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Sweetpotato Research Front

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Contents

Our Targets in Livestock and Grassland Research

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A quarter of the animal production output in Japan is produced in the Kyushu-Okinawa region, but feed self-sufficiency there is not high. The region's warm climate contributes to plant growth, but in the summer farm animals are exposed to heat stress, resulting in reduced productivity and fertility.

The Livestock and Grassland Research Division of NARO/KARC has three mandated research fields: the improvement of feed self-sufficiency, biomass utilization, and climate change adaptation technologies for farm animals. We have completed the second five-year research period and started the new five-year research period this year.

To improve feed self-sufficiency, we have developed preparation and feeding techniques of sweetpotato, rice, and barley shochu distillery by-product concentrate for beef and dairy cattle, and calf production techniques that use year-round grazing. In the new period, we will develop fermented Total Mixed Ration (TMR) feed that consists mainly of forage rice as a starch source and shochu distillery by-product concentrate as a protein source. We will also develop Japanese beef cattle finishing production techniques based on year-round grazing with corn silage. Furthermore, we will develop forage crop varieties of oats with activity against nematodes, Italian ryegrass with rapid growth in winter, highly digestible sorghum, and a cultivation method for harvesting five forage crops over two years.

In biomass utilization, technologies have been established for producing nitrogen-enriched compost. Plans are being developed to eliminate odor emission by bacteria during composting. The development of a biomass boiler that can burn animal waste and chopped bamboo is another goal during this period. Heat from the boiler will be used for warming facilities for cultivation, and ash will be used for fertilizer. Breeding will be performed to develop *Erianthus* varieties that produce a large amount of biomass and are suitable for machine harvesting; low-cost cultivation methods will then be proposed.

We found that anthocyanins from purple sweetpotato effectively reduced intracellular oxidative stress in heat-shocked embryos, and dietary sweetpotato leaf and vine suppressed lipid peroxidation in the muscle of pigs reared in a chronically hot environment. These results indicate that functional ingredients have some effect on animal production and fertility. We will propose adaptation technologies for farm animals in a hot environment via suppressing oxidative stress with antioxidative components.

Research Paper

Satsumamasari: New Sweetpotato Cultivar for Sweetpotato *Shochu* (Spirits)

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Introduction

"Satsumamasari" is a newly released cultivar for *shochu* (spirits) developed at the NARO Kyushu Okinawa Agricultural Research Center. It was evaluated at prefectural agricultural experimental stations as breeding line "Kyushu No. 153" and submitted for variety registration in 2010.

Origin

"Satsumamasari" is the progeny of a cross between "Tokimasari" and "Kyushu No. 102" conducted at the Sweetpotato Crossing Laboratory in 2000. "Tokimasari" has a high brewing ability and "Kyushu No. 102" has a high starch content and high yield. Two hundred forty nine seeds were sown in the nursery. Selection was based on field performance, starch content and brewing ability.

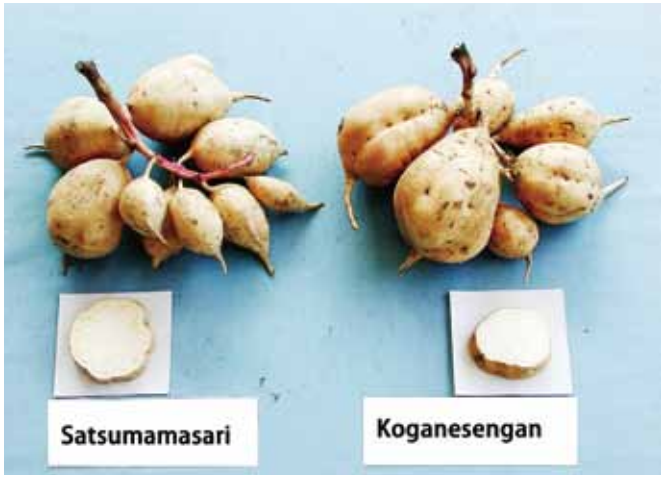
Description

"Satsumamasari" exhibits slightly better sprouting ability and is a slightly prostrate plant. The top leaves are light green. The mature leaves are green and toothed-triangular. The vine diameter is intermediate, with a somewhat short internode length. Pigmentation of anthocyanin is intermediate in the veins and the vine nodes. The storage root is short and fusiform with a yellowish white skin and yellowish white flesh. The appearance of the roots is intermediate.

Performance

The yield of "Satsumamasari" is comparable to that of "Koganesengan", a leading Japanese variety for *shochu* (spirits). The dry matter content and starch content of "Satsumamasari" are 1 to 2% higher than those of "Koganesengan". The starch yield of "Satsumamasari" is higher than that of "Koganesengan". The alcohol yield of "Satsumamasari" is higher than that of "Koganesengan" in the brewing of *shochu*. *Shochu* made from "Satsumamasari" has a sweet and fruity flavor, and refreshing taste.

"Satsumamasari" is somewhat susceptible to black rot, is moderately resistant to root-lesion nematode, and is resistant to root-knot nematode. The storage ability of "Satsumamasari" roots is superior to that of "Koganesengan".



Yield and other traits of "Satsumamasari" in a yield trial (2005 to 2009, standard harvesting)

Traits	Satsumamasari	Koganesengan
Root yield (t/ha)	32.1	29.8
Starch content (%)	25.2	23.6
Starch yield (t/ha)	8.1	7.1
Appearance of roots[1)]	I	SL
Alcohol yield (L/t of root)	201	191
Root-knot nematode resistance[2)]	R	SS
Root-lesion nematode resistance[2)]	I	SS
Black rot resistance[2)]	SS	S
Storage ability of root[1)]	H	SL

1) H: High. SH: Slightly High. I: Intermediate. SL: Slightly Low. L: Low
2) R: Resistant. SR: Slightly Resistant. I: Intermediate. SS: Slightly Susceptible. S: Susceptible.

The State of Sweetpotato Breeding for Top Use in Japan

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Introduction

Though sweetpotato leaves have a high nutritional content, they are used as a vegetable in only a few provinces in Japan because of the bad taste of ordinary sweetpotato leaves. "Suioh", released in 2004 at the Kyushu Okinawa Agricultural Research Center, is a sweetpotato cultivar with good-tasting leaves and petioles. For this reason, the tops of "Suioh" is acceptable as a vegetable.

Sweetpotato breeding for top use

Two sweetpotato cultivars for top use were bred before "Suioh". "Tsurusengan" was released in 1981 for livestock feed, and "Elegant Summer" was released in 1996 for the use of its petioles as a vegetable. The very thick, long petioles of "Elegant Summer" are tasty, although its leaves are unsuited for use.

"Suioh" was first selected for use as a summer leafy vegetable. However, it is currently used mainly as an ingredient in health food. For example, *Aojiru* (green juice) is produced from "Suioh". The tops of "Suioh" have high nutritional value and contain polyphenols, which have many physiological functions. "Suioh" is also used in confectioneries and other dishes.

"Kyuikuyou No.2" is a new cultivar selected from the self-fertilization seeds of "Suioh" released in 2009 at the Kyushu Okinawa Agricultural Research Center and demonstrates a plant type different from that of "Suioh". For example, its evaluation of taste and the amount of functionary compounds are at least equivalent to those of "Suioh" (Table 1). Thus, like "Suioh", it can be used as a vegetable and as material for processed food. "Kyuikuyou No. 2" is a compact plant type (Fig. 1) that is suitable for cultivation in a small vegetable garden, or in a container or a pot.

Breeding objective for sweetpotato top use in the future

1) Breeding sweetpotato lines with a high polyphenol content

Caffeic acid and five kinds of caffeoylquinic acid derivatives are the main polyphenolic compounds in sweetpotato leaves. These polyphenolics exhibit various physiological functions: radical scavenging activity, anti-mutagenicity, anti-cancer, anti-diabetes, anti-bacterial activity and hypotensive effects. A new sweetpotato cultivar with a high polyphenol content is needed as a raw material of functional foods and supplements to reduce their production cost. Therefore, we attempted to breed a new sweetpotato line with higher content of caffeic acid derivatives than that of "Suioh". We selected a new sweetpotato line with a high polyphenol content in tops. The total polyphenol content of the new line was one and half times that of "Suioh".

2) Breeding sweetpotato lines with purple tops for use as a vegetable

"Kyuikukan No.1" and "Kyuikukan No.2" are sweetpotato cultivars with purple tops. The yields of their tops are low, and the taste is bad because they were intended for ornamental use. Their tops are not suitable for vegetable use. Therefore, we crossed "Suioh" and "Kyuikukan No. 1" in order to breed new sweetpotato lines with purple tops for eating and processing. We are now in the process of selecting promising lines from their progeny.

Fig. 1. Kyuikuyou No.2

Table 1. Amount offunctionary compounds in leaves compared with "Suioh"

amount of compounds	Kyuikuyou No.2	Suioh
total polyphenoles (mg/100 g FW)	1247±225	1063±325
β-carotene (mg/100 g FW)	6.8±1.0	5.5±2.1
lutein (mg/100 g FW)	14.8±1.7	11.8±5.0

Average of 4 times sampling±standard deviation

Research Paper

Contents of Lutein and Polyphenol in Suioh Leaf Blades with Different Cooking Methods

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"Suioh" is a new sweetpotato cultivar with edible leaves (1). The leaves taste good and are rich in nutrients (e.g., vitamins and minerals). In addition, the leaves are rich in such physiological functional components as lutein and polyphenol.

Lutein is a carotenoid (a natural pigment) found in dark green leafy vegetables, such as spinach and kale. Recently, it has been confirmed that lutein reduces the risk of age-related macular degeneration (AMD) and cataracts. The main polyphenol in the leaves of sweetpotato is caffeic acid derivatives, which have antioxidant, antihypertensive, and antidiabetic effects.

We usually eat "Suioh" leaves as cooked products. However, how much of these components remain in leaves after cooking is unclear. This study examined the content of the functional components in cooked "Suioh" leaves.

The leaf blades of "Suioh" were cooked by steaming, simmering, boiling, and stir-frying. The contents of lutein, total caffeic acid derivatives (TCQA), and total polyphenol (TP) in the cooked leaf blades were then determined. Lutein and caffeic acid derivatives were analyzed according to the HPLC method previously reported (2, 3). TP content was determined by the Folin-Ciocalteu method.

The lutein content of the cooked leaf blades was 10.6 to 15.8 mg/100 g, and was highest when stir-fried (Table 1).

The TCQA content was 244.7 to 428.2 mg/100 g. In addition, 3,4,5-tri-caffeoylquinic acid, having higher activity among caffeic acid derivatives, was contained after cooking. The TP content of the leaf blades remained high when boiled or simmered.

It has been reported that a daily intake of 6 mg of lutein reduces AMD risk (4). Estimated from the results of this study, this amount is equivalent to 40 to 60g of cooked "Suioh" leaf blades, which is a feasible level in our diet.

Even after cooking, lutein and caffeic acid derivatives in "Suioh" leaves were not significantly impaired. Thus, we can ingest these components by eating cooked products that contain them. These results can be used to design recipes with high contents of physiologically functional components in cooked foods.

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Table 1. Contents of functional component in Suioh leaf blades with different cooking (per 100 g of cooked food or dry matter)

Cooking methods	Lutein	TCQA	3,4,5-triCQA	TP
	mg	mg	mg	mg GAE
cooked food basis				
Steamed	12.2 ± 1.6	428.2 ± 59.9	19.4 ± 2.9	363.7 ± 55.6
Simmered	10.1 ± 0.3 **	346.9 ± 93.0 *	20.8 ± 8.7	305.2 ± 48.5 *
Boiled	10.6 ± 0.5 **	244.7 ± 23.2	18.3 ± 1.6	203.8 ± 17.3
Stir-fried	15.8 ± 1.0 **	359.8 ± 61.1	28.6 ± 6.0	401.3 ± 54.6 **
raw (uncooked)	13.3	426.7	34.9	362.3
dry matter basis				
Steamed	115.5 ± 4.0	4,046 ± 292	182.5 ± 10.9	3,429 ± 200
Simmered	115.0 ± 2.8 * **	3,941 ± 1,096	236.6 ± 101.7	3,465 ± 585 *
Boiled	128.3 ± 4.0 * **	2,959 ± 350 * *	221.2 ± 25.8	2,469 ± 341 * *
Stir-fried	94.5 ± 7.0 **	2,138 ± 297	170.3 ± 31.9	2,386 ± 226
raw (uncooked)	96.4	3,092	252.9	2,625

TCQA= total caffeic acid derivatives; CA + ChA + 4,5-diCQA + 3,5-diCQA + 3,4-diCQA + 3,4,5-triCQA

3,4,5-triCQA= 3,4,5-tri-*O*-caffeoylquinic acid

TP= total polyphenol, GAE = gallic acid equivalent

Values are expressed as mean ± standard deviation (SD) of triplicate except for raw materials which were obtained by a single measurement.

* $p<0.05$. ** $p<0.01$.

Research Meeting Related to Organic Agriculture

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The Upland Farming Research Division has three main research fields: an upland crop rotation system for Kyushu large-scale farming, forage crop breeding, and sweetpotato breeding and utilization.

Organic agricultural production has recently increased in EU and the USA but not in Japan. NARO has planned a project involving an organic farming system over the next five years, in order to establish a crop cultivation system of organic farming. A research meeting involving 110 persons was held in Miyakonojo (Oct. 13, 2011) to discuss the technology of organic farming. The participants were researchers as well as farmers, agricultural processors, and sellers. Some farmers requested the latest technical information of our research results as soon as possible. At the meeting, participants eagerly discussed organic fertilizer, pests, weeds, and agricultural product processing.

Local inspection of organic farming was performed the next day. The following is an example.

Farmer A (a producer of sweetpotatoes (4ha) and carrots (1.5ha). His parents began organic farming 30 years ago. The organic products are shipped a long distance to the Kansai and Kanto areas.

Farmer B (a producer of root vegetables, Japanese-taro, carrot, and burdock (Gobou): In addition to producing vegetables, he manufactures and sells high-quality compost made from the droppings of beef cattle and the leftover food of school cafeterias and restaurants.

One of our technologies involves the new organic upland cropping system of Japanese radish and sweetpotato. In the system, Japanese radish is cultivated with organic fertilizer, and then the ridges are used for sweetpotato cropping continuously, without tillage and fertilizer application. Moreover, rows are covered with oats through Japanese radish and sweetpotato cropping seasons (photo). As the result the yield both of Japanese radish and sweetpotato are comparable to those of general cropping system using chemical fertilizer and agricultural chemical.

Sweetpotato between oats rows as intercropping.

Reader's Talk

Letter to the editor

Forming an International Consortium for Sweetpotato Genome Sequencing

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In July of this year, potato genome sequencing and analysis was published in *Nature*[1]. The genome of *Fragaria vesca*[2] was published in February, and that of *Brassica rapa*[3] was published in August. Sweetpotato is the 7th most important crop in the world; however, basically it has been poor people's food. Little investment has been made in its research and development. Only a few countries (e.g., Korea, Japan, China, the U.S., and India) have invested in sweetpotato research.

With the recent increase in food, feed, and fuel prices, the sweetpotato is now receiving attention as a good source of carbohydrates[4]. This crop certainly has a bright future, as the starch-based industry is gradually replacing the petroleum-based industry. As a raw material, starch is becoming more important not onlys for the agro-food industry, but also for non-food industrie (e.g., pharmaceutical, cosmetic, textile, plastic, paper, automobile, mining, construction, and metallic industries). It is expected that the demand for starch will grow rapidly, particularly among non-food industries.

The sweetpotato has wide adaptability, requires little input to produce, has a high energy fixation rate, and produces a large amount of starch in a unit area. With increased focus on research, production, and processing, this crop may become one of the best crops to meet the future demand for starch.

Many researchers are interested in the sweetpotato sequencing initiative; therefore, I suggest forming a preliminary discussion group during the Korea-Japan-China sweetpotato workshop, which will be held in Korea next year. Few genomic resources, including ESTs and markers, have been developed for sweetpotato. No strategy has yet been developed for whole genome sequencing and assembly. I am not aware of the availability of any proper candidate plant material, either *batatas* or *trifida*. Therefore, we may have to start from scratch. Even so, I believe it is a worthwhile endeavor, as sweetpotato will be a very important crop in the future.

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Editor's note

Winter came on. The burned sweetpotato is the food in which the face of woman and children smiles. When the spectacle is seen, our sweetpotato researchers feel joy for our work. (I.S.)

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