New Sweet Potato Cultivars, Benihayato and Satsumahikari, Making a New Turn for Processing

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Introduction

The sweet potato cultivation in Japan has only 400 years history since the introduction from the New World through China. It is believed that the first landing at Ryukyu and Kyushu was in the beginning of 1600's. After the introduction, sweet potato spread to all over Japan except Hokkaido, due to its tolerance against typhoon, drought, pests and diseases and its attributes to produce starch efficiently and to be rich in vitamins. Recent sweet potato cultivation in Japan, however, is suffering from the pressure of imported agricultural products of low prices and from the changes of eating habit of the nation. Under such a situation, unless new scope of sweet potato utilization is exploited, the crop will become one of trivial vegetable crops in Japan's agriculture. In order to run well-ballanced upland farming in Kyushu and Kanto districts where the productivity is very low because of volcanic soil with poor water supply, sweet potato is one of the most indispensable crops. Therefore, the development of new demand at the market is most urgently needed.

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Utilization of sweet potato

Approximately 65,000 ha is planted to sweet potato annually in recent 10 years as shown in Fig. 1[1]. It is only 15% of the acreage in the late 1940's during food crisis immediately after the World War II. Average yield, however, of the total area of Japan has increased by 1.7 times since then. At present, the total annual production of sweet potato in Japan is 1,500,000 t, including 470,000 t for table use through the market, and 54,000 t for starch production. Transition of utilization is shown in Fig. 2[1]. There was a large change in ratios of utilization. Table use through the market largely increased, and processing use also increased although the amount is very limited. Sectors of home use of farmers and feeding to animals greatly decreased. This change was brought about by imported agricultural products which magnificently flowed in after the liberalization of foreign trade, and by improvement of the food situation after the War.

Average consumption of sweet potato per household is 3.7 kg/year in 1986, being only 1/3 of Irish potato. Considering that urban family consumed 32.2 kg/year and farming family consumed 47.4 kg/year in 1955, there has been a drastic decline of consumption of sweet potato in Japan.

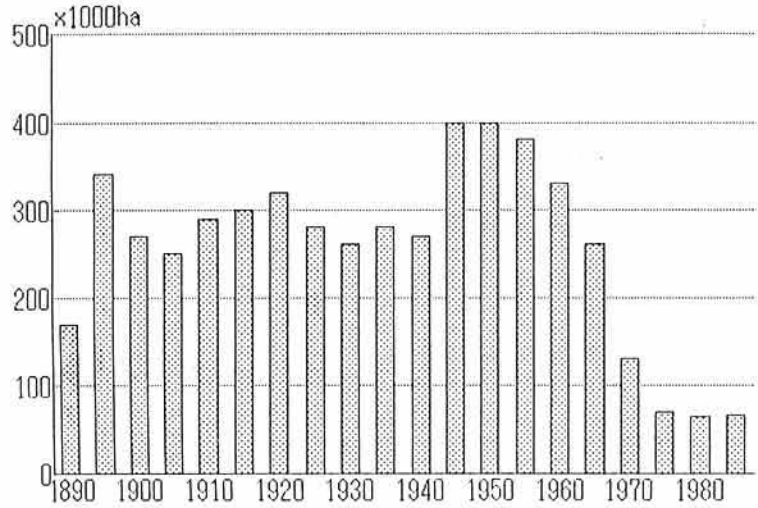

Fig. 1. Acreage of sweet potato cultivation in Japan (1890-1985)

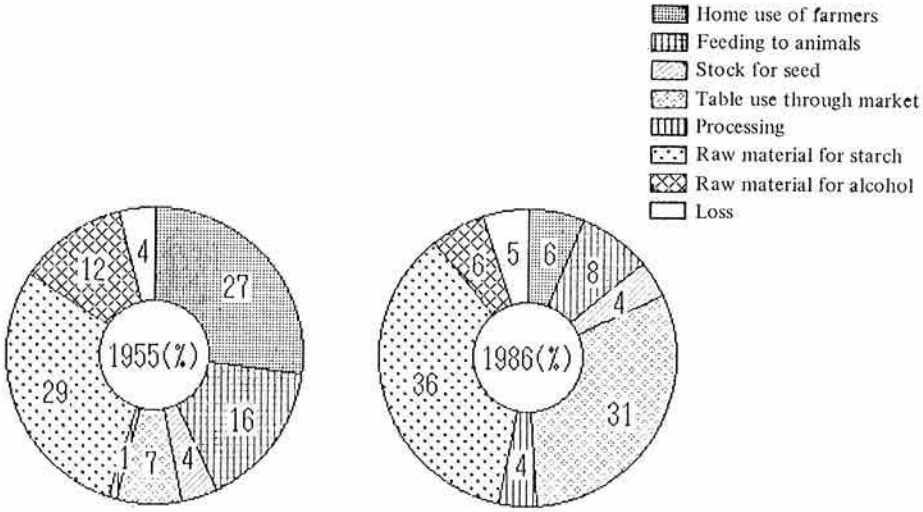

Fig. 2. Utilization of sweet potato in Japan in 1955 and 1986

Sweet potato as raw material for processing

For the purpose of maintaining sweet potato cultivation in Japan, it is important to develop and to distribute new cultivars which meet new demand of the times. There are three major uses in sweet potato; starch production, table use, and processing. For starch use, high starch content, high resistance to pests and diseases and high yield which facilitate low cost production are needed. For table use, high marketability (bright red skin color, good shape, and high palatability) is needed. For processing, besides the attributes for starch production, other attributes required for processing are needed.

Consumption of snack food in Japan has remarkably increased in recent years. In case of Irish potato, only 40,000 t (1% of the total net production) was utilized for processing in 1965. But, in 1975, it increased to

Table 1. Consumption of raw materials for processing in sweet potato and Irish potato

Year	Sweet potato		Irish potato		
	Total production (million t)	Processing use (thousand t)	Total production (million t)	Processing use (thousand t)	Imported amount (Fresh tuber equivalent) (thousand t)
1955	7.18	21.4 (0.3)	2.91	—	—
1960	6.28	53.4 (0.9)	3.59	—	—
1965	4.96	20.2 (0.4)	4.06	34.4 (0.8)	—
1970	2.56	11.4 (0.5)	3.61	40.8 (1.1)	—
1975	1.42	39.4 (2.8)	3.26	169.2 (5.2)	18.2 (0.6)
1980	1.32	38.0 (2.6)	3.42	363.8 (10.6)	217.6 (6.4)
1985	1.53	60.3 (4.0)	3.73	484.2 (13.0)	195.2 (5.2)
1986	1.51	61.1 (4.1)	4.07	550.0 (13.5)	235.3 (5.8)

Numerals in parentheses indicate % to the total production.

360,000 t (11%), and in 1986 to 550,000 t (14%). They are processed to mashed potato, potato chips (crisps) and refrigerated food. In 1986 raw materials for this purpose were not sufficiently supplied by domestic production, so that imported primary products of Irish potato such as dried potato flour and frozen tubers reached 235,000 t equivalent to fresh potato. Consequently, the total amount of Irish potato used for processing (nearly 800,000 t) corresponds to 20% of the total amount of domestic production (Table 1). On the contrary, in case of sweet potato 20,000 t (0.4% of the total net production) was utilized for processing in 1965, and 61,000 t (4.1%) in 1986.

To promote the use of sweet potato for processing it is urgently needed to develop new cultivars which are highly suitable for processed food. If we can develop new types of sweet potato with nice taste and flavor and high suitability for making various snack food, a considerable amount of raw material will be supplied to food processing industry.

New sweet potato cultivars developed for processing

We have developed and released two new sweet potato cultivars for processing, Benihayato and Satsumahikari (Plate 1). Breeding procedures, characteristics and suitable usages of them will be described below.

1) Benihayato (Norin 37)[2,3]

High carotene sweet potato is widely grown for table consumption, especially in China, Taiwan and U.S.A. In Japan, however, it is known in only southern part of Kyushu. High carotene sweet potato is a supply source of vitamine A. Benihayato is a new cultivar for processing use with high carotene content released from our laboratory. It was tested throughout Kyushu in the regional field trials as a breeding line, Kyushu 87, and was officially registered as 'Sweet potato Norin 37' in 1985 by the Ministry of Agriculture, Forestry and Fisheries.

(1) Origin

Benihayato is the result of a cross made in 1980 at the Ibusuki Branch of the Station between Centennial (U.S. cultivar of high carotene content) and Kyushu 66 (a breeding line of high yielding and of nematode resistance). The latter parent is one of the derivatives from the second back cross generation of interspecific hybridization. A wild relative, *Ipomoea trifida* (H.B.K.) G. Don., is contained in the pedigree of Benihayato at the kinship of 1/16. After the F_1 seedling generation all the breeding procedures were carried out at our laboratory (Sweet Potato Breeding Lab., Kumamoto).

(2) Description

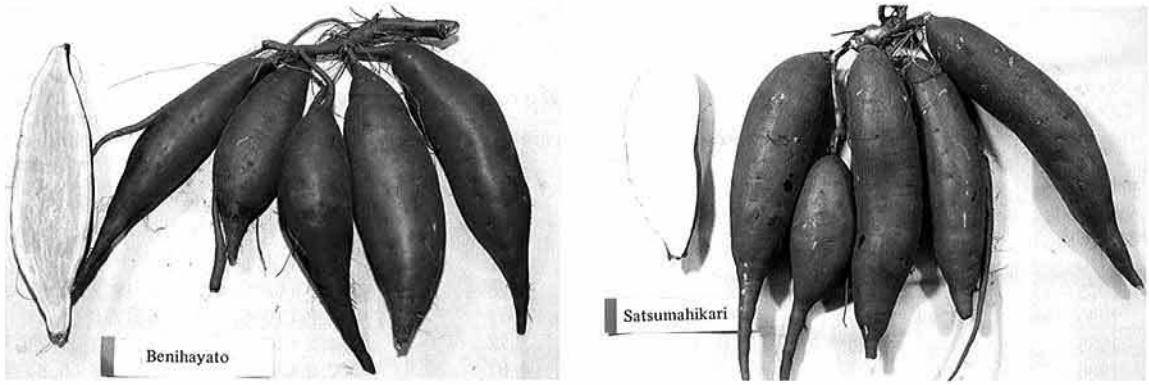

Plate 1. Storage roots of Benihayato and Satsumahikari

Benihayato has good sprouting ability and vigorous vine growth. The leaf is entire with toothing of the leaf margin. Mature leaf color is pale green, but immature leaf color is purplish brown. The storage root (tuberous root) is fusiform, and uniformly good-shaped with bright red purple skin, and bright orange flesh of a moist texture. A distinctive characteristic of Benihayato is the extremely high carotene content in the storage root. As shown in Table 2, total carotenoids content of Benihayato is ca. 12 mg% which exceeds Centennial by more than 50% and is approximately 3 times that of Hayatoimo (U.S. cultivar Port Rico occasionally grown in Kagoshima Prefecture).

(3) Performance

Benihayato is more productive than Koukei 14, the check cultivar of ordinary cooking type used in yield trials carried out in Kumamoto in four years. However, yield trials conducted in Kagoshima Prefecture where Benihayato is expected to be raised, showed that its yield was around 75% of Koukei 14. But Benihayato was not significantly different from the cultivar Hayatoimo, traditionally grown in Kagoshima Prefecture (Table 2), and showed extremely high total carotenoids yield per unit area. Benihayato is moderately resistant to black rot disease (*Ceratocystis fimbriata* (Ellis et Halstead) J. A. Elliot) and root lesion nematode (*Pratylenchus coffeae* Zimmermann) and is resistant to southern root knot nematode (*Meloidogyne incognita* Kofoid et White). Keeping quality of Benihayato is medium to medium-poor and is less superior to that of Koukei 14. Care must be taken on storage temperature when the storage is made in winter.

(4) Utilization

Benihayato can be utilized mostly for processing and cooking. Since the texture is rather soft and moist, it is not suitable to eat after merely boiled or baked. It is recommended to be used for home cooking such as making pie, icecream, cake and so on. For processing, Benihayato can be utilized as dried granules and dried mash which are used for snack food production.

2) Satsumahikari (Norin 40)[4]

Satsumahikari is released for processing use from the Kyushu National Agricultural Experiment Station. It was tested in regional trials throughout Kyushu as a breeding line Kyushu 98 and was officially registered as 'Sweet potato Norin 40' in 1987 by the Ministry.

(1) Origin

Satsumahikari is the result of a cross made in 1980 at the Ibusuki Branch of the Station between Kyushu 84 and Kyushu 88. Both parents are high yielding breeding lines with early maturity and resistance to nematodes. A wild relative, *I. trifida* is utilized in its pedigree, being 5/32 kinship. After the F_1

Table 2. Productivity of Benihayato at different locations

Institution (Location)	Cultivar	Storage root yield (kg/a)	Index (%)	Dry mater content (%)	Total carotenoids content (mg %)
Kyushu Nat. Agr. Exp. Sta. (Nishigoshi, Kumamoto Pref.)	Benihayato	227	142	28.3	11.6
	Koukei 14	166	100	33.8	—
	Koganesengan	237	144	37.1	—
	Hayatoimo (Port Rico)	134	65	34.7	3.3
	Centennial	—	—	—	7.4
Kagoshima Pref. Agr. Exp. Sta. (Kagoshima-city)	Benihayato	253	71	—	11.8
	Koukei 14	362	100	—	—
	Koganesengan	327	91	—	—
	Hayatoimo (Port Rico)	282	82	—	4.4
Osumi Branch, Kagoshima Pref. Agr. Exp. Sta. (Osumi, Kagoshima Pref.)	Benihayato	128	67	—	—
	Koukei 14	191	100	—	—
	Koganesengan	194	102	—	—
	Hayatoimo (Port Rico)	134	70	—	—

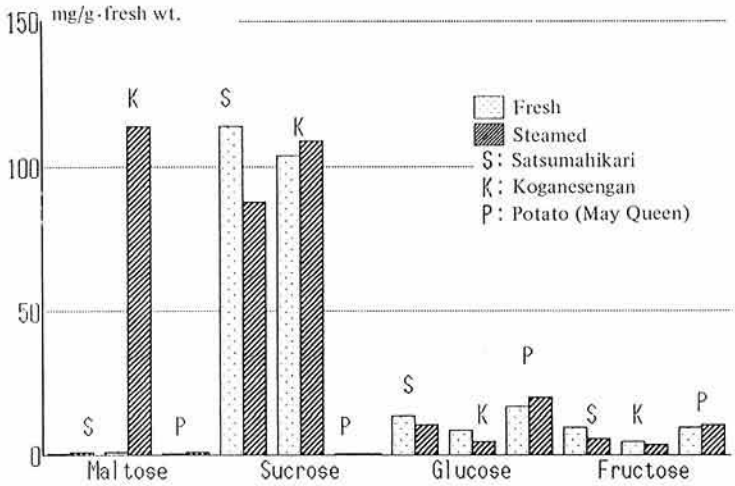

Fig. 3. Analysis of free sugars in storage roots (by TLC)

seedling generation all the breeding procedures were carried out at the Laboratory of Sweet Potato Breeding, Kumamoto. Test for processing use was carried out at the Department of Marketing and Processing, Kagoshima Prefectural Agricultural Experiment Station.

(2) Description

Satsumahikari has good sprouting ability and vigorous vine growth. The leaf is heart-shaped and mature leaf color is green, but immature leaf color is purplish brown. The storage root is fusiform and uniformly good-shaped with deep red skin, and yellowish white flesh of a powdery texture. A distinctive characteristic of Satsumahikari is the lack of β-amylase activity in storage roots. Since the low activity of β-amylase results in very little hydrolysis of starch to maltose (Fig. 3), cooked roots do not taste sweet. It is likely that this characteristic is controlled by a few recessive genes. Satsumahikari can be utilized for processing such as making snack food in a similar manner to that of Irish potato.

Table 3. Suitability of sweet potato and Irish potato for processing (Assessment by the Dept. of Marketing and Processing, Kagoshima Prefectural Agricultural Experiment Station)

Product	Sweet potato		Irish potato	Reasons for suitability or unsuitablity of Satsumahikari
	cv. Satsumahikari	cv. Koganesengan	cv. May Queen	
Traditional foodstuffs				
Imokarinto (Fried dough cookies)	×～△	◎	×	Red skin of storage root, low dry matter content
Mushikiriboshi (Dried chips after steamed)	×	×	×	Low total sugars content after cooking, powdery texture
Daigakuimo (Fried chips with caramel)	×	◎	×	Low total sugars content after cooking
Modern foodstuffs				
French fry	◎	×	◎	Less sweetness, less changeability of quality during storage
Dried flakes (Golden mush)	◎	◎	◎	Excellent yellow coloring when imbibe water
Dried granules	◎	×	◎	Low viscosity, excellent yellow coloring
Fried chips (Crisps)	△～○	◎	△	Browning by reducing sugars to some degree
Sweet stuffs				
Sarashian (Powder jam)	◎	×	○	Low viscosity, plain flavor

◎: Excellent, ○: Good, △: Rather not good, ×: Not good.

Table 4. Productivity of Satsumahikari at different locations

Institution (Location)	Cultivar	Storage root yield (kg/a)	Index (%)	Dry matter content (%)	β-amylase activity (IU/ml)
Kyushu Nat. Agr. Exp. Sta. (Nishigoshi, Kumamoto Pref.)	Satsumahikari	180	113	34.6	—
	Koukei 14	160	100	32.1	—
	Koganesengan	180	113	36.1	—
Kagoshima Pref. Agr. Exp. Sta. (Kagoshima-city)	Satsumahikari	308	95	30.6	0.11
	Koukei 14	325	100	30.5	950.0
	Koganesengan	365	112	33.6	1090.0
Osumi Branch, Kagoshima Pref. Agr. Exp. Sta. (Osumi, Kagoshima Pref.)	Satsumahikari	189	106	—	—
	Koukei 14	178	100	—	—
	Koganesengan	241	135	—	—

Satsumahikari was proved to be utilizable for various food manufactured goods as shown in Table 3 on account of no sweetness and bright yellow coloring of the material. The activity of β-amylase in Satsumahikari is 0.11 IU/ml, and the maltose content in the cooked root is 0.6%. The corresponding values for Koukei 14, a conventional cultivar for table use, are 950 IU/ml and 11.5% respectively (Table 4).

(3) Performance

The yield of Satsumahikari was, in general, higher than that of Koukei 14 and was nearly similar to that of Koganesengan, the most productive cultivar for starch in Kyushu district as shown in Table 4.

Satsumahikari is moderately resistant to black rot disease and resistant to southern

root knot nematode. It is slightly susceptible to the root lesion nematode. The storage roots can be stored fairly well in winter.

Satsumahikari is currently distributed within Kagoshima Prefecture as an officially recommended cultivar for making fried chips and dried granules.

(4) Utilization

Satsumahikari is a cultivar of special use for processing. Eating quality is quite different from ordinary table use sweet potato cultivars. Careful distinction should be made at the planting, forwarding and marketing of Satsumahikari. There is much possibility of utilizing Satsumahikari for various manufactured goods. For example, snack food of fried chips, and bread mixed with the flour processed from Satsumahikari are experimentally manufactured and market studies are going on. Liquors distilled from Satsumahikari have good reputation of consumers. It is likely that there is a great potential demand for Satsumahikari in food processing industry.

Conclusion

Of the two new cultivars for processing released from our laboratory, Benihayato with high carotene content was planted to ca. 150 ha in Kagoshima Prefecture in 1987, the third year from the release. Total production of fresh tuberous root amounted to 2,000 t. Manufactured foodstuffs from this cultivar have already appeared on the market in the forms of ice cream, jam, fermented snack food and crisps. In Kagoshima Prefecture Benihayato is used to make bread and which is served to children at lunch in school. They prefer the carotene sweet potato to carrot as a source of vitamine A. The marketing route has already been established between producers of Benihayato and consumer's co-ops in cities by the name of health food.

As Satsumahikari, non-sweet type, was released only recently, its position at the market is yet unknown. Food manufacturing industry is greatly interested in this cultivar because of its characteristics; low content of total sugars, low viscosity, and bright yellow coloring after cooking. It has great potential in processing ability. It can be successfully used as the raw material for dried granules and mashed flake which are primary products for snack food. Up to now, only Irish potato has been used for the above purpose. The domestic supply of Irish potato for that purpose is not sufficient as already mentioned. To make up 5% of that shortage by using Satsumahikari, an amount of 40,000 t produced from ca. 1,600 ha is anticipated. Seed sweet potato multiplication project is urgently progressing in Kagoshima Prefecture and Kagoshima United Agriculture Cooperatives and private firms are going to construct processing plants of Satsumahikari. It is expected that new manufactured foodstuffs made from Satsumahikari can find a good market in near future.

The remarkable characteristics of Satsumahikari, low β-amylase activity and low content of sugars after cooking, attracted much attention of sweet potato workers in U.S. and China where sweet potato cultivation contributes a great deal to their agriculture.

It is hopefully expected that the new cultivar Satsumahikari exploits new demand for sweet potato and contributes to enhance the role of sweet potato in future agriculture.

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