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Sweetpotato Research Front

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Contents

Let's Totally Exploit Sweetpotato Power!

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I have been working at KONARC's Miyakonojo Upland Farming Research Station since April 2009. My specialty is farm mechanization. Therefore, I'm interested in the working technology, for instance, transplanting systems, cultivation management technology, and harvest and drying systems. We know that the main research field of sweetpotato is breeding, but other fields, for instance, cultivation, harvesting, post harvesting, and food processing, are also important. In these fields, a system for directly sowing sweetpotato is expected to significantly reduce working hours and lead to low-cost cultivation.

Here, I will provide a general view of the present sweet potato production in Japan. About one million tons (2008) of sweetpotatoes is produced each year, 45% of which is used for vegetables, 21% for an alcohol drink (Shochu), 18% for starch, and 9% for food processing. The famous variety "Beniazuma" used as a vegetable accounts for 28% of the production area (2006), and "Koukei-14" accounts for 20%. Recently, KONARC developed a new variety, "Beniharuka", for consumption as a vegetable. It has a new texture that is called "SHITTORI" in Japanese, meaning smooth, and a slightly damp taste. The old type texture is called "HOKUHOKU" in Japanese, which means a somewhat powdery taste. "Beniharuka" has recently become popular among young persons. The spread of purple sweetpotatoes, such as "Ayamurasaki" or "Murasakimasari", for food processing is also considerably advanced. The production area of the famous variety "Koganesengan" used for starch and alcohol drink is 18%. It was developed in 1966 and remains the top producer for starch and alcohol. We anticipate a new variety of sweetpotato for starch and alcohol that will have excellent characteristics. It guarantees long-term storage, is tolerant to Meloidogyne spp, and has a smoother surface than "Koganesengan".

Sweetpotato production worldwide is 126 million tons (2007), of which Asia produces 86% and Africa, 11%. For Asia, the production exceeds 100 million tons in China, 1.8 million tons in Indonesia, 1.5 million tons in Vietnam, and 1.0 million tons in Japan. These production levels are achieved because the sweetpotato is an upland crop that likes a warm region and is able to get good production even if soil fertility is low. However, the sweetpotato production worldwide and in Japan is only 1/3 of the production of potatoes.

The sweetpotato has much higher quality as well as more starch calories, calcium, potassium, β-carotene, dietary fiber, and vitamins than potatoes and has recently been revaluated as a functional food like anthocyanin. Therefore, the sweet potato has great potential for utilization all over the world as good future health food.

In future sweetpotato research, we must develop a new strategy for breeding, cultivation management technology, farm mechanization, and food processing. The strategy horizon shouldn't be just two or three years but should extend to five or ten years or even more. However, we should surely firmly advance the research today or tomorrow promote the research steadily day-by-day and encourage researchers from all over the world to cooperate with each other. By doing so, we will hasten in a new world in which the potential of the sweetpotato can be fully exploited.

Beniharuka: A New Sweetpotato Cultivar for Table Use

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Fig 1 Storage root of Beniharuka

Introduction

"Beniharuka" is a newly released cultivar with yellowish-white flesh and good appearance, developed by the National Agricultural Research Center for Kyushu Okinawa Region (KONARC). It was evaluated in prefectural agricultural experiment stations as breeding line "Kyushu No. 143" and officially registered for table use as "Sweetpotato Norin No. 64" by the Ministry of Agriculture, Forestry and Fisheries in 2007.

Origin

Beniharuka is a progeny from a cross between "Kyushu No.121" and "Harukogane" performed at NONARC in 1996. "Kyushu No.121" is a cultivar for table use, especially for baking; "Harukogane" is a cultivar for table use. Two hundred and seventy eight seeds were collected and sown in the nursery, then selected based on field performance, taste, and appearance.

Description

"Beniharuka", a slightly prostrate plant type, has moderate sprouting ability. The top leaves are light green, and the mature leaves are green and heart-shaped. The vines are slightly thick with a somewhat short internode length. Vine pigmentation of the anthocyanin is pale, and vine nodes are very pale. Storage roots are uniformly fusiform, with good shape, reddish purple skin color, and cream flesh color. The steamed root texture is slightly dry soon after harvesting but become slightly moist after about one month storage when the taste becomes sweeter.

Fig 2. Baked Beniharuka root

Performance

Beniharuka's yield exceeds that of "Kokei No.14", but is slightly less than that of "Benimasari". Dry matter content is higher than that of "Kokei No.14" and "Benimasari", and the Brix percent of steamed root is higher than those of "Kokei No.14" and "Benimasari".

"Beniharuka" exhibits resistance to root-knot nematode, and is slightly resistant to root-lesion nematode.

Yield and other traits of Beniharuka in yield trial (2001 to 2006, standard cultivation)

Traits	Beniharuka	Kokei No. 14	Benimasari
Root yield (t/ha)	33.5	29.4	35.6
Root size (g)	222	248	285
Number of roots per hill	4.0	3.2	3.7
Dry matter content (%)	37.0	32.6	34.4
Brix (%)1)	6.2	5.2	4.9
Root-knot nematode resistance2)	R	SS	I
Root-lesion nematode resistance2)	SR	SR	I
Storability	High	High	High

1) Measured exudates from steamed root mash with three times volume of water.

2) R: Resistant. SR: Slightly Resistant. I: Intermediate. SS: Slightly Susceptible. S: Susceptible.

Research Paper

Apoptosis Induction of Human Cancer Cells by Polyphenolics from Sweetpotato (*Ipomoea batatas L.*) Leaves

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Sweetpotato leaves (*Ipomoea batatas L.*) contain a high content of polyphenolics that consist of a caffeic acid (CA) and caffeoylquinic acid (CQA) derivatives with plural caffeoyl groups bound to quinic acid (QA)(1). Our previous report recently found physiological functions, like DPPH-radical scavenging activity, antimutagenicity, and diabetes treatment. In this study, we describe the effect of these CQA derivatives on human tumor cells.

The effects of CA, chlorogenic acid (ChA), 3,4-di-O-caffeoylquinic acid (3,4-diCQA), 3,5-di-O-caffeoylquinic acid (3,5-diCQA), 4,5-di-O-caffeoylquinic acid (4,5-diCQA), and 3,4,5-tri-O-caffeoylquinic acid (3,4,5-triCQA) from sweetpotato leaves on the growth of three kinds of cancer cells were examined. The human cancers investigated were stomach cancer (Kato III), colon cancer (DLD-1), and promyelocytic leukemia (HL-60). CA, diCQAs, and triCQA depressed cancer cell proliferation dose-dependently (Fig. 1), and the difference in sensitivity between CQA derivatives and each kind of cancer cell was observed. Specifically, 3,4,5-triCQA was found to effectively depress the growth of three kinds of cancer cells, and CA had an exceptionally greater effect against HL-60 cells than did di- and 3,4,5-triCQA. When apoptotic inhibitor N-ethylmaleimide was added, the nuclear granulation observed in 3,4,5-triCQA-treated HL-60 cells suggested apoptosis induction (Fig. 2). This was confirmed by DNA fragmentation, increased caspase-3 activity, and expression of *c-Jun*. Growth suppression of HL-60 cells by 3,4,5-triCQA was determined to be the result of apoptotic death of the cells. These results indicate that 3,4,5-triCQA may have potential for cancer prevention.

(1) Islam, M. S. et al., Identification and characterization of foliar polyphenolic composition in sweetpotato (Ipomoea batatas L.) genotypes, J. Agric. Food Chem., 50, 3718-3722 (2002).

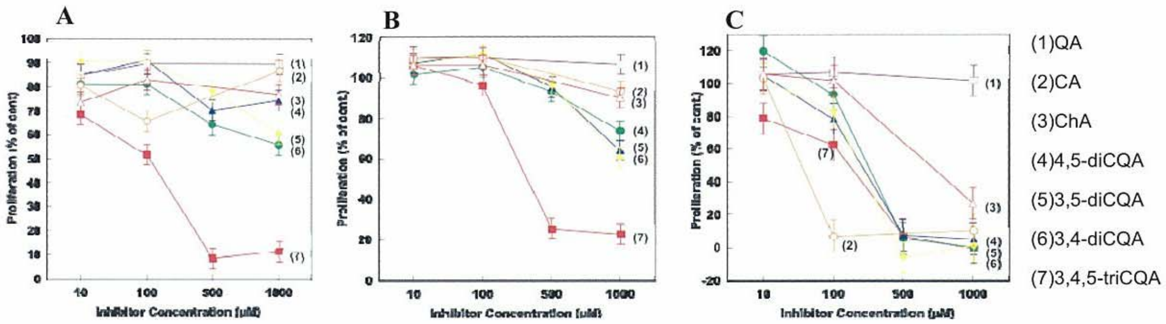

Fig.1. Effect of each polyphenol component on proliferation of Kato-III (A), DLD-1 (B), and HL-60 (C) cells.

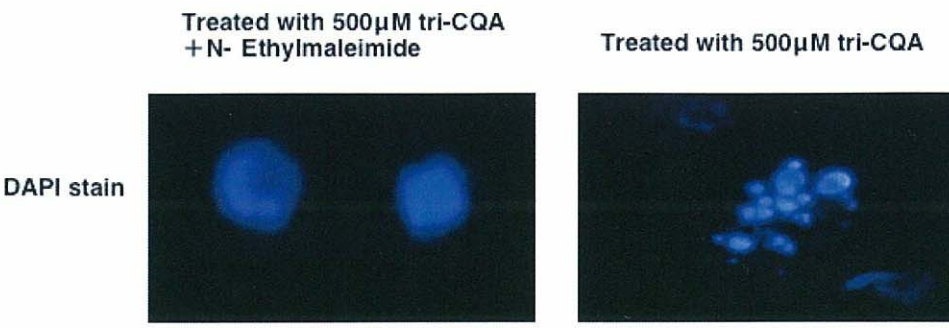

Fig.2. Morphological changes by 500μM 3,4,5- tri CQA in HL-60 cells (DAPI stain).

Research Paper

Advanced Resistance to *Sweetpotato Feathery Mottle Virus* (SPFMV) in Transgenic Sweetpotato

Yoshihiro Okada and Masaru Yoshinaga

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Viral diseases of the sweetpotato (*Ipomoea batatas* L. (Lam)) are highly prevalent and often cause serious damage to the plants, particularly the severe strain *sweetpotato feathery mottle virus* (SPFMV-S) that causes "obizyo-sohi" disease in Japan. In addition, reported strains in Japan include the ordinary (O) strain and Tokushima (T) strain. Some varieties have been found to be genetic resources of SPFMV resistance. However, the degree of the resistance is inadequate, and much time is required to introgress the resistant gene(s) into the hexaploid genome of the sweetpotato by conventional breeding. On the other hands, a transgenic sweetpotato has been developed to confer viral resistance to SPFMV using current biotechnology by introducing SPFMV-S coat protein (CP) genes, which have a significant resistance to purification virus of SPFMV-S. In this report, virus resistance was evaluated under conditions nearer to those of the field environment to confirm the advanced resistance in the transgenic sweetpotato.

First, 116 virus-infected clones were collected and investigated to determine the viral infection and infected strains by RT-PCR/RFLP. The investigations determined that SPFMV was independent infection, or rather coincidentally complex under natural conditions. Furthermore, the infection was induced by a dominant strain between complex infecting SPFMVs and was differentiated by the area of infection. Next, we will establish a method for testing resistance to SPFMV by aphid transmission in the sweetpotato. Transgenic sweetpotatoes expressing the SPFMV-S CP gene were challenged by graft-inoculation and aphid transmission with field infected SPFMVs. All of the transgenic sweetpotato plants were highly protected in the long term against SPFMVs complex infection compared to the control plants (Fig. 1). In this report, we used field-infected stock as an inoculation source including SPFMV-O, S and T. The result of this resistance evaluation suggested that the transgenic sweetpotato exhibited resistance to not only the S strain but also to the O and T strains. Most of the sweetpotatoes with different virus symptoms reacted to a SPFMV antiserum, whereas there was little serological variation. This is consistent with a finding that the amino acid and DNA sequences of the CP genes were highly homologous among SPFMV-S, Russet crack (RC) strain and common (C) strain. However, the amino acid sequence of the CP gene was not highly homologous in SPFMV-T and the other two strains. Nevertheless, the transgenic sweetpotato is also resistant to the T strain. Thus, the transgenic sweetpotato containing the SPFMV-S CP gene might have the potential to confer general SPFMV resistance. In these results, transgenic sweetpotatoes acquired higher levels of resistance to the SPFMV complex. Consequently, transgenic sweetpotatoes possess advanced resistance to field SPFMVs.

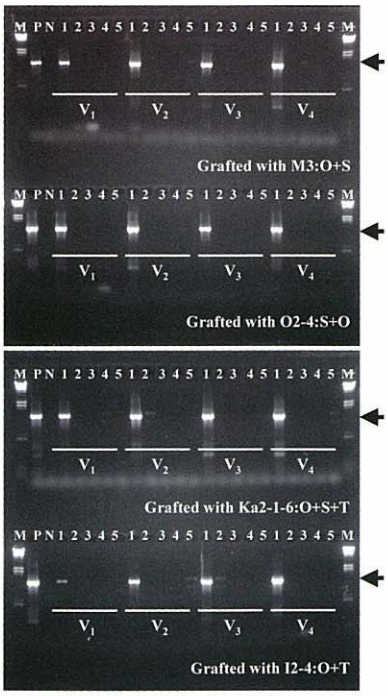

Fig. 1 Analysis of NIb-CP region on graft inoculation with SPFMVs and herbaceous cutting progeny (V_1 - V_4) of transgenic sweetpotato by RT-PCR. M : λ -Hind III. P : Virus-infected plant. N : Virus-free plant. 1. Graft-inoculated control plant. 2. Graft-inoculated transgenic plant EP200-1. 3. Graft-inoculated transgenic plant EP200-2. 4. Graft-inoculated transgenic plant EP220-1. 5. Graft-inoculated transgenic plant EP220-2. Four independently infected clones were grafted and analyzed.

Research Paper

Oxygen Radical Absorbance Capacity and Anthocyanin Content of Purple-Fleshed Sweetpotato

Tomoyuki Oki[1], *Maki Sato*[1], *Masaru Yoshinaga*[2], *Tetsufumi Sakai*[2], *Terumi Sugawara*[1], *Norihiko Terahara*[3] *and Ikuo Suda*[1]

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Multiple antioxidant indices, such as oxygen radical absorbance capacity (ORAC), 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical-scavenging capacity, and superoxide anion scavenging capacity, are used to express the antioxidant capacity of foods. In 2007, scientists with the United States Department of Agriculture (USDA) published an updated list of ORAC values for 277 foods commonly consumed by the U.S. population. Moreover, antioxidant dietary supplements and foods with ORAC values are now being marketed in the U.S. Purple-fleshed sweetpotato (*Ipomoea batatas*) plants containing anthocyanin pigments exhibit a potent DPPH radical-scavenging capacity ; however, sweetpotato cultivars bred in Japan have not yet been evaluated by ORAC assay. This research paper reports ORAC values of ten sweetpotato cultivars with various flesh colors, and the correlation between anthocyanin content and ORAC value for purple-fleshed sweetpotato cultivars and breeding lines.

The ORAC values were similar among the sweetpotato cultivars with white, yellow, and orange flesh ; however, purple-fleshed sweetpotato cultivars exhibited activity about 10 times higher than those with other flesh colors (Fig. 1). In the USDA database, the ORAC value of the sweetpotato range from 756 to 1020μmol Trolox equivalent (TE)/100g (average 858). Compared with sweetpotatoes consumed in the U.S., the ORAC values of white-, yellow-, and orange-fleshed sweetpotatoes in Japan were lower. Purple-fleshed sweetpotato cultivars rank the highest in ORAC, like fruits with bright pigmentation such as berries, red grapes, cherries and apples. These pigments are anthocyanins and are also contained in purple-fleshed sweetpotatoes. Eight major acylated anthocyanins have been identified as a cyanidin- or peonidin-form in purple-fleshed sweetpotatoes. The total content of eight major anthocyanins was highly correlated with ORAC (r^2=0.694) for three cultivars and seventeen breeding lines (Fig. 2). We previously reported that the dominant antioxidants were anthocyanins rather than caffeic acid esters in the cultivars with higher anthocyanin content, based on DPPH radical-scavenging assay with an electron-transfer reaction-based mechanism (1). The high correlation revealed that anthocyanins in purple-fleshed sweetpotatoes were the major components for ORAC assay with a hydrogen atom transfer reaction-based mechanism, as well as DPPH radical-scavenging assay (2).

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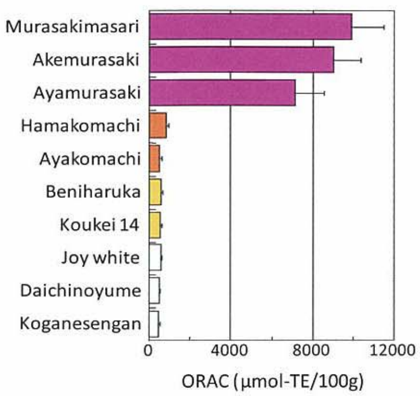

Fig. 1. ORAC values of sweetpotato cultivars with various flesh colors

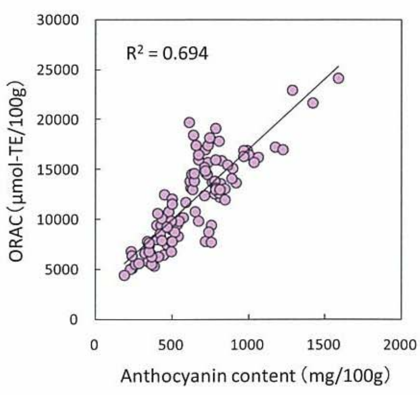

Fig. 2. Correlation between anthocyanin content and ORAC value of purple-fleshed sweetpotato cultivars and breeding lines

Reader's Talk

Letter to the editor

China Xuzhou 4th International Sweetpotato Symposium & 4th China-Japan-Korea Workshop

Daifu Ma

Deputy Director/Professor, Institute of Sweetpotato Research, Chinese Academy of Agricultural Sciences (CAAS), Xuzhou Sweetpotato Research Center

The Jiangsu Xuzhou Sweetpotato Research Centre (JXSRC) is homonymous with the Jiangsu Xuhuai Regional Institute of Agricultural Sciences (JXRIAS) and Xuzhou Academy of Agricultural Sciences (XAAS). In 2002, it was renamed the Institute of Sweetpotato Research, China Academy of Agricultural Sciences (SRI, CAAS). It is now also the National Sweetpotato Improvement Centre and National Sweetpotato Industrialization Research & Development Centre. For a long time, JXSRC has been conducting research on improving and industrializing China's sweetpotato varieties. It presides over and coordinates the National Key Projects and International Cooperation and Communication programs in sweetpotato research; maintains good contact with CIP, Japan, USA, Korea, and regional institutes; and has organized many international and domestic workshops.

From 13 to 28 November 1996, JXSRC coordinated with CIP to hold the "International Sweetpotato Breeding Technology Study and Training Workshop," in which more than 20 scientists came from different countries including China, India, Indonesia, the Philippines, Vietnam, and Korea. From 18 to 20 August 1999, JXSRC held the "International Sweetpotato Breeding Symposium" with more than 70 scientists including CIP's vice director Wanda Collins and others from Japan, Korea and so on. In this meeting, the China-Japan-Korea International Communication Organization was launched. During 12 to 14 November 2002, JXSRC held the "3rd International Sweetpotato Symposium" with the theme "Application of modern sweetpotato techniques", and more than 50 scientists from CIP, China, America, Japan, Korea, New Zealand, Malaysia, Belgium, France, Thailand, Austria, and so on were present. This meeting cooperatively promoted biotechnology applications in sweetpotato breeding, developed the biofuel crop potential of the sweetpotato, and enhanced internationally coordinated research.

XAAS will celebrate its 100th anniversary in 2010, making it one of the oldest and most powerful institutes of agricultural sciences. The sweetpotato is the most special crop in the research field of XAAS, where key national sweetpotato research projects are being conducted. The National Modern Agricultural Industrialization Research System Program has now started in China. This program includes developing the National Sweetpotato Industrialization System and National Wheat, Rice, Cotton, Soybean, and Peanut Experimental Station in XAAS. The Jiangsu Xuzhou Sweetpotato Research Centre organized and cooperated with most powerful institutes and universities to form a large group containing the most famous domestic sweetpotato scientists and to develop the National Sweetpotato Industrialization System. China is the world's largest producer and is obliged to take more responsibility, and so we wish to hear different voices from different countries and to cooperate in studying and drafting sweetpotato development plans and perspectives.

To welcome the XAAS's 100 anniversary, Chief Scientist Prof. Daifu Ma contacted and communicated with Japanese and Korean scientists many times and was eventually able to organize the 4th China-Japan-Korea Sweetpotato Workshop in China. The International Sweetpotato Workshop has previously been held in Xuzhou three times, and this time XAAS will sponsor the meeting, so the workshop was named the "China Xuzhou 4th International Sweetpotato Symposium & 4th China-Japan-Korea Workshop" with the theme of "Sweetpotato - the food of security and energy." XAAS' Principle Director Prof. Ping Chen and Chief Scientist Prof. Daifu Ma sincerely invite all sweetpotato scientists worldwide to attend the meeting to receive the latest sweetpotato technology information, and enjoy the VIP services.

China welcomes you! Xuzhou welcomes you!

Editoer's note

Nematode damage is one of the most important problem for sweetpotato cultivation. We will introduce a relevant topic in next SPORF.

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