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A new sweetpotato cultivar, "quick sweet" has an altered starch structure and low gelatinization temperature

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Abstract. "Quick Sweet" is a new cultivar released for fresh market use in Japan. It was derived from a cross between "Beniazuma" and "Kyushu 30." The gelatinization temperature of "Quick Sweet" starch is about 20 ºC lower than those of ordinary cultivars including its parents. Its starch granules show an abnormal morphology characterized by cracking into granules. Analyses of the chain-length distribution of amylopectin determined by high-performance anion-exchange chromatography (HPAEC) showed that "Quick Sweet" starch had a higher proportion of short chains (DP 6 - 11) compared to those in normal sweetpotato starch. The change in chain length distribution of amylopectin is thought to be the reason for the unique starch properties of "Quick Sweet". Because of these starch properties, the storage roots can be cooked more quickly than ordinary cultivars. Eating quality of "Quick Sweet" after micro-waving is also good. Ordinary cultivars do not taste nice after micro-waving. It is thus expected to be a convenient cultivar for the busy Japanese.

Introduction

Sweetpotato (*Ipomoea batatas* (L.) Lam.) is used as direct food, processed food, industrial starch, and animal feed in Japan. An investigation into the consumers' preferance and eating habits by the government showed that Japanese consumers' preferences are guided by healthy issues and then convinience. This seems to be related to the changes in work and life styles of Japenese who are so busy that they cannot spend much time cooking their own foods. To promote sweetpotato consumption and production in Japan, breeding must meet the concept of "convenience" as much as possible. Therefore, quick cooking ability is an important objective in Japanese breeding program. Starch properties may affect the cooking properties or taste of sweetpotato. However, it is known that variations in starch properties such as pasting properties and molecular structure of starch among sweetpotato varieties are rather small (Noda *et al.*, 1995; Katayama *et al.*, 1999). Sweetpotato breeding programs in Japan have been looking for genetic variations in starch properties. A breeding line, "Kanto No.116 (later released as "Quick Sweet")" showed an abnormal morphology of starch granules. In this report, we describe the gelatinization and pasting properties, molecular structure of starch and cooking properties of this line and discuss a new breeding target in highly commercialized nations utilizing these starch properties.

Materials and Methods

Pedigree of "Quick Sweet". The pedigree of "Quick Sweet" is shown in Figure 1. This cultivar was developed from a single cross of "Beniazuma" x "Kyushu No.30" at Ibusuki Branch of Kyushu National Agricultural Experiment Station in 1993.

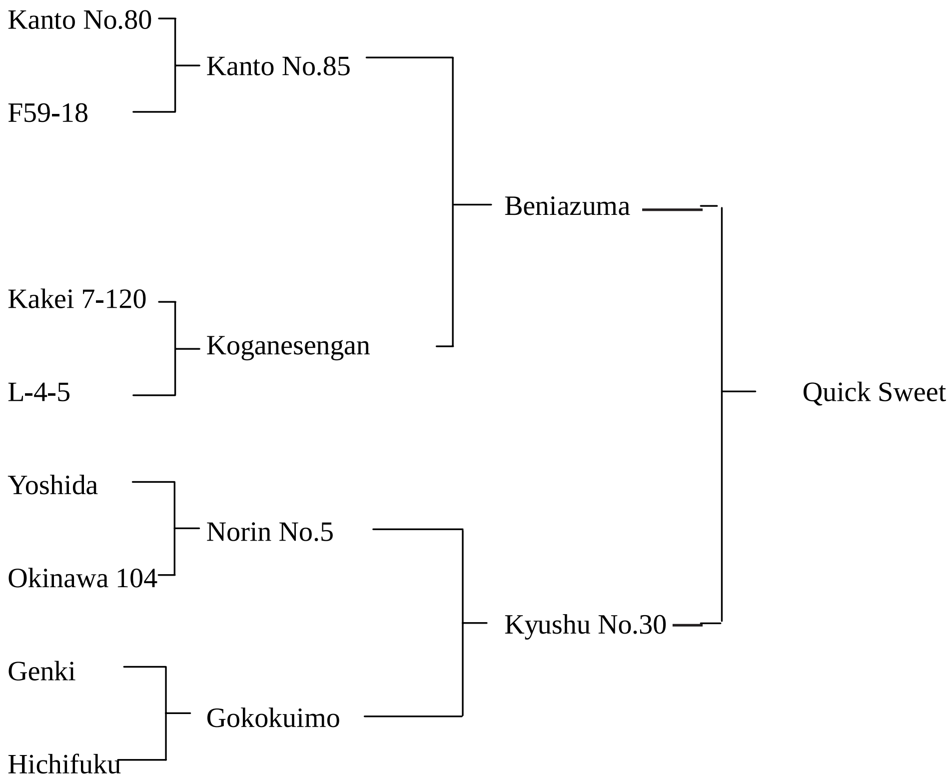

Figure 1: Pedigree of "Quick Sweet".

Plant materials and field experiments. The field experiments were carried out from 1998 to 2001 at the Yawara Upland Experimental Field of the NICS, Ibaraki in Japan. All plant materials were grown under standard sweetpotato cultivation practices. In brief, they were grown with vinyl mulching in a randomised block design with three replications. The materials were transplanted in late May and harvested in the middle of October. Harvested storage roots were stored at 15ºC and 80% relative humidity for at least two weeks. Four to eight medium-sized storage roots per line were randomly selected for the extraction of starch. The storage roots were sliced, and the root tissues homogenized in water with a blender, and filtered through a 200-mesh sieve. The starch collected from the filtrate was washed with deionized water several times and then air-dried.

Starch Analytical Methods. The starch content, amylase content, starch pasting properties, gelatinization properties and chain-length distribution of amylopectin were analyzed as described by Katayama *et al*. (2002).

Cooking Experiments. To determine the time needed for cooking of the storage roots, tissue blocks (20mm x 15mm width) were subjected to steaming. They were taken out at 0, 3, 6, 9 and 12 minute intervals and homogenized in water (4 times volume of block). The homogenized were centrifuge and their brix values determined. In 2001, a panel of about 20 experts was used to determine the taste of the storage roots. The storage roots were subjected to two cooking methods: normal steaming for about one hour and microwave oven heating for about 10 minutes. After tasting, their brix values were determined as above.

Results and Discussions

Yield performance of "Quick Sweet". As shown in Table 1, "Quick Sweet" has similar yield performance as "Beniazuma" the most popular cultivar for table use in Japan. Although the dry matter content of "Quick Sweet" is slightly lower than that of "Beniazuma", it still fits within the range of Japanese table cultivars. Storage root yield and dry matter content of this cultivar were lower than those of Japanese cultivars used for starch production.

Morphology of starch granules. Starch granules from "Quick Sweet" showed an abnormal morphology characterized by cracking into granules.

Gelatinization and pasting properties of "Quick Sweet" starch. Differential Scanning Calorimeter (DSC) analysis of 30% starch solutions showed that onset temperature, peak temperature and conclusion temperature of "Quick Sweet" starch were 39.0ºC, 46.9ºC, 64.8ºC, respectively. These values were approximately 20ºC lower than those of normal sweetpotato starches including the parents of "Quick Sweet". Pasting temperatures of "Quick Sweet" starch determined by Rapid Visco Analyzer with 7% and 10% starch suspension were 51.4 - 52.6ºC. These values were also approximately 20ºC lower than those of normal sweetpotato starches. These starch properties are quite unique and unknown among sweetpotato cultivars.

Amylose content of "Quick Sweet". Amylase content of "Quick Sweet" starch was about 16 %. Since this value is similar to those of normal sweetpotato starches, it is unlikely that the unique starch properties of "Quick Sweet" are caused by shift of amylose content.

Chain-length distribution of amylopectin of "Quick Sweet" starch. Analyses of the chain-length distribution of amylopectin determined by high-performance anion-exchange chromatography (HPAEC) showed that "Quick Sweet" starch had a higher proportion of short chains (DP 6 - 11) and a lower proportion of chains between DP 12 - 28 than those in normal sweetpotato starch including the parents. Kitahara *et al*. (1999) reported the high proportion of short chains in amylopectins of two sweetpotato lines with low pasting temperatures of 61.5 and 66.5ºC. Thus, the change in chain length distribution of amylopectin is thought to be the reason for the unique starch properties of "Quick Sweet".

Cooking properties of "Quick Sweet". When small blocks of storage roots (20mm x 15mm width) were subjected to steaming, the brix values of "Quick Sweet" blocks increased more rapidly than those of normal sweetpotato, "Beniazuma" and "Kokei No.14". It rose to a plateau at 7% within 3 min. This suggests that "Quick Sweet" can be cooked more quickly by steaming

Table 1: Yield performance of "Quick Sweet".

Cultivar	Quick Sweet	Beniazuma	Kokei No.14
Marketable root yield (t/ha)	28.6	26.7	26.7
Dry matter content (%)	34.3	35.5	31.2
Storage root shape	Spindle	Long spindle	Long spindle
Skin color	Purplish red	Deep purplish red	Purplish red
Flesh color	Light yellow	Yellow	Light yellow

Note: Values are the average of data from 1998 to 2000.

compared to other normal varieties. Tasting panel experiments showed that "Quick Sweet" was as sweet as "Beniazuma" after conventional steam cooking. The brix values of steamed "Quick Sweet" were about 7%. These values were similar to those of "Beniazuma". The brix values of "Beniazuma" after microwave cooking were around 5% compared to "Quick Sweet" brix values of about 6.5%. "Quick Sweet" remained sweet enough even after microwave cooking. The sweetness of sweetpotato is derived from maltose, which is formed from pasted starch by β-amylase during cooking. It is likely that changes in cooking properties of "Quick Sweet" are derived from the shift of pasting properties of its starch.

We investigated the origin of the starch properties of "Quick Sweet". All the progenitors of "Quick Sweet" have normal sweetpotato starch. Therefore, it is likely that recessive gene(s) controls this starch property and the parents have this gene(s) heterogeneously. Since similar shift in starch property was reported in some plants which had modified starch synthase II or III gene (Kossmann and Lioyd, 2000), we are investigating the genes coding starch synthase II and III of "Quick Sweet" to understand the genetic mechanism of its starch properties. It is expected that this variety will meet the healthy requirements and fast cooking time cherished by the busy Japanese.

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