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Sweetpotato Research Front

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Contents

Food Functionality Supported by Scientific Evidence

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A few years ago, Japanese traditional food "NATTO" (a fermented soy bean) disappeared from every super market shelf. This strange phenomenon continued a few weeks. The reason was that a famous TV program had broadcast that NATTO was very effective for dieting. The next day, people rushed to buy NATTO!

Later, it was proven that this statement was not based on scientific evidence. TV media was just an instigator of that affair. The TV program was terminated as a result.

Today, people have become very sensitive to diet or health food fads.

In recent years, studies on food functionality have made great strides. Anthocyanins such as included in the purple-fleshed sweetpotato have antioxidant properties. Usage of sweetpotato might thus be greatly expanded. In Western countries, the EU and the USA, the oxygen radical absorbance capacity (ORAC) has been established for processed foods and supplements and listed on labels of organic products stocked on store shelves.

However, it is very important to inform the public about food functionality without creating the confusion caused by the NATTO incident.

The importance of scientific evidence is unquestionable. In addition, we must propose food ingredients to provide total health functionality, not as separate functional ingredients. In other words, we must propose food ingredients as a balanced and comprehensive food culture, not just food supplements.

In Japan, publishing functional ingredients of food has gradually increased.

The possibility of food analysis has been growing. The need for developing food varieties, analysis of health functions, and a gastronomic food culture is increasing more and more.

Organic products listed on labels with "ORAC".
(Photo by S.Yano & K.Goto)

Research Paper

Transgenic Introduction of Low-Temperature Pasting Properties of Starch in Sweetpotatoes

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The sweetpotato cultivar Quick Sweet (QS) with a lower pasting temperature of starch is a unique breeding material, but the biochemical mechanism of this property is unknown. We preliminarily found that most of the transcripts of the isoform II starch synthase (*SSII*) gene were inactive alleles based on the nucleotide sequence analysis of QS, suggesting that *SSII* possibly plays an important role in the biosynthesis of low-pasting-temperature starch also in the sweetpotato storage root.

To investigate the physiological effects of the reduced SSII activity on the starch properties in sweetpotato storage roots, transgenic sweetpotato plants with reduced expressions of the *SSII* gene were produced and evaluated[1]. All of the starches from transgenic plants exhibited lower pasting temperatures and breakdown measured by a Rapid Visco Analyzer (Table 1). The pasting temperatures in transgenic plants were about 10 to 15 ℃ lower than those in wild-type plants. The distribution of the amylopectin chain length of the transgenic lines exhibited marked differences from that in wild-type plants. Specifically, there were more chains with DP (degree of polymerization) 6-11 and fewer chains with DP 13-25. The starch granules from the storage root of transgenic plants exhibited cracking on the hilum, while those from wild-type plants appeared to be typical sweetpotato starch.

These results clearly indicate that the activity of SSII in sweetpotato storage roots, like those in other plant species, affects the pasting properties of starch through alteration of the amylopectin structure. A lower pasting temperature starch leads to more efficient starch saccharification. The method developed in this study would contribute to enhancing the productivity of bio-ethanol made from sweetpotatoes.

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Table 1. Physiological trait and RVA starch properties of transgenic sweetpotato plants (cv. White Star)

Plant	Weigt of aerial part[a)]	Storage root weight[a)]	Dry matter content[b,c)]	Starch content[b)]	Pasting Temp (℃)[d)]	Peak Visc (RVU)[d)]	Breakdown (RVU)[d)]	Setback (RVU)[d)]
White star	72.0	101.3	29.1	21.1	75.3	185	80	130
White star	75.1	89.1	27.5	19.7	74.2	190	78	128
White star	61.2	109.3	26.9	19.7	76.0	182	84	119
WS_SSi-2	73.7	95.4	30.8	22.5	62.6	145	33	130
WS_SSi-5	68.8	96.7	30.4	20.7	63.0	139	38	135
WS_SSi-12	74.9	98.4	27.1	19.9	63.3	144	34	135
WS_SSi-28	78.5	61.3	27.9	18.5	62.7	164	42	199
WS_SSi-34	86.6	69.9	25.0	17.5	60.4	141	47	144
WS_SSi-39	70.1	100.4	28.8	19.4	64.7	126	36	145

All plants were grown in a temperature-controlled greenhouse.
a) g fresh weight/plant; b) % to total fresh weight of storage root; c) % of total fresh weight based on freeze-drying
d) RVA properties were determined on 7% starch suspension by Rapid Visco Analyzer.

Research Paper

New Sweetpotato Cultivar "Tamaakane" Suitable for Brewing and Direct Planting

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"Tamaakane" is a newly released sweetpotato cultivar with good brewing properties. It has been adapted for direct planting and was developed by the National Agricultural Research Center for Kyushu Okinawa Region. Performance and local adaptability tests were conducted at prefectural agricultural experiment stations, and the brewing properties of this cultivar were evaluated by distilling companies in Miyazaki and Kagoshima prefectures.

These efforts confirmed that the yield of Tamaakane for direct-planting culture exceeded that for transplanting culture, and that the flavor of shochu can be clearly distinguished from that of shochu made from pre-existing cultivars. Subsequently, Tamaakane was released in 2009 as the first exclusive cultivar with orange flesh for use as a raw material in producing shochu.

Origin

The Tamaakane breeding program was initiated in 1996, and "Resist" and "Kyukei179" were used as the crossing parents. Resist is a β-carotene-containing cultivar, which was introduced from the United States, and the breeding line Kyukei179 has a good appearance and shape.

Description

The storage roots are uniformly short, fusiform, and well-shaped; the skin of the roots is light brown and the flesh is deep orange. Furthermore, this cultivar exhibits high storability and resistance to root-knot and root-lesion nematodes.

The shochu yield of Tamaakane is slightly less than that of "J-Red," but the results of sensory evaluation conducted by panelists of the distilling company revealed that Tamaakane products were superior in terms of flavor and aroma (Table 1).

In addition, Tamaakane can be adapted for direct planting because the seed-tuberous root (seed tuber) of this cultivar disappears during the growth process, as in the case of the Irish potato (Fig. 1), and the yield of this cultivar under direct planting culture exceeds that under the transplanting culture (Fig. 2).

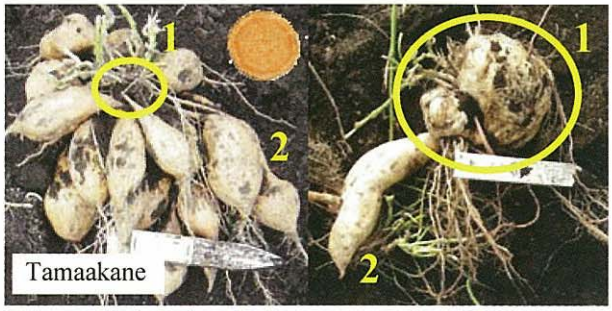

Fig. 1. Comparison of root types between cultivars adapted for direct planting and those not adapted
1) seed tubers
2) newly generated tubers

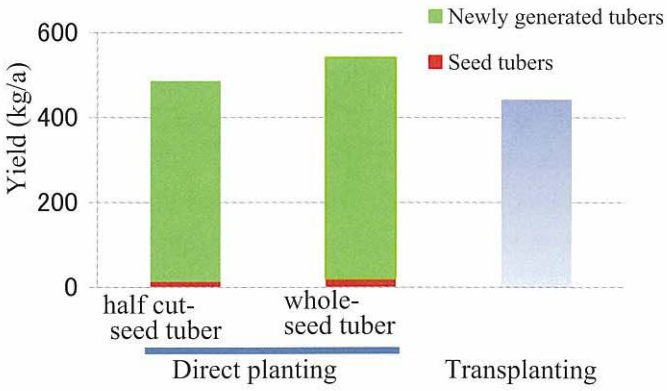

Fig. 2. Effects of cultivation conditions on total tuber yield of "Tamaakane" (2004–2007)

Table 1. Brewing tests with "Tamaakane"

Category	Cultivar	Brix (%)	Alcohol content(%)	Alcohol yield	Sensory evaluation score[1)]	Sensory evaluation Impression
Distilled liquor (Imo shochu)	Tamaakane	-	-	132[2)]	1.8	sweet, mild, flowery, etc.
	J-Red	-	-	143	2.1	carrot-like, burnt odor, etc.
Liquor	Tamaakane	10.6	8.9	70[3)]	1.3	bright orange, balanced taste, etc.
	J-Red	10.2	8.9	60	1.6	sweet, slightly inferior flavor, etc.

[1)] 3-score scale (1, good; 2, moderate; 3, bad)
[2)] L/t: alcohol yield per ton of sweetpotato
[3)] %: vol. of product / wt. of raw materials

Influence of Root-knot Nematode on Damage of Tuberous Roots in Sweetpotato

Takayuki Suzuki

Upland Farming Research Team (Kyusyu Region), National Agricultural Research Center for Kyushu Okinawa Region

Root-knot nematode (*Meloidogyne* spp., RKN) is widely distributed in the warm upland farming area of Japan and severely damages sweetpotatoes. Many nematode-resistant cultivars have been developed in Japan. Resistance is evaluated by degrees of RKN parasitism and reproduction. However, the influence of RKN on damage to tuberous roots of these resistant cultivars has not been sufficiently investigated. Our group evaluated the damage of tuberous roots in high RKN density field conditions.

Treatments consists of two RKN density treatments, low (LD) and high (HD) as main plots and sweetpotato cultivars as subplots. Before cropping, there were three RKN per 20 g soil for LD and 174 for HD. A nematicide, DD (1,3-dichloropropene 97%), was injected into the soil in LD.

Results of four sweetpotato cultivars, Kokei-No.14 and Koganesengan (slightly susceptible), J-red and Tamaotome (resistant) were as follows. The numbers of RKN in the plots of slightly susceptible cultivars were high, and those in resistant cultivars were low at harvest (Table 1). Slightly susceptible cultivars were heavily injured in HD areas. Holes and cracks were found on their tuberous roots. These results demonstrate that cultivating these resistant cultivars effectively maintains low RKN population densities and avoids nematode injuries to tuberous roots.

However, the yield of tuberous roots of every cultivar was lower in HD areas than in LD areas (Fig. 1). Similarly, there were fewer tuberous roots per plant in HD areas than in LD areas, and tuberous roots were thicker in HD areas than in LD areas (Table 2). It is reported that RKN appear to penetrate the root system of resistant cultivars. The above suggest that RKN affects formation of tuberous roots regardless of the resistance of the cultivar, and each remaining tuberous root thickens and compensates for the loss in total yield. Further investigation of each cultivar's characteristics is required for using resistant cultivars.

Table 1. Number of root-knot nematodes at harvest

	No. of nematodes per 20 g soil	
Cultivars	HD	LD
Kokei-No.14	155	0
Koganesengan	155	0
J-red	7	0
Tamaotome	0	0

The number of second-stage root-knot nematode juveniles is shown.

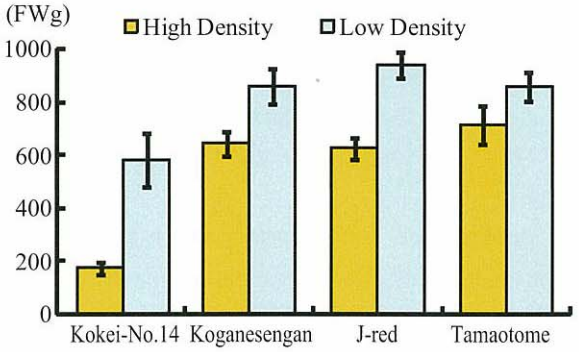

Fig.1. Yield of tuberous roots per plant
Tuberous roots that weighed 50g or more were measured.

Table 2. Number, length and diameter of tuberous roots

	No. of TR per plant		length (cm)		diameter (cm)	
Cultivars	HD	LD	HD	LD	HD	LD
Kokei-No.14	2.8	3.3	N.A.	N.A.	N.A.	N.A.
Koganesengan	4.6	5.2	15.8	15.3	6.5	6.1
J-red	3.5	4.5	13.6	17.1	6.7	6.5
Tamaotome	3.2	4.5	15.2	18.5	6.9	6.1

TR: tuberous roots, .N.A.: not applicable.
Tuberous roots that weighed 50g or more were measured.

Effect of Application of Condensed Liquid Made from Sweetpotato Shochu Distiller Waste on Emergence of Upland Weeds

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Condensed liquid is made from sweetpotato shochu distiller waste, which is separated into solid and liquid portions. Condensed liquid is produced from the liquid portion, which is concentrated to 10 times its original strength.

We studied the inhibitory effect of condensed liquid on the growth of upland weeds. Pot experiments were conducted in a green house at 30℃. We planted 50 seeds of *Digitaria ciliaris* (Retz.) Koeler and *Amaranthus patulus* Bertoloni in a pot. After seeding, 0, 80, 160, 400, or 800 mL m^{-2} of condensed liquid was applied to the soil surface.

Emergence of the weeds was significantly inhibited by the 800 mL m^{-2} application. It seems that the inhibitory effect on weed emergence was likely to be affected by germination inhibiting compounds contained in shochu distiller waster. At 28 days after application of condensed liquid, counts of emergence of the weeds were decreased for the application of 800 mL m^{-2} compared with control, i.e. the counts of *Digitaria ciliaris* (Retz.) Koeler emergence after treatment was 70% of the control (Fig 1.), and *Amaranthus patulus* Bertoloni emergence after treatment was 44% of the control (Fig 2.). Some seedlings of *Amaranthus patulus* Bertoloni died after emergence, suggesting that the condensed liquid also has an inhibitory effect on growth in some weed species. After application of condensed liquid, the number of weeds seedlings gradually increased for 28 days. It seems that the inhibitory effect on weed emergence gradually decreases with time. Growth of the weed seedlings increased in proportion to application dosage of condensed liquid because the condensed liquid contains nutritional elements of fertilizers. The condensed liquid had less effect on the emergence of weeds than chemically synthesized herbicides.

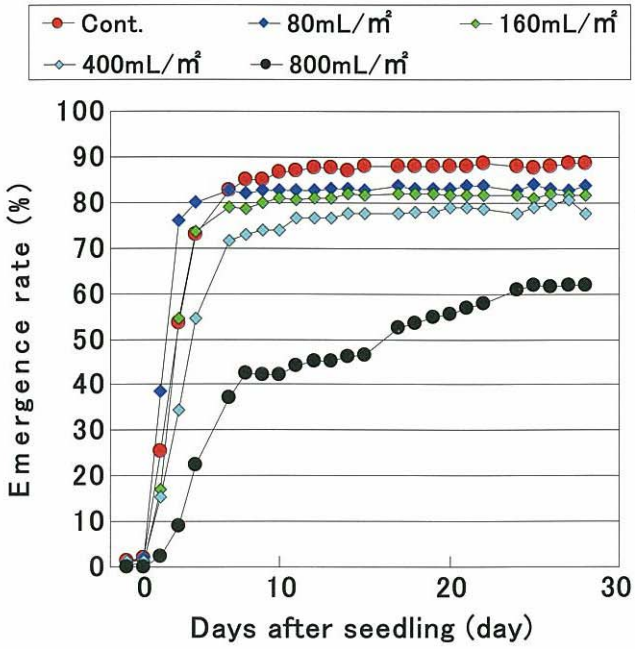

Fig.1. Effect of application of condense liquid on emergence of *Digitaria ciliaris* (Retz.) Koeler

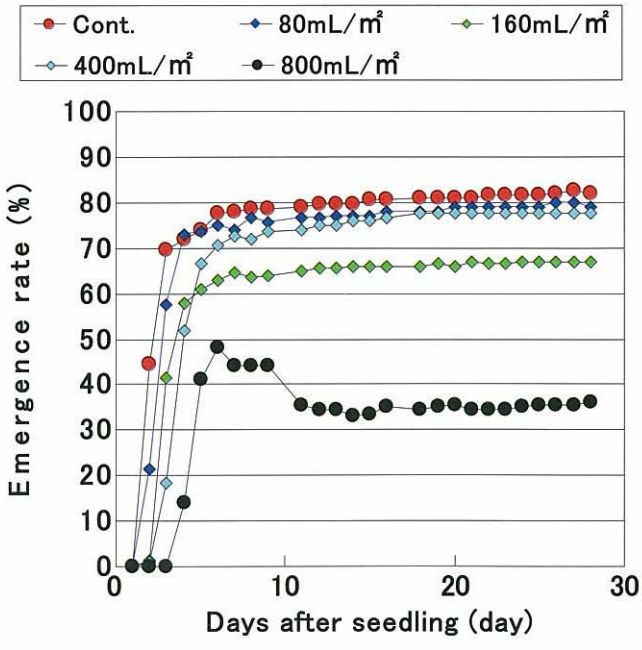

Fig.2. Effect of application of condense liquid on emergence of *Amaranthus patulus* Bertoloniat

Research Paper

Functional Characterization of the Genes Expressed in the Storage Roots of Sweetpotato

Masaru Tanaka[1], *Yasuhiro Takahata*[1] *and Hiroki Nakayama*[2]

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2. Sweetpotato Breeding Research Team, National Agricultural Research Center for Kyushu Okinawa Region

We previously identified ten genes differentially expressed in fibrous and storage roots of sweetpotato (*Ipomoea batatas*) and named them *SRF1* to *SRF10*[1]. Because these genes were expected to be involved in important physiological processes of storage root formation, their functions were investigated using transgenic sweetpotato plants. These studies revealed that the *SRF1* gene is involved in the regulation of carbohydrate metabolism in storage roots.

SRF1 was found as one of the genes upregulated genes in storage roots[1] and encodes a transcription factor belonging to group II Dof zinc finger protein (Fig. 1). The dry matter and starch content increased significantly in the storage roots of transgenic plants overexpressing *SRF1* under the control of modified CaMV35S promoter (Table 1). In these transgenic plants, glucose and fructose contents in the storage roots were drastically reduced. Measurement of enzymatic activities related to sugar metabolism suggested that this reduction of glucose and fructose was caused by reduced soluble acid invertase activity (Table 1). Gene expression analysis indicated that expression of *Ibβfruct2*, one of the vacuolar invertase genes, was suppressed in the storage roots of these transgenic plants.

These results suggest that *SRF1* regulates the carbohydrate metabolism in the storage roots through negative transcriptional regulation of a vacuolar invertase gene and thus provides novel possibilities for molecular breeding of carbohydrate metabolism in storage roots.

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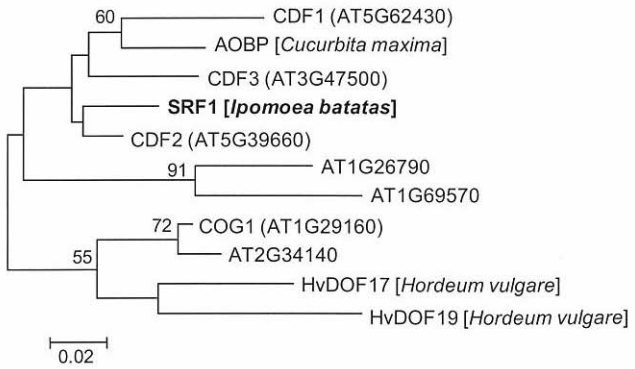

Fig.1. Phylogenetic relationship of the group II Dof proteins

Table 1. Physiological characteristics of storage roots harvested from wild-type and *SRF1*-overexpressing plants

Plant Line[a]	Dry matter (%)	Starch (% FW)	Soluble sugars[b] (mg g^{-1}FW)			Enzyme activity[c] (μmol h^{-1} mg^{-1} protein)				Vacuoler invertase expression (-fold)		
			Glu	Fru	Suc	aINV	SuSy	HK	FK	*Ibβfruct1*	*Ibβfruct2*	*Ibβfruct3*
WT	23.9	14.5	4.62	5.70	14.9	1.01	13.3	4.06	7.98	1.00	1.00	1.00
S1	28.7**	17.9**	1.33**	1.47**	17.1	0.34**	15.4	3.49**	8.21	1.08	0.14**	0.45
S2	27.7**	17.8**	1.29**	1.52**	15.9	-[d]	-	-	-	1.36	0.14*	0.63
S3	28.8**	17.9**	0.77**	1.07**	14.0	-	-	-	-	1.62	0.16*	0.84
S4	28.3**	17.8**	1.37**	1.48**	17.6*	-	-	-	-	1.17	0.26	0.75

[a] WT, wild-type plants (cv. Kokei No.14); S1-S4, transgenic plant lines overexpressing *SRF1*
[b] Glu, glucose; Fru, fructose; Suc, sucrose
[c] aINV, soluble acid invertase; SuSy, sucrose synthase; HK, hexokinase; FK, fructokinase
[d] not measured
Each number represents the average of 6 plants. *, $P < 0.05$; **, $P < 0.01$ (Dunnett's multiple comparison test)

Research News

Research Activities of the Upland Farming Research Team (Kyushu Region)

Katsuki Adachi

The Upland Farming Research Team (Kyushu Region) is conducting research to establish sustainable crop rotation systems that are environmentally friendly and suitable for large-scale upland farming in order to increase both the utilization rate of regional arable land and the profitability of farm management.

The research topics are 1) application of "Tachiibuki", an oat variety that suppresses root-knot nematodes, in crop rotation systems; 2) development of effective farm-work management systems by using information management technology and Global Positioning System (GPS) technology; 3) techniques for continuously using cultivation ridges for soil environment control in root-crop-based rotation systems; 4) developing novel technologies for supporting sweetpotato production, one of which is the technology for highly efficient sprouted vine production systems with elevated nursery beds; and 5) developing environmentally friendly upland crop rotation systems among sweetpotato, vegetable crops, and forage crops to increase the utilization rate of arable land and land productivity and to reduce excessive use of agrochemicals.

We utilize these research items as key technologies to develop systematic techniques for sustainable upland farming.

Sweetpotato Breeding Research Team

Masaru Yoshinaga

The Sweetpotato Breeding Research Team, formed in 2006 through NARO reorganization, is comprised of 11 researchers working in the field of breeding, biotechnology, and food processing. The mission is to create new varieties for starch, alcohol, and food processing and for fresh market consumption in order to encourage both sweetpotato producers and industries. To accelerate the breeding, we are developing DNA markers related to root knot nematode resistance, using diploid wild relative species. We have also developed techniques to introduce virus resistance into sweetpotato by gene transfer. The gene encodes for coat protein of sweetpotato feathery mottle virus, a severe strain, and the transgenic sweetpotato was demonstrated to be highly resistant to the virus under greenhouse conditions (see SPORF No.23). Further achievements of this team since 2006 include a series of unique varieties that effectively enhance the demand for sweetpotato and promote the growth of the processing industry. Beniharuka is a very sweet and tasty variety with soft texture (see SPORF No.23). Tokimasari (see SPORF No.24) and Satsumamasari are both for *shochu* spirits with rich flavor and the aroma of steamed sweetpotatoes. Konamizuki is a variety for effectively increasing the added value of sweetpotato starch. The starch gelatinizes at a lower temperature, i.e., 50℃ in contrast to normal sweetpotato starch that gelatinizes at 70℃ . This unique starch exhibits an extremely low degree of retrogradation of starch gel after gelatinization and is useful for food processing. The Sweetpotato Breeding Research Team is pressing on toward our goal of supporting both sweetpotato producers and industries by improving sweetpotato potential.

Reader's Talk

Letter to the editor

Research and Development Efforts in Agro-Processing of Sweetpotato by the Caribbean Agricultural Research and Development Institute

Pathleen Titus

Roots and Tubers Commodity Leader

The Caribbean Agricultural Research and Development Institute (CARDI) was started in 1975 to provide for the research and development needs of agriculture in the Caribbean Region. There is a CARDI Unit in each of the twelve Caribbean Community (CARICOM) countries.

The sweetpotato has been produced in the Region for centuries and significant germplasm exists in each island. The crop is produced mainly for food, and there is some export trade mainly with the UK, Canada, and intra-regionally. The sweetpotato is considered an underexploited crop and was identified for development by regional governments. CARDI was charged with the task of leading the process.

The Institute is using the Commodity Chain Development approach in an attempt to create sustainable industries where collaborators and stakeholders are involved in technology generation and transfer.

Along the commodity chain, value-added product development of sweetpotato has been identified as important for driving the industry through increased production and utilisation. Currently, there is limited agro-processing of sweetpotato. The main products produced include flour, pudding mixes, cereals, fries and chips.

CARDI recognizes the need for strong alliances for successfully implementing its work programme. As a result, in 2006, CARDI, in collaboration with the University of the West Indies, forged a strategic linkage with KONARC, which resulted in Japanese scientist Dr. Masaru Yoshinaga visiting the Caribbean and evaluating 34 sweetpotato varieties to assess their suitability for processing into flour, chips and juice. The Institute also collaborated with The University of the West Indies to evaluate physicochemical properties of 21 Caribbean sweetpotato cultivars grown in St. Vincent and the Grenadines. The information generated would also be used in product development.

To build on that knowledge and to further exploit the identified potential of some of these varieties, the Institute is partnering with private sector agencies in Barbados, Jamaica, St. Vincent and the Grenadines, Dominica and Trinidad, and Tobago. CARDI is the implementation agency for a regional project conducted by the Common Fund for Commodities (CFC). This project aims to increase production of selected roots and tubers in the Caribbean Region. Adding value to the sweetpotato is an important activity in the participating countries, and resources are allocated for purchasing equipment and product development.

It is hoped that, at the end of this project, significant strides will have been made towards achieving the goal of sweetpotato industry development and increased production, consumption, and utilization of the crop.

Editoer's note

The fourth China-Japan-Korea workshop on sweetpotato held on November 27-29 was a great success. The workshop will be reported in the next issue. (M.Y.)

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