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Where Are You Now, Dr. El-Kattan and Dr. Stark?

Atsushi Oyanagi
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About 30 years ago when I was still young, I conducted research on sweetpotatoes at the National Agriculture Research Center, Tsukuba, Japan for 3 years.

Sweetpotatoes for the Japanese market must be spindle-like in shape, have beautiful red skin color, and be limited in size to around 200 g. One of the least preferred market characteristics is tuber-cracking, which seriously reduces the market value of the tuber. We thus decided to study tuber-cracking.

We first sought to clarify the mechanism of tuber cracking. Although it had been reported before our studies that nematodes were major causes of the cracking, our preliminary observations did not support this: also, cracking appeared on tubers cultivated under nematode-free conditions in our experiments. Hence, we assumed that cracking would be related to physiological disorders in the plant.

Nonetheless, we had not found any clues of the cracking for a long time. The cracking often occurred under various environmental conditions. We were thus at a loss what to do in our study. One day, we found a paper by El-Kattan and Stark (Proc. Amer. Soc. Hort. Sci., 63, pp378-388, 1954), entitled “Tissue activity and structural differences in the storage roots of Maryland Golden and Jersey Orange sweetpotatoes as related to cracking.” We felt as if we had found the cause of the problem. They observed that cracking occurred in the early stage of tuber growth and detected that crack healing varied according to the position of the cracks on the tuber.

Their report thus led us to launch research on the healing of tubers, and we eventually succeeded in finding factors for tuber-cracking in Japan. The polyethylene-mulch cultivation that began to be popular in Sweetpotato cultivation in Japan created poor conditions: both lower temperatures and moisture that were unsuitable for tubers and distorted their growth.

Our success in solving the cracking problem is thus due to El-Kattan and Stark as well as to other researchers. I would like to thank them for giving us the motif of the study. Unfortunately, no email was available in their era. Where are you now, Dr. El-Kattan and Dr. Stark? I would like to say, “Thank you”!

Research Paper

Protecting the Sweetpotato from the West Indian Sweetpotato Weevil, *Euscepes Postfasciatus*

II. Resistance evaluation of sweetpotato varieties to weevils in the field

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In the last issue of this journal, we reported the resistance of sweetpotato varieties to the weevil *Euscepes postfasciatus*. The resistance was evaluated from laboratory experiments that led us to expect that resistant varieties would be attacked less by weevils in the field. We tested this hypothesis by field experiments carried out in Okinawa, southern Japan, in 2012 and 2013. In 2012, 25 varieties selected based on laboratory experiments were examined for field resistance to weevils, and only nine varieties were tested for resistance in 2013. In both years, sweetpotato vines were planted in late April, and tubers were harvested in October. Tuber damage was rated in five ranks (Fig. 1). Resistance of a given variety was evaluated by the damage index defined as the mean of its damage rank and the proportion of damaged tubers.

Mean damage index (damaged tuber proportion) was 3.5% (47.1%) for all varieties in 2012. Bmas (1.4 and 5.6%), K34Mu (2.3 and 11.9%) and K166 (1.6 and 17.5%) were rated the most resistant, and Kogane was rated the most susceptible (4.1 and 67.9%) (Fig. 2). One susceptible and four resistant varieties were selected among the 25 varieties for a field experiment the next year. Four varieties that were thought resistant from other experiments were also included in the experiment. The mean damage index (damaged-tuber proportion) was 1.2% (18.3%). Note that since resistant varieties were selected for this experiment, both damage index and damaged-tuber proportion over all varieties were less this year than in the previous year. The most resistant variety in this experiment was K166 (1.1 and 6.6%). The consistency of the resistance to the weevil in this variety suggests that the resistance could be controlled genetically and that the variety can be used for further breeding resistant varieties. We are examining the weevil-resistance of this variety on larger scales for extension to growers on weevil-infested islands, especially Okinawa Island.

Fig. 1. Rank (yellow) of tuber damage according to the maximum damaged area on the cross section of the tuber. 1. No symptoms of weevil infestation. 2. Less than 5% damaged. 3. 5 to 30%. 4. 30 to 50%. 5. Above 50%.

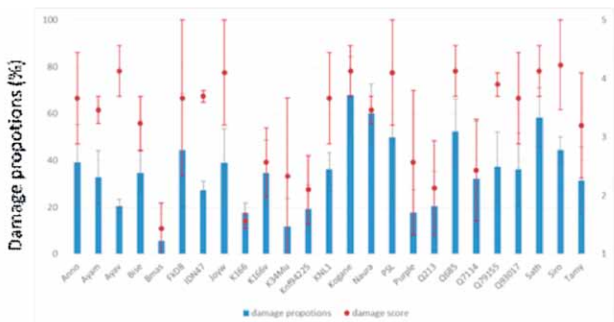

Fig. 2. Resistance evaluation based on the damage proportions and index damage in the field test.

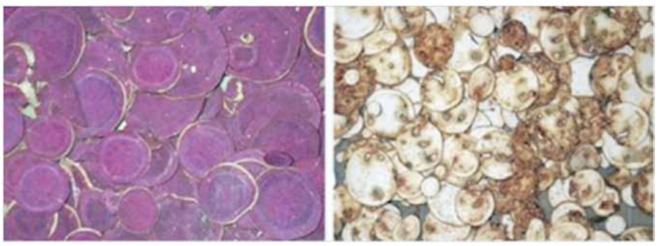

Fig. 3. Comparison of the damage in resistant (left) and susceptible (right) tubers by tuber slice.

Karayutaka: A New Sweetpotato Cultivar for Table Use

Akiko Ohara-Takada[1,2], Toru Kumagai[1], Toshikazu Kuranouchi[1],
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Sweetpotatoes should be planted in Japan in April to May and harvested in 120 to 160 days, but the cultivation period is sometimes too long. Early enlargement of tubers that in turn enables early harvesting is a desired trait for farmers. The price of sweetpotatoes is the highest from May to August, promising high returns to those harvesting early.

Fig. 1. Storage roots of Karayutaka

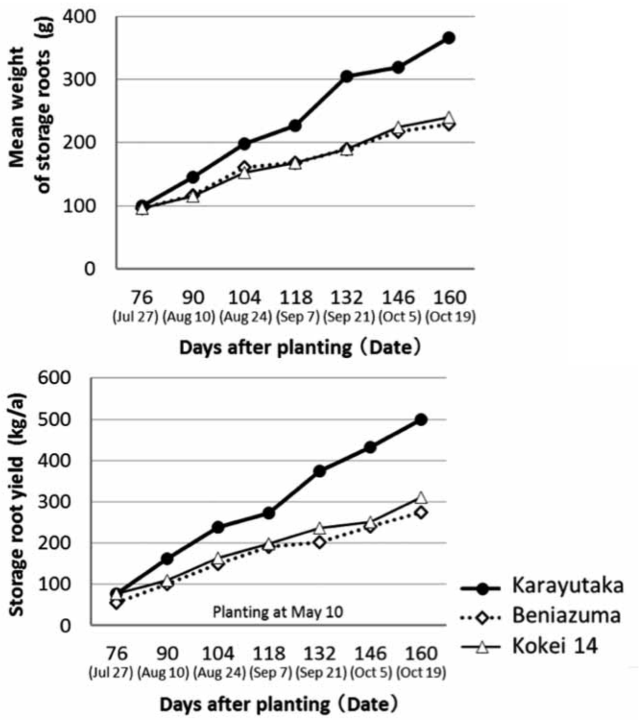

Fig. 2. Mean weight of storage roots in three sweetpotato cultivars (upper panel) and their yields. (Average of 2010 and 2011, NICS).

Cultivation condition: With mulching film and 400 plants/a. Roots < 50g were excluded.

The early harvesting thus facilitates introducing Sweetpotato cultivation into areas where the cultivation has been confined due to cultivation of other crops or the lack of warm days. Kokei 14, one of the most widely cultivated sweetpotatoes in Japan, is often cultivated in shorter periods for early harvesting. However, neither the yield nor the appearance of the product of this cultivation satisfies the level demanded by consumers. We attempted to breed a new sweetpotato cultivar that produces sufficient storage roots in a shorter cultivation period.

The new cultivar, "Karayutaka," was released by NARO Institute of Crop Science (NICS) in 2014. It was a progeny of Kanto 123 and Beniotome. This cultivar is resistant to stem rot and has moderate storage ability (Table 1).

The storage roots of Karayutaka exhibited good appearance, with no longitudinal grooves (Fig. 1). The skin was smooth, and the flesh color was light yellow. These storage roots reached 200 g 100 days after planting (Fig. 2). More of its storage roots were harvested, and the yield was 40% heavier than those of Kokei 14 and Beniazuma. The baked storage roots of Karayutaka tasted good and had moist texture (Table 1).

Overall, Karayutaka is suitable for early harvesting and possible incorporation into crop rotation with other crops. We expect that this cultivar can be introduced into more northern regions where sweetpotato cultivation is a little now due to the cooler climate.

Table 1. Characteristics of three sweetpotato cultivars (2008-2013 NICS)

Trait	Karayutaka	Beniazuma	Kokei 14
Texture of baked root[1,2]	Moist	Slightly dry	Medium
Brix of baked root[1] (%)	20.8	19.6	18.2
Taste of baked root[1,2]	Slightly good	Slightly good	Slightly good
Root-knot nematode resistance[2,3]	M	M	MS
Soil rot resistance[2,3]	M	MR	S
Stem rot resistance[2,3]	R	M	M
Black rot resistance[2,3]	M	M	MR
Storage ability[4]	Moderate	Low	High

1) Storage roots were examined after three months storing.
2) Texture and taste were distinguished into five levels.
Texture: Moist, Slightly moist, Medium, Slightly dry, Dry. Taste: Good, Slightly good, Medium, Slightly bad, Bad.
3) R: resistant, MR: moderately resistant, M: moderate, MS: moderately susceptible, S: susceptible.
4) In a temperature-uncontrolled room throughout winter.

Research Paper

Maltose Generation in "Quick Sweet" : Its Starch-gelatinization at Lower Temperatures

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"Quick Sweet" (QS)[1] released in 2002 was bred by crossing "Beniazuma" (BA) and "Kyushu 30". Its starch is detected to be uniquely gelatinized at about 55°C measured by a rapid visco analyser (RVA). This temperature is lower than the temperatures for starch gelatinization in other cultivars (60°C or higher). This indicates that QS can be cooked more quickly and can produce much amount of maltose than other sweetpotato. We studied the mechanism of maltose generation by heating storage roots of QS and characterised it in comparison with BA in which higher temperatures are required for starch-gelatinization[2].

Starch-gelatinization and maltose- generation were induced in the storage roots of QS above 60°C, which was 20°C lower than for BA (Figs. 1, 2). Beta-amylase in heated storage roots of QS was still active at 80°C. Surprisingly, it was not inactivated even at 90 and 100°C, at both of which it was 50% as active as under preheated conditions. In contrast, the activity of BA was greatly reduced above 70°C (Fig. 3). However, the enzyme from the raw roots of BA was as active as that of QS under the heated conditions (data not shown). This indicates that beta-amylase in the heated storage roots of QS remained stable owing to the starch-gelatinization at lower temperatures before its inactivation during heating.

Therefore, maltose generation in QS storage roots started at lower temperatures and continued at higher temperatures than that in BA during heating.

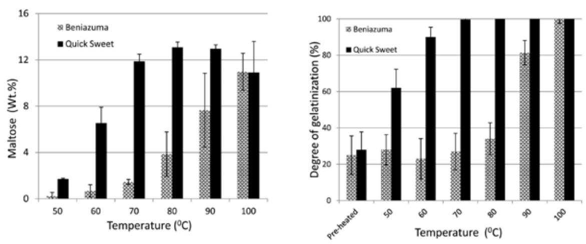

Fig. 1. Maltose concentration and starch pasting (gelatinization) in QS and BA heated at various temperatures.

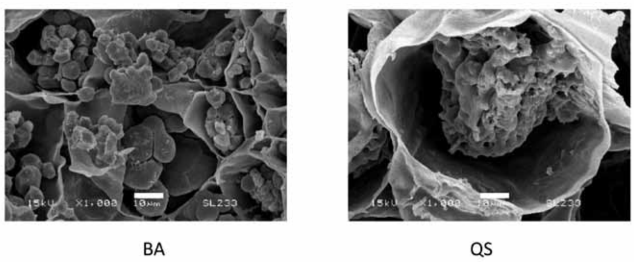

Fig. 2. Starch in root cells of BA (left) and QS (right) heated at 60°C under a scanning-electron microscope (SEM) at a magnification of 1000.

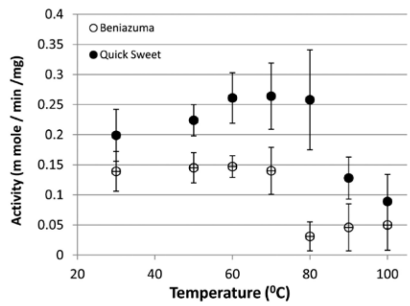

Fig. 3. Beta-amylase activity (mean ± SD), evaluated by maltose formation in mmol/min/mg of protein in enzyme solution, in storage roots of BA and QS heated at various temperatures.

Acknowledgments: The authors are grateful to Prof. Y. Nitta of Ibaraki University for his kind permission to use SEM.

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Research Paper

Caffeic Acid and Seven Caffeoylquinic Acids Contents in *Aojiru* Powder Products Containing Sweetpotato Cultivar "Suioh" Leaves Determined by Single-laboratory Validated HPLC Method

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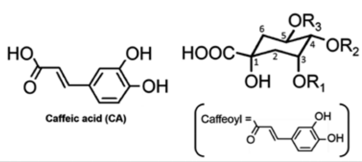
Sweetpotato (*Ipomoea batatas* L.) leaves are rich in caffeoylquinic acids (CQAs), which are formed by esterification of one molecule of quinic acid with one to three molecules of caffeic acid (Fig. 1). CQAs are polyphenolic compounds found in many edible and medical plants and are well known for having various biological benefits for human health. No standard methods for quantifying CQAs have been established yet in sweetpotato leaves. We conducted a single-laboratory validation of a high-performance liquid chromatography (HPLC) method to quantify CA and seven species of CQAs in sweetpotato leaves. We also determined the extraction and HPLC conditions that would optimize the separation of CA and seven species of CQAs. The developed method is as follows. 1) CA and 5-CQA, one of the CQAs, were quantified using the calibration curve of each standard. 2) The relative response factors (RRFs) of the CQAs to 5-CQA were calculated by the molar extinction coefficient and the molecular mass of each CQA. 3) The other CQAs were quantified using the calibration curve of 5-CQA and the RRF of each CQA. RRF is widely used to compute true concentrations of compounds in samples. The method had good precision when carried out repeatedly on five different days, and the Horwitz ratio (HorRat) scores ranged from 0.5 to 1.0 for all analytes, well within the limits of performance acceptability. Therefore, this method can be applied for quantitative evaluation of CA and CQAs in sweetpotato leaves [1].

We tried the HPLC method to analyze CQAs in *aojiru* containing sweetpotato cultivar Suioh leaves. *Aojiru* is a commercial powder product in Japan. It is consumed as vegetable juice and is most commonly made from kale. Suioh was bred for the use of its leaf and petiole as a green vegetable. As shown in Fig. 2, the total CQA content in nine kinds of *aojiru* powder products ranged from 865 to 13,256 μg/g dw, albeit less than lyophilized powder of Suioh leaves (41,532 μg/g dw). The lyophilized powder contained 3,5-diCQA, occupying the largest proportion, 61.2%, among the eight target analytes of the matter. 3,5-DiCQA was the most abundant among them in all nine products with a range of 31.9 to 63.1% of the powder. Interestingly, products C to I contained CQAs differing both quantitatively and qualitatively from the lyophilized Suioh powder, while products A and B revealed similar contents. The former products were divided into two groups according to the CQA contents. One group is characterized by high 5-CQA content (C to F), and the other showed high 3-CQA contents (G to I). It was thus rather surprising that both groups contained mono-CQAs in similar proportions. This property may be involved in chemical reactions during the processing: boiling of the aqueous solutions of the mono-CQA standards at 100°C leads to a chemical reaction to form structural isomers from each mono-CQA[2]. It has been suggested that the CQAs in Suioh leaves are structurally changed via processing such as blanching or drying during production of *aojiru* powder.



Compound name	Abbreviation	Common name	Substituent
3-caffeoylquinic acid	3-CQA	Neochlorogenic acid	R_1 = Caffeoyl, R_2 = R_3 = H
4-caffeoylquinic acid	4-CQA	Cryptochlorogenic acid	R_2 = Caffeoyl, R_1 = R_3 = H
5-caffeoylquinic acid	5-CQA	Chlorogenic acid	R_3 = Caffeoyl, R_1 = R_2 = H
3,4-dicaffeoylquinic acid	3,4-diCQA	Isochlorogenic acid B	R_1 = R_2 = Caffeoyl, R_3= H
3,5-dicaffeoylquinic acid	3,5-diCQA	Isochlorogenic acid A	R_1 = R_3 = Caffeoyl, R_2= H
4,5-dicaffeoylquinic acid	4,5-diCQA	Isochlorogenic acid C	R_2 = R_3 = Caffeoyl, R_1= H
3,4,5-tricaffeoylquinic acid	3,4,5-triCQA	–	R_1 = R_2 = R_3 = Caffeoyl

Fig. 1. Chemical structures of caffeic acid and caffeoylquinic acids in sweetpotato leaves.

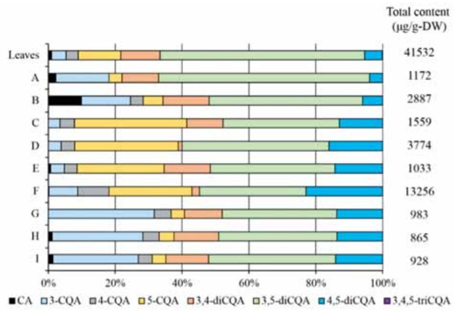


Fig. 2. Composition of caffeic acid and caffeoylquinic acids in Aojiru and lyophilized powders of sweetpotato leaves.

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Reserch News

Report of the 6th Japan -China- Korea Workshop on Sweetpotato

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The 6th Japan -China- Korea Workshop on Sweetpotato was held at Kagoshima Prefectural Citizen Exchange Center, Kagoshima, Japan from 28 to 30 November 2014. It was held as NARO International Symposium 2014 entitled "New Era of Sweetpotato Research in East Asia". The workshop was organized by NARO Kyushu Okinawa Agricultural Research Center and NARO Institute of Crop Science, Japan, and supported by Faculty of Agriculture, Kagoshima University, Japan Root and Tuber Crops Development Association. It should be noted that a century has passed since 1914, when the first crosses of sweetpotatoes were performed in Okinawa, Japan. Over the past 100 years, the sweetpotato has significantly contributed to agriculture, industry, and the economies of East Asian countries.

There were about 180 participants in the workshop, 57 from China (including Taiwan), 21 from Korea, 1 from Austria and about 100 from Japan. The symposium consisted of seven sessions: (1) Keynote lectures, (2) Breeding and Genetic Resources, (3) Cultivation, Physiology and Local Reports, (4) Biotechnology (Genomics), (5) Poster Sessions, (6) Biotechnology (Molecular physiology) and Pest Control, (7) Functionality, Crop Quality and Processing. Twenty-seven research papers were presented orally, and 57 papers were delivered by posters. On the third day of symposium, participants visited sweetpotato storage and shipment facility (at Chiran district in Minami-Kyushu city), shochu factory and museum (in Makurazaki city) and Kagoshima product promotion center (in Kagoshima city) as the on-site workshop of this symposium.

Symposium participants from China, Korea, and Japan shared and discussed recent research activities and the current status of, and future prospects for sweetpotato research. The organizing committee believes this symposium contribute to the ongoing development of East Asia.

Editor's note

The genome data of *Ipomoea trifida*(2x) have been published and are available at the Sweetpotato GARDEN (http://sweetpotato-garden.kazusa.or.jp).We hope you enjoy them as a powerful tool for your sweetpotato research(Y.T).

NARO

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