



# Sweetpotato Research Front

Kyushu Okinawa Agricultural Research Center, NARO No35. December 2019

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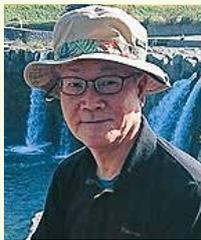
## Taking Sweet and Sweeter Sweetpotato Sweets to the World

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**The Chief Editor of SPORF**



Thank you very much for your interest in this issue of SPORF.

Baked whole sweetpotato has been popular as one of the traditional food items in Japan. Formerly, the texture of baked sweetpotato was mainly favored as a dry texture and the baked sweetpotatoes were often considered a kind of staple food that only satisfied hunger. However, recently, baked sweetpotatoes with a moist texture and high sweetness are favored, especially by the young generation, and are considered a kind of confectionary sweet. Breeding of sweetpotato in Japan also shifted to develop sweeter sweetpotato cultivars and some promising cultivars were developed successfully. In addition, scientific evidences related to the sweetness in sweetpotato storage roots such as starch gelatinization, free sugar content, and amylase activities have also been reported in recent decades.

Recently developed sweeter sweetpotato cultivars are not only used as baked whole sweetpotato but also for primarily processed products such as paste, dried powder and cut dices and for various value-added confectionary sweets such as tarte,

cake, and frozen desert. Nowadays, many confectionary shops and department stores provide attractive commodities featuring the sweetpotato.

At present, the image of the sweetpotato has changed completely and it has been reborn as a new food item from which various superior confectionary products can be created. I have a dream that these excellent sweetpotato confectionary products will bring smiles and happiness to all the people in the world. Our institute, NARO, will continue to put in the best efforts into research and development of the sweetpotato in collaboration with farmers, industries, consumers, and all other people interested in the sweetpotato.



# Research Paper

## Yield and Polyphenol Content of Sweetpotato (*Ipomoea batatas* L.) Foliage in Long-term Greenhouse Cultivation

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### Introduction

Despite the increasing demand for sweetpotato foliage, which is rich in functional components, efficient methods to maximize yield are still needed. In this study, cultivation tests for sweetpotato (line Kyukei05303-3) were conducted over three consecutive years at a greenhouse to characterize seasonal changes in the yield of foliage (leaves and stem-petioles) and the polyphenol content.

### Materials and Methods

Sweetpotato plants (line Kyukei05303-3) were cultivated in a plastic greenhouse (40 m in length, 5 m in width, and 3.2 m in height, covered with a 0.1-mm-thick plastic sheet) at Kyushu Okinawa Agricultural Research Center, NARO (Miyakonojo, Miyazaki, Japan) from 2010 to 2012. The air in the greenhouse was ventilated by forced air. This ventilation was started at 35 °C using a thermostat. Stem cuttings with 2 to 3 nodes were planted to achieve 44.4 cuttings·m<sup>-2</sup> (15 × 15 cm) in 2010 (planted on April 28) and 2011 (planted on April 15), and 66.7 cuttings·m<sup>-2</sup> (15 × 10 cm) in 2012 (planted on April 2), in a 1.5-m-wide nursery bed in the greenhouse. Stem cuttings were used instead of seed tubers to avoid variation in planting density, which may result from variation in the number of sprouts per seed tuber. One month after transplantation, the foliage of plants with more than seven nodes was harvested once a week from

9 am to 10 am. Seven or more seedlings were harvested every week for uniform sampling.

### Results and Discussion

The sweetpotato foliage was harvested from May to November every week, and the average leaf yield was 855.3 g·m<sup>-2</sup>·year<sup>-1</sup> on a dry weight (DW) basis (Table 1)<sup>1</sup>. The yield and polyphenol content of the leaves were negatively correlated ( $r = -0.258, p < 0.05$ ). The yield increased from spring to summer but decreased after mid-August. In contrast, the polyphenol content was the highest in May, low during the summer (June to August), and increased again after September. The average polyphenol content in the leaves was 6.9 g·100 g<sup>-1</sup> DW and the total annual polyphenol yield was 59.0 g·m<sup>-2</sup>. The major component of polyphenols was caffeoylquinic acids. The seasonal changes in caffeoylquinic acids were highly correlated with the changes in total polyphenols. The polyphenol content was significantly ( $r = -0.336, p < 0.01$ ) correlated with air temperature but not with sunshine duration, suggesting that air temperature is an important determinant of the polyphenol content during cultivation. These results provide a basis for the rapid cultivation of sweetpotato for foliage production.

### Reference

1) Kobayashi T. et al. (2019) *Hort. J.* 88: 270-275

Table 1. Annual yield of sweetpotato leaf, petiole and stem average and total amount of polyphenol contents.

Year	Sampling period (Number of Samplings)	Annual yield		Average yield per sampling		Average polyphenol content		Annual polyphenol yield	
		Dry weight (g·m <sup>-2</sup> ·year <sup>-1</sup> )		(g DW·m <sup>-2</sup> )		(g·100g <sup>-1</sup> DW)		(g·m <sup>-2</sup> ·year <sup>-1</sup> )	
		Leaf	Stem-petiole	Leaf	Stem-petiole	Leaf	Stem-petiole	Leaf	Stem-petiole
2010	5/26~10/10 (22)	740.3	-	33.7	-	6.5	-	48.4	-
2011	5/13~11/11 (27)	854.2	606.9	31.6	22.5	7.8	3.5	66.5	21.4
2012	5/11~11/30 (30)	971.5	732.3	32.4	24.4	6.4	2.7	62.3	20
Average		855.3±94.4	669.6±62.7	32.6±0.87	23.5±0.95	6.9±0.64	3.1±0.40	59.1±7.73	20.7±0.70

# Research Paper

## Recent Progress in Breeding Low-Temperature Tolerant Sweetpotato Lines

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Sweetpotatoes are one of the most important crops originating from the tropics, and low soil temperature inhibits thickening of sweetpotato roots. It was reported that the growth of ordinary sweetpotato cultivars is limited below 15–16 °C (Ueki et al. 1987).

In recent years, commercial production of sweetpotatoes has been attempted in the cooler regions of Hokkaido and Tohoku, in addition to warm areas. Agronomical research of sweetpotatoes by public institutes has also begun in Hokkaido. Takahama et al. (2013) reported that Brix (%) of steamed sweetpotato roots was higher when they were cultivated in Hokkaido prefecture than the roots harvested in warmer areas.

To cope with the above, it is important to breed new sweetpotato lines having low-temperature tolerance. Therefore, we have developed a device for testing low-temperature tolerance in sweetpotato vines (Kuranouchi et al. 2019). In this system, containers fabricated from aluminum boards were filled with horticultural soil and set in a cooled water tank (Fig. 1). Sweetpotato vines were cultivated in soil with temperature of 17 °C for three weeks. We recorded vine weight, the number of the leaves, the number of the roots, and root weight. Vines of low-temperature tolerant lines grew vigorously at 17 °C; in contrast, vines of many other cultivars and lines grew moderately or slightly.

Thereafter, we have continued screening from worldwide genetic resources of sweetpotato using this testing device and have found some tolerant lines. These lines have been used as parents to breed new tolerant cultivars and lines. Among them, some lines showed high tolerance to low-temperature conditions with a comparatively high root yield during early planting in a field at Yawara (Tsukubamirai, Ibaraki) (Fig. 2). However, the cooking quality of these lines is insufficient, and it is necessary to improve this characteristic.

It is important to breed low-temperature tolerant sweetpotato lines with high yields and

high quality to expand the crop's cultivation range. We are currently breeding new sweetpotato lines with low-temperature tolerance and with better practical performance.

This work was partially supported by grants from the Project of the NARO Bio-oriented Technology Research Advancement Institution (Research program on development of innovative technology, 27033C).

### REFERENCES

- 1) Ueki & Sasaki, Bull. Fac. Agric., Kagoshima Univ. (In Japanese with English summary) 37, 1-8 (1987).
- 2) Takahama et al., Hort. Res. (In Japanese) 12 (suppl. 1), 234 (2013).
- 3) Kuranouchi et al., Breeding Res. (In Japanese) 12(suppl. 2), 233 (2010).
- 4) Kuranouchi et al., Root Res. (In Japanese with English summary) 28, 3-8 (2019).

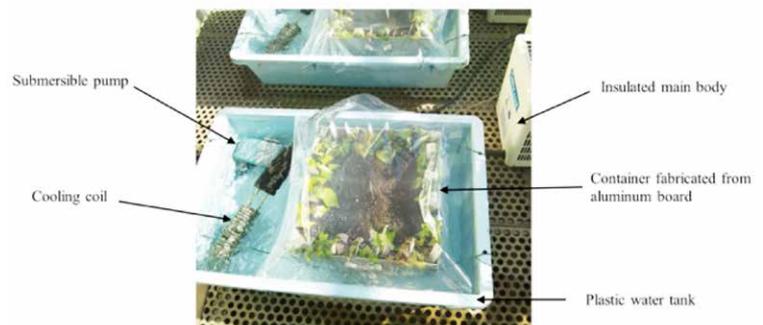


Fig.1 Low soil temperature testing device. Kuranouchi et al. (2019)

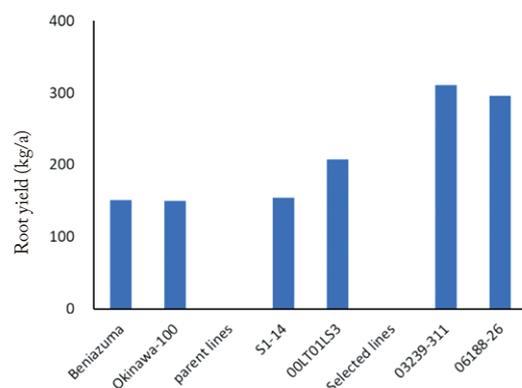


Fig. 2 Root yield (kg/a) of low-temperature tolerance selected lines in early planting. Plants were grown in the experimental field at Yawara in 2009. Modified from Kuranouchi et al. (2010).

# Research Paper

## Inheritance of Low Pasting Temperature in Sweetpotato Starch

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Sweetpotato (*Ipomoea batatas* (L.) Lam.), which is an outcrossing hexaploid, is one of the most important starch-producing crops in the world. During the last decade, new sweetpotato varieties, e.g. ‘Quick Sweet’ and ‘Konamizuki’, which have approximately 20 °C lower pasting temperature, slower retrogradation, and higher digestibility of raw starch than ordinary varieties, have been developed in Japan. Genetic analysis of these variants with low pasting temperature starch was conducted in this study.

We used ‘Quick Sweet’ and breeding lines with low pasting temperature and varieties or lines with normal pasting temperature for crossing. Using 8 variants and 15 normal clones, 26 families were generated. Starch pasting temperature was investigated using a Rapid Visco-Analyzer with 7% starch suspension.

Some of the results of testcrosses are shown in Table 1 (for full results, see Katayama et al. 2015). The upper families from crosses between variant parents generated all variant progenies. In the next families from crosses between normal and variant parents, all progenies had various segregation ratios (1:1, 4:1, or 19:1) for normal and variant phenotypes. The lower families from crosses between normal and variant parents had no variant segregants. These results suggested that this trait is a qualitative character controlled by one recessive allele (designated *spt*) that is inherited in a hexasomic manner.

Fig. 1 shows the relationship between pasting temperature and the number of wild-type *Spt* alleles in the crossing parents. A dosage effect of the wild-type *Spt* allele was found for starch pasting temperature, although the effect was not linear.

Recent studies, in which inhibition of the expression of the starch synthase II gene led to low pasting temperature of sweetpotato starch, suggested that the *Spt* allele encodes starch synthase II. These results will aid breeders develop sweetpotato varieties with a range of starch pasting temperatures.

Reference

Katayama et al. (2015) *Breed. Sci.* 65: 352-356

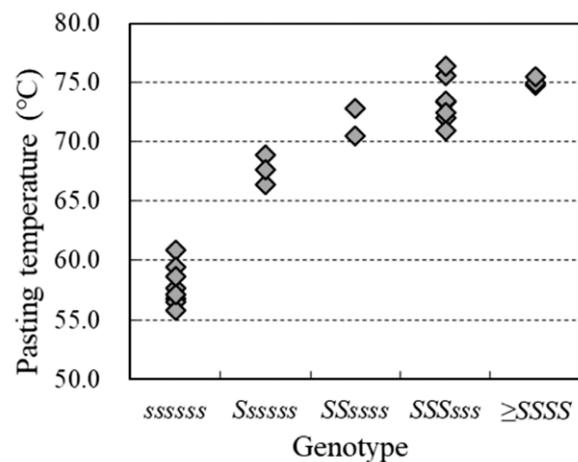


Fig. 1. Relationship between starch pasting temperature and the number of wild-type *Spt* alleles.

Table 1. Segregation of variants with low pasting temperature in F<sub>1</sub> progenies and expected genotypes of their parents

Cross combination		Pasting temperature (°C)		No. of F <sub>1</sub> plants		Expected ratio	$\chi^2$	P	Genotype	
Female	Male	Female	Male	Normal	Variant <sup>a</sup>				Female	Male
99L04-13	Quick Sweet	59.5	56.8	0	27	0 :1			ssssss	ssssss
Quick Sweet	Kyukei00214-3	56.8	67.7	24	23	1 :1	0.021	0.884	ssssss	Ssssss
Norin No.5	Quick Sweet	72.8	56.8	41	9	4 :1	0.125	0.724	SSssss	ssssss
Quick Sweet	Daichinoyume	56.8	73.4	60	4	19 :1	0.211	0.646	ssssss	SSSsss
Sroyutaka	Quick Sweet	75.5	56.8	191	0	1 :0			≥SSSS	ssssss

The segregation ratio fits with the expected ratio, when  $\chi^2 < 3.841$  and  $P > 0.05$ .

<sup>a</sup> Variants with low pasting temperature

# Research Paper

## Sweetpotato Flour can Reduce Crumb Firmness of Rice Bread without Gluten

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### Introduction

Gluten-free bread is suitable for people with gluten sensitivity such as wheat allergy or celiac disease. However, in general, compared with wheat bread, gluten-free bread has an issue of rapid firming during storage. One approach to retard the bread firming is to use starch-hydrolyzing enzyme. Sweetpotato can be a good material for the enzyme source because it contains high content of  $\beta$ -amylase and is easy to obtain at a reasonable price. Here, I report that firmness of rice bread can be reduced using sweetpotato flour.

### Materials and Methods

Five commercial sweetpotato flours and rice flour made from rice 'Mizuhochikara' were used.  $\beta$ -Amylase activities were measured using a  $\beta$ -amylase assay kit. The ingredients of rice bread are rice flour, sugar, salt, olive oil, dry yeast, and water. Part of the rice flour was replaced with sweetpotato flour for bread making. The bread was made using the fast bake mode of a bread maker. Three days after baking, bread firmness was evaluated with a compression test using a creep meter. Loaf volume was measured using the rapeseed displacement method. Specific loaf volume was calculated as volume per weight.

### Results and Discussion

$\beta$ -Amylase activity was extremely low in rice flour ( $< 0.01$  U/g). There were diverse ranges of

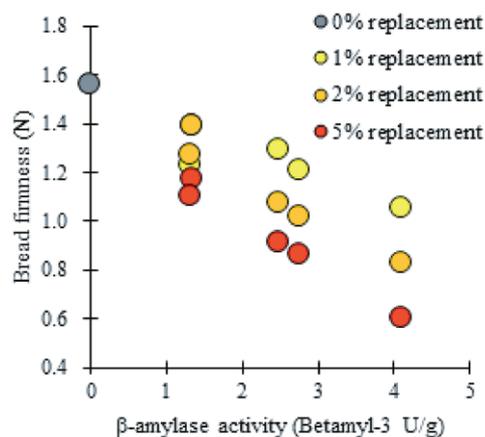


Fig. 1. Crumb firmness of rice bread made from 0, 1, 2, and 5% flour replaced with sweetpotato flour, three days after baking.

$\beta$ -amylase activities among samples from 1.32 U/g to 4.10 U/g. Fig. 1 shows firmness of rice bread made from 0%, 1%, 2%, or 5% flour replaced with sweetpotato flour, three days after baking. Multiple regression analyses showed that there were significant negative correlations between the replacement ratio of sweetpotato flour and bread firmness and between  $\beta$ -amylase activity in sweetpotato flour and bread firmness ( $P < 0.01$ ). These results indicate that  $\beta$ -amylase had a crucial role in reducing bread firmness. Similar results were obtained using purified  $\beta$ -amylase from sweetpotato (data not shown).

Rice bread made from the rice flour replaced with 10% and 20% of sweetpotato flour showed markedly inferior shape (Fig. 2). Multiple regression analyses showed that there were significant negative correlations between replacement ratio and specific loaf volume, and between  $\beta$ -amylase activity and specific loaf volume ( $P < 0.01$ , data not shown). These results indicate that  $\beta$ -amylase is also related to bread shape and that acceptable replacement ratio of sweetpotato flour is up to about 5%.

In this study, some sweetpotato flour samples showed low  $\beta$ -amylase activity and were not suitable for reducing the firmness. To obtain sweetpotato flour with high  $\beta$ -amylase activity, making sweetpotato flour at home is recommended such as by grinding thinly sliced sweetpotato after drying under low temperature such as sun drying.

Detailed results of this study can be seen in Aoki (2018).

### Reference

Aoki, N. (2018) *Food Sci. Technol. Res.* 24: 105–110



Fig. 2. Rice bread made from 0, 1, 2, 5, 10, and 20% flour replaced with sweetpotato flour, respectively, from left to right.

# Editor' Note

## The Weird Crop, “SWEETPOTATO” : Names through History from Spanish Colonization to the Microsoft Era

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For issue No. 32, the editorial board of SPORF had a debate regarding the official term for *Ipomoea batatas* (L.), “sweet potato” or “sweetpotato”. Both words currently appear in scientific reports. Despite extensive discussions, no conclusions were reached.

Here I would like to consider the variation in the naming of this crop, referring to its expansion and introduction history. While colonizing Central to South America, the Spanish conquerors confused two Incan words for this crop, papa and bappa, and created the derivative words bapata, patata, and potato. Potato was eventually used for the Irish potato, *Solanum tuberosum* L. Thereby, *I. batatas* was re-named as “sweet potato”. The National Sweetpotato Collaborators Group of the USA decided in 1989 to spell this crop as “sweetpotato”. The US Department of Agriculture follows this rule, though The International Committee on Taxonomy of Viruses still uses “sweet potato”.

In Japan, two different words are officially used for sweetpotato, “kansho” and “satsumaimo”. The former is read for two Chinese characters, 甘藷 or 甘薯(gān shǔ), which mean “sweet-potato”. Satsumaimo means potato of “Satsuma”, which is the ancient name of Kagoshima before 1800s (see the attached map). More than 20 words are used for sweet potato in Japan, and they somewhat reflect the history of the introduction to locales. The first introduction of sweet potato into Japan is believed to be some years between 16th to 17th centuries in Miyako and Okinawa. Although satsumaimo is most popular in Japan, this word is likely avoided in Kyushu. In the South including Kagoshima, it is called “kara-imo”, the meaning unspecified. In western Kyushu, “Ryukyu- or

Rikin-imo”, meaning Okinawa potato, is preferred though. An interesting name is remained in Tsushima, ko-ko-imo, which means potato for the devotion to parents. Although the islanders often had inevitably suffered from famine due to the severe environmental conditions, sweetpotatoes alleviated the starvation after the introduction. This word thus became the origin of sweetpotato in Korea, “kogma”. How is this crop called in your country?

Currently, most documents, either official or private, are written using Word of Microsoft. I would like to request this company to include “sweetpotato” in the default dictionary of their products, following the rule of their own country; no one will be required to add “this” word to their own personal dictionary. Are you getting tired? OK, let us take a break with some food, such as “sweet corn” icecream or spicy snacks flavored hot with “hotchili”. Am I spelling these words wrongly? Or, do you like “hot dog” or “hotdog”? Comments and opinions to [ichis@affrc.go.jp](mailto:ichis@affrc.go.jp).



### Sweetpotato Research Front (SPORF)

Published by the support from the Kyushu Okinawa Agricultural Research Center / NARO

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