	Oosaka	M	-
93	Oonoimo	Ehime	D	-
120	Oonoimo	Fukui	D	-
96	Futagoimo	Ehime	I	-
98	Oyazeme	Ehime	D	-
104	Binroshin	Oosaka	B	-
117	Aka-karatori	Yamagata	T	T
118	Shiro-karatori	Yamagata	T	T

¹⁾developed at this Institute (NIVOT).

∴ could not classified, or considered as independent cultivar.

Materials and Methods

A total of 85 Japanese taro cultivars collected and preserved at this Institute was used as materials (Table 1).

Eighty cultivars were cultivated in 1984 and the other five in 1985, based on standard procedures applied in Japan. The morphological characters of the aerial parts were examined in mid-summer, and those of the subterranean parts in autumn after harvest in 5 individuals for each cultivar. These characters and standards for scoring are listed in Table 2. Cluster analysis of the taro cultivars based on the characters was performed using a program developed in the Norin Library (SUZUKI 1978).

For the analysis of the corm proteins, after the fibrous surface and the cortex were removed from a mature corm, 0.2g of the flesh tissue was homogenized with 1ml of 0.1M phosphate buffer, pH 7.0, containing 0.2% Triton X-100. The homogenate was centrifuged and the supernatant was used for the electrophoresis. Non-denatured polyacrylamide gel (7.5%) electrophoresis was carried out according to DAVIS (1964). After the electrophoresis was completed the gel was stained with Coomassie Brilliant Blue 250.

Table 2. Morphological characters of taro (*Colocasia esculenta*) examined

No.	Plant character	Description (score)
1.	growth habit	non-fasciculated (1), fasciculated (9).
2.	plant type	erect (3), medium (5), spreading (7).
3.	plant height	(1)<100cm, 100≤(2)<110, 110≤(3)<120, 120≤(4)<130, 130≤(5)<140, 140≤(6)<150, 150≤(7)<170, 170≤(8)<200, 200cm≤(9).
4.	bud color	white-green (1), reddish (9).

Table 2. (continued)

No.	Plant character	Description (score)
5.	number of leaves emerging from a single corm	(3) < 5, 5 ≤ (4) < 6, 6 ≤ (5) < 7, 7 ≤ (6) < 8, 8 ≤ (7).
6.	number of sprouting cormels	(3) < 3, 3 ≤ (4) < 4, 4 ≤ (5) < 5, 5 ≤ (6) < 7, 7 ≤ (7).
7.	leaf color	light green (3), green (5), dark green (7).
8.	leaf length	(3) < 40 cm, 40 ≤ (4) < 45, 45 ≤ (5) < 55, 55 ≤ (6) < 60, 60 ≤ (7) < 70, 70 ≤ (8) < 80, 80 cm ≤ (9).
9.	leaf width	(1) < 15 cm, 15 ≤ (2) < 20, 20 ≤ (3) < 25, 25 ≤ (4) < 30, 30 ≤ (5) < 35, 35 ≤ (6) < 40, 40 ≤ (7) < 45, 45 ≤ (8) < 50, 50 cm ≤ (9).
10.	depth of leaf base sinus	(3) < 6 cm, 6 ≤ (4) < 8, 8 ≤ (5) < 10, 10 ≤ (6) < 12, 12 ≤ (7) < 14, 14 cm ≤ (8).
11.	leaf thickness	(2) < 0.3 mm, 0.3 ≤ (3) < 0.35, 0.35 ≤ (4) < 0.4, 0.4 ≤ (5) < 0.45, 0.45 ≤ (6) < 0.5, 0.5 mm ≤ (7).
12.	leaf shape	very long (2), long (3), medium-long (4), medium (5), medium-round (6), round (7).
13.	tip shape of leaf	pointed (3), intermediate (5), round (7).
14.	anthocyanin pigmentation in leaf center	absent (1), slight (3), medium (5), intense (8)
15.	anthocyanin pigmentation in leaf vein	absent (1), present (9).
16.	gloss of leaf surface	slight (3), medium (5), intense (7).
17.	petiole length	(1) < 50 cm, 50 ≤ (2) < 60, 60 ≤ (3) < 70, 70 ≤ (4) < 80, 80 ≤ (5) < 90, 90 ≤ (6) < 100, 100 ≤ (7) < 110, 110 ≤ (8) < 120, 120 cm ≤ (9).
18.	sheathed petiole length	(2) < 20 cm, 20 ≤ (3) < 30, 30 ≤ (4) < 40, 40 ≤ (5) < 50, 50 ≤ (6) < 60, 60 ≤ (7) < 70, 70 ≤ (8) < 80, 80 cm ≤ (9).
19.	petiole thickness	(1) < 5 cm, 5 ≤ (2) < 7, 7 ≤ (3) < 11, 11 ≤ (4) < 14, 14 ≤ (5) < 17, 17 ≤ (6) < 20, 20 ≤ (7) < 25, 25 ≤ (8) < 30, 30 cm ≤ (9).
20.	petiole bending at lamina junction	almost absent (1), slight (3), medium (5), deep (7).
21.	anthocyanin pigmentation in petiole at lamina junction	absent (1), slight (3), medium (5), intense (7).
22.	anthocyanin pigmentation at basal part of petiole	absent (1), slight (3), medium (5), intense (7).
23.	distribution of anthocyanin pigment in petiole	absent (1), partial (5), complete (9).
24.	anthocyanin pigmentation at sheathed edge of petiole	absent (1), present (9).
25.	flowering under natural conditions	frequent (1), rare (9).
26.	corm shape	not massive (1), massive (9).
27.	corm weight	(1) < 50 g, 50 ≤ (2) < 100, 100 ≤ (3) < 200, 200 ≤ (4) < 350, 350 ≤ (5) < 500, 500 ≤ (6) < 700, 700 ≤ (7) < 1000, 1000 g ≤ (9).
28.	cormel shape	straight (1), curved (9).
29.	cormel weight	(1) < 100 g, 100 ≤ (2) < 200, 200 ≤ (3) < 300, 300 ≤ (4) < 400, 400 ≤ (5) < 500, 500 ≤ (6) < 700, 700 ≤ (7) < 1000, 1000 ≤ (8) < 1500, 1500 g ≤ (9).

Table 2. (continued)

No.	Plant character	Description (score)
30.	number of cormels	(1)<4, 4≤(2)<6, 6≤(3)<8, 8≤(4)<10, 10≤(5)<12, 12≤(6)<14, 14≤(7)<17, 17≤(8)<20, 20≤(9).
31.	cormlet shape	short (3), intermediate (5), elongated (7).
32.	cormlet weight	(1)<25 g, 25≤(2)<50, 50≤(3)<100, 100≤(4)<200, 200≤(5)<300, 300≤(6)<400, 400≤(7)<600, 600≤(8)<800, 800 g≤(9).
33.	cormlet number	(1)<2, 2≤(2)<5, 5≤(3)<8, 8≤(4)<10, 10≤(5)<12, 12≤(6)<14, 14≤(7)<17, 17≤(8)<20, 20≤(9).
34.	degree of fibrousness of corm & cormel surface	sparse (3), medium (5), dense (7).
35.	stolons	absent (1), present (9).
36.	abortion of axial bud	absent (1), rare (3), medium (5), frequent (7).
37.	external color of corm & cormel	light brown (3), brown (5), dark brown (7).
38.	flesh color of corm & cormel	white-cream (3), reddish (7).
39.	texture of corm	coarse (3), medium (5), fine (7).
40.	texture of cormel	coarse (3), medium (5), fine (7).

Results

Fig. 1. Electrophoretic pattern of tuber storage proteins of taro (*Colocasia esculenta* (L.) Scott). E: Eguimo (No. 2), I: Ishikawa-wase-marui (No. 15), D: Dodare (No. 25), A: Serebesu (No. 83), T: Ebiimo (No. 39), M: Migashiki (No. 103), B: Binroshin (No. 104), C: Takenokoimo (No. 47).

The electrophoresis revealed remarkable variations in the patterns among the varieties of taro, and five patterns were observed in the major cultivars in Japan. These patterns are designated as E, D, I, T and A, using the initials of the names of typical cultivars, Eguimo, Dodare, Ishikawa-wase, Tonoimo and Akame. Additional three patterns, designated as M, B, and C, were recognized for the minor cultivars, Migashiki, Binroshin and Takenokoimo, respectively. These patterns are shown in Fig. 1, and listed in Table 1.

The relationship among taro cultivars based on the morphological characters is illustrated in a dendrogram presented in Fig. 2. This clustering principally corresponded to the grouping based on the electrophoretic pattern. We recognized six major and three minor groups, and also found some addi-

Fig. 2. Dendrogram of taro cultivars based on morphological characters. The name of each cultivar is shown in Table 1. The letters after the identification number indicate the electrophoretic pattern of the tuber protein. Letter on the cultivar at the extreme left indicates the grouping based on the dendrogram.

tional independent cultivars. Of the six groups, the first group, which contained most of the cultivars called Eguimo, was designated as Eguimo (E) group. All the cultivars in this group showed the E pattern in the electrophoresis. The second group contained most of the cultivars named Dodare, and some other cultivars (Dodare (D) group). These cultivars exhibited the D pattern. The third group contained Hasubaimo, Onna-wase, Yaichi and some other cultivars. The cultivars showed the absence of bending of the petiole at the lamina junction, which characterizes the Hasubaimo group (KUMAZAWA *et al.* 1956). This group was, therefore, designated as Hasubaimo (H) group. All the cultivars in this group showed the D pattern. The fourth group contained Ishikawa-wase and Ehime-wase. These cultivars showed the I pattern and were assigned to the Ishikawa-wase (I) group. Most of the cultivars named Akame and Serebesu (Celebes) are classified into one group designated as Akame (A). All except one exhibited the A pattern. The sixth group contained the cultivars named Tonoimo and Ebiimo (Tonoimo (T) group). The electrophoretic pattern was T. Three cultivars named Uhan (Nos. 34 and 90), and Hamakita (No. 52) can be classified into one minor group. These cultivars showed the I pattern, and exhibited a dark purple pigmentation in the petiole, which characterizes the Kurojiku (KUMAZAWA *et al.* 1956). This group was thus designated as Kurojiku (K) group.

The fasciculated cultivars were separated into two groups, including Yatsugashira (Nos. 45 and 95) and (Shogaimo No. 73) in one group (Yatsugashira (Y) group). These three cultivars showed the T pattern. The other fasciculated cultivars, Shogaimo (Nos. 55 and 86) and Kirin (No. 79) showed a close relationship with each other, and exhibited the D pattern in the electrophoresis (Shogaimo (S) group).

Discussion

Comparing morphological and biochemical classifications, TANIMOTO and MATSUMOTO (1986) pointed out the discrepancy in the two systems, whereas in the current study we demonstrated that the results based on the two systems were in agreement. The morphological characters selected here included those sometimes used for the identification of cultivars. Some isozymes change depending on the developmental stage of the organ, while, the protein pattern used here was more stable and thus suitable for use for classification.

Sexual propagation of taro is considered to be impossible under the natural condition in Japan, because of low temperature in the autumn. Variations among taro cultivars may be, therefore, ascribed to mutational events or introduction of new cultivars from neighboring countries.

It is important to elucidate the origin of the fasciculated cultivars. The cultivars in the Yatsugashira and Tonoimo groups showed the same protein pattern, although Yatsugashira is distinct from Tonoimo in its fasciculated type of growth. In addition the Shogaimo group, which also shows a fasciculated type of growth, had the same electrophoretic pattern as a non-fasciculated cultivar, Dodare. In our previous study, the exogenous application of gibberellic acid to a non-fasciculated cultivar resulted in the activation of the lateral buds, and subsequently in fasciculated type growth of the leaves (SATO *et al.* 1986). Moreover, KUMAZAWA *et al.* (1956) already reported the occurrence of spontaneous mutational changes in the growth

habit from the Yatsugashira type to the Tonoimo type, and *vice versa*. Anthocyanin pigmentation in the Yatsugashira group also resembled that in the Tonoimo group. These facts strongly suggest that the Yatsugashira group and non-fasciculated Tonoimo group are closely related, and interchangeable with each other by bud mutation. The mutation may alter the hormonal regulation and then change the growth habit. Similarly, the Shogaimo group is considered to be related to the non-fasciculated Dodare group.

Ishikawa-wase which had not been cited in the old literature, is considered to have originated in Oosaka prefecture (KUMAZAWA *et al.* 1956). Although MATSUBARA and HIDAKA (1970) assumed that Ishikawa-wase was derived from Dodare or Kurojiku by bud mutation, the origin is still obscure. Besides Ishikawa-wase, the pattern I was found only in Hamakita (No. 52), Uhan (Nos. 34 and 90) and Futagoimo (No. 96). In these four cultivars the petiole was dark purple in color, which is a characteristic of the Kurojiku group. TANIMOTO and MATSUMOTO (1986) also pointed out the close relationship between Ishikawa-wase and Hamakita. Moreover, the plants regenerated from meristem culture of Ishikawa-wase sometimes showed a dark purple pigmentation in their petioles, and a reduced production of cormels (NAGATA 1985, MORISHITA 1988). Kurojiku has been recorded as Kuroimo in the literature in the 18th century (KUMAZAWA *et al.* 1956), and is less productive than Ishikawa-wase. The above findings suggest that Ishikawa-wase was derived from the Kurojiku group by bud mutation. The mutation may involve the disappearance of petiole pigmentation, reduction of plant size, and increment of cormel production. The mutant had been selected due to its high cormel production.

Hasubaimo which has been classified as an independent variety, var. *nymphaeifolia* by KUMAZAWA *et al.* (1956) is characterized by the absence of bending at the junction between petiole, while the leaf of Dodare deeply bends (KUMAZAWA *et al.* 1956). It is interesting to note that both the Hasubaimo and Dodare groups showed the same D pattern in the electrophoresis, suggesting a close phylogenetic relationship of the two groups. Comparison of the morphological characters of the cultivars in the two groups revealed that the cultivars in Hasubaimo group showed a smaller plant size, as well as a smaller number and weight of cormlets than the Dodare group.

Some cultivars could not be classified based on the current morphological scoring. Among them Takenokoimo (No. 47) is unique in the presence of elongated tubers, and may be an independent cultivar. Two cultivars named Migashiki (Nos. 92 and 103) were closely related with each other, while Binroshin (No. 104) showed some affinity to Migashiki. The remaining cultivars may be classified in the groups mentioned above. The cultivars Nos. 87 and 8, which showed natural flowering in the other season, and an E pattern in the electrophoresis, may belong to the Eguimo group. Akame (No. 85) was assigned to the A group. But its protein showed the T pattern, suggesting an affinity to the Tonoimo group. In some cases, morphological scoring in a single season did not enable to classify the cultivars. The genetical variations in morphology within a group may be the second reason for the difficulty in classifying these cultivars. Niimo (No. 89) which is considered to belong to the Tonoimo group differed from the normal Tonoimo in the scant pigmentation of the petiole.

The current study also revealed that some of the taro cultivars had not been designated

correctly. Both the biochemical and morphological results suggest that Dodare (No. 53), Dodare (No. 30), and Ebiimo-shirokuki (No. 40) were classified as Eguimo, Ishikawa-wase and Dodare, respectively. Similarly Shogaimo (No. 73) may have been erroneously classified as Yatsugashira.

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塊茎タンパク質の電気泳動パターンおよび形態的形質による 日本産サトイモ品種の分類

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サトイモは熱帯アジア原産であるが、古くから日本で栽培され、多くの品種が知られているが、形態的によく似ており、品種の分類、同定、識別は困難である。

ここでは野菜・茶業試験場で保存している日本産サトイモ 85 品種について形態的及び生化学的形質に基づく分類を試みた。常法により栽培したサトイモの地上部 25, 地下部 15, 合計 40 の形態的形質を調査した。この形質に基づいたクラスター分析により、分析したサトイモ品種のほとんどはエグイモ、土垂 (どだれ)、蓮葉芋、石川早生、唐芋 (とうのいも)、赤芽、黒軸、八つ頭、およびショウガイモの 9 品種群に分かれた。またタケノコイモ、ミガシキ、ピンローシはそれぞれ独立のものと考えられた。しかしいくつかの品種はこの形態的特徴による分析によって品種群に分類することができなかった。

サトイモ塊茎を緩衝液で磨砕しポリアクリルアミドゲル電気泳動にかけ、泳動後タンパク質をクーマシーブリン

アントブルーで染色し、貯蔵タンパク質の泳動パターンを調べた。日本産の主要品種ではE, I, D, A, およびTの5つの、そのほかの品種ではM, BおよびCの3つのパターンが得られた。この貯蔵タンパク質による分類は上記の形態的形質によるそれとよく一致した。

エグイモ群の品種の貯蔵タンパク質は電気泳動でEパターンを示した。土垂、大和、愛知早生、三州、および早生芋等を含む土垂群と、蓮葉芋、早生蓮葉芋、女早生、および女芋等を含む蓮葉芋群は共通のパターンDを示した。石川早生、愛媛早生、および文久早生等の石川早生群の貯蔵タンパク質はIパターンであった。またウーハン、および浜北の黒軸群も石川早生群と同じIパターンを示した。海老芋、唐芋、アカカラトリ、およびシロカラトリ等の唐芋群はTを、セベレス、大吉、および赤芽等の赤芽群はAのパターンを示した。叢生品種では八つ頭群およびショウガイモ群はそれぞれTおよびDパターンを示した。まれな品種であるピンローシン、ミガシキおよびタケノコイモの貯蔵タンパク質はそれぞれ上記の5つのいずれとも異なったパターン、M, BおよびCを示した。

叢生品種である八つ頭と非叢生の唐芋が塊茎タンパク質では同じTパターンを示した。同じく土垂群とショウガイモ群も共通のDパターンを持っていた。熊沢ら（1956）は唐芋から八つ頭によく似た叢生する変異体を報告している。また我々は既に外生ジベレリンにより側芽の伸長が促進され、非叢生品種が叢生となることを報告している。今回の結果と合わせて考慮すると八つ頭、ショウガイモはそれぞれ唐芋、土垂とかなりの近縁であり、植物ホルモン代謝の変異により相互に変化するものと推定される。

石川早生は大阪で出現した品種とされているが、黒軸群と同じタンパク質パターンを示した。黒軸は18世紀の文献に黒芋として記載されており、古くから日本に存在したと考えられる。石川早生は、黒軸より植物体がやや小さく、子芋の着生が多いため栽培品種として優れているが、この黒軸群から突然変異によって生じたものと推定された。この推定は石川早生の成長点培養において葉柄の着色し、子芋の着生の少ない変異個体が出現するという報告によっても裏づけられる。

蓮葉芋群は熊沢らによりサトイモ品種の中では独立の変種とされていたが、タンパク質のパターンからむしろ土垂群と近縁なものと推定された。

日本ではサトイモの開花がほとんど見られない上、主要品種が3倍体であるため、ほとんどすべて栄養体によって繁殖している。今回の結果から日本のサトイモ品種の多くは比較的少数の品種から突然変異によって生じたものと推定される。