Near infrared routine analysis of sugarcane juice in a sugar manufacturing company in Japan

Reiji Sekiguchi, Ken-ichi Fuchigami, Sumiko Hara and Chuichi Tutumi

Japan Food Research Laboratories, Motoyoyogi-cho, Shibuya-ku, Tokyo 151, Japan.

Introduction

Sugarcane produced in Japan has always been purchased by weight in sugarcane manufacturing factories. However, it is impossible to properly evaluate the sugar content, which is the most important factor of sugarcane, by this inspection method depending on weight. Thus, some problems have arisen, including (i) farmers are not strongly motivated to produce high quality sugarcane; (ii) the qualities of the primary product does not affect the results of the inspection etc.

To cope with these problems, the government decided to introduce the Sugarcane Quality Inspection (SQI) Network which uses near infrared (NIR) spectroscopy for inspection of products in sugarcane manufacturing factories in order to improve the qualities of sugarcane and highly motivate farmers to produce sugarcane. Following this decision, Japan Food Research Laboratories (JFRL) has repeated experiments in laboratories and fields in cooperation with national research laboratories and finally established the SQI Network.

In this report, we will explain the establishment of the SQI Network, the summary of a sugarcane juice automatic analyzer (SJAA) by which sugarcane juice pol can be automatically measured, the maintenance and management of a system where JFRL serves as the quality control center, and the present situation of an infrared (NIR) routine analysis on sugarcane juice, which has been introduced into practical business operations for the first time in Japan.

A detailed process for the establishment of the Sugarcane Quality Inspection (SQI) Network

The SQI Network is the system by which a sugarcane juice automatic analyzer (SJAA) located in the Sugarcane Quality Inspection (SQI) Station of each factory is directly connected to the SJAA in JFRL in Tokyo via a computerized network to quickly inspect the qualities of sugarcane in a sugarcane manufacturing factory (Figure 1).

The process for establishment of the SQI Network was as follows.

1989: Liaison Conference for Promoting Sugarcane Quality Inspection was established for planning test projects and discussing the results.

1990: Attempts to apply NIR to the analysis of sugarcane juice were started in The National Food Research Institute, the Kagoshima Prefectural Agricultural Experiment Station and the Okinawa Prefectural Agricultural Experiment Station.[1,2]

1991: Liaison Conference selected " juice pol " as the item to be analyzed by NIR.

1992: Liaison Conference specified SQI Network on the basis of SJAA.

1993: SQI network based on SJAA was introduced into all sugar manufacturing factories (21).

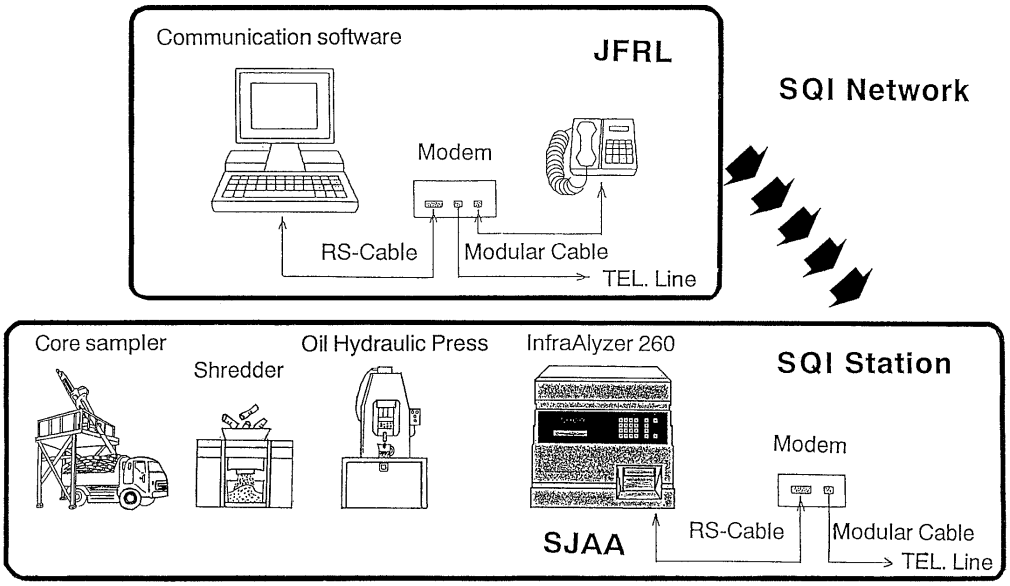

Figure 1. Sugarcane Quality Inspection (SQI) network.

Then each SJAA having a calibration, which had been developed by JFRL, was installed therein and was subjected to test runs for about 1 month.
1994: Sugarcane quality inspection by NIR routine analysis was started in each sugarcane manufacturing factory.

Sugarcane Quality Inspection (SQI) station in sugarcane manufacturing factory

Constitution of SQI station and method for quality inspection in the SQI station

An SQI station consists of (1) a core sampler, (2) a shredder, (3) an oil hydraulic press, (4) a sugarcane juice automatic analyzer etc.

In the SQI station, quality inspection is performed in the following manner.

1. Sugarcane transported into the factory is weighed together with the truck (3 to 6 t). After unloading the cargo, the truck alone is weighed again.
2. A sample (about 5 kg) for quality inspection is taken up with the core sampler.
3. The sample thus taken up is accurately weighed.
4. The sample is manually divided into clean cane and trash (leaves, roots) and then the clean cane is weighed.
5. The clean cane is cut into small pieces with the shredder. A portion (about 500 g) of the shredded sample is collected for analysis and accurately weighed.
6. The shredded sample for analysis is treated with the oil hydraulic press (face pressure: 260 kg cm^{-2},1 minute) to give juice. Then the shredded sample is divided into cane juice and bagasse. The bagasse is weighed.
7. The cane juice is filtered through a 200-mesh stainless sieve (75 μm) and transferred into a test tube. Bubbles contained in the cane juice are removed with an ultrasonic cleaner.

8. The pol of the degassed cane juice is measured with the sugarcane juice automatic analyzer which will be described in detail later.

Sugarcane juice automatic analyzer (SJAA)

SJAA consists of an InfraAlyzer 260, a liquid control system (LCS), a constant temperature automatic sampler, a constant temperature circulator and an ultrasonic cleaner (Figure 2). By using this SJAA, pol is measured in the following manner.

1. Small bubbles contained in the cane juice, are removed with the ultrasonic cleaner.
2. The test tubes containing the degassed cane juice is set on the automatic sampler.
3. The temperature of the sample in the automatic sampler is regulated to 27°C with water supplied from the constant temperature circulator.
4. The sample taken up with the automatic sampler is transported to the liquid sample holder of the InfraAlyzer 260 via a pump of the LCS. The temperature of the liquid sample holder is regulated to 25°C.
5. After transporting a definite amount of the sample, the absorbance of the sample at a definite wavelength is automatically measured by the transflectance method.
6. After measuring the absorbance, the liquid sample holder and the inside of the tube connecting the holder with the automatic sampler are washed with a cleansing liquid.
7. One minute is required for analyzing a sample including the washing step.

Significant items in the development of the sugarcane juice automatic analyzer (SJAA)

To develop the SJAA, the following items were discussed in particular detail.

Development of a liquid sample holder for sugarcane juice

Because it contains fine particles, sugarcane juice is easily contaminated and less stable compared with conventional samples in the liquid sample holder. Accordingly, a novel liquid

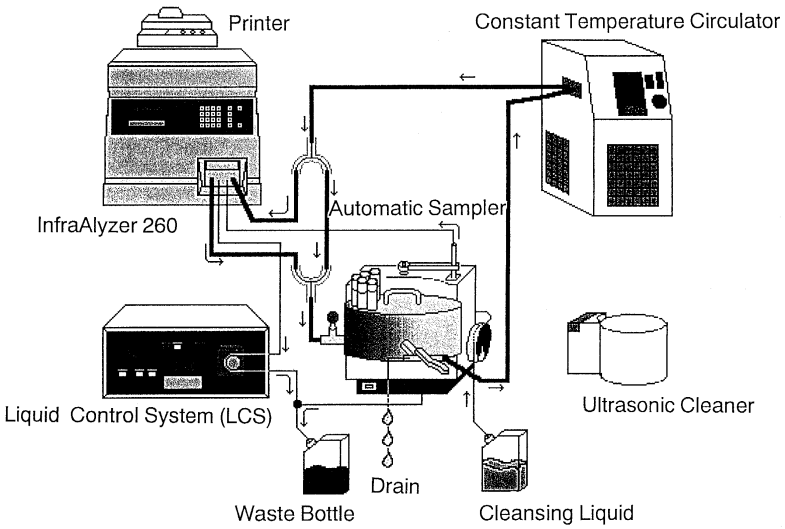

Figure 2. Sugarcane juice automatic analyzer (SJAA).

sample holder, which is highly resistant against contamination, has been developed by Bran+Luebbe.

Development of the cleansing liquids

To wash away small particles of material in the liquid sample holder and tube due to the sugarcane juice, two cleansing liquids have been developed. After completion of the measurement of the absorbance, the liquid sample holder and tube is washed with one cleansing liquid which is called " Cleansing Liquid A ". After completion of the routine analysis the liquid sample holder and tube are filled with another cleansing liquid, which is called "Cleansing Liquid B", until the next measurement is started. The " Cleansing Liquid B " also has antiseptic and antimicrobial effects.

Development of calibration for measuring juice pol

The major sugarcane production areas in Japan are distributed among isolated islands in Kagoshima and Okinawa, which are 1000–2000 km away from JFRL which is located in Tokyo (Figure 3).

JFRL has developed a universal calibration for measuring juice pol which is applicable to all of these areas. The calibration thus developed has the following characteristics.

1. This calibration was developed by using about 300 samples collected from Kagoshima and Okinawa, which are the major sugarcane producing areas, during the harvesting period. Thus it is applicable to any area, regardless of variety or harvesting time.
2. The measurement accuracy expressed in *SEP* is 0.19%.

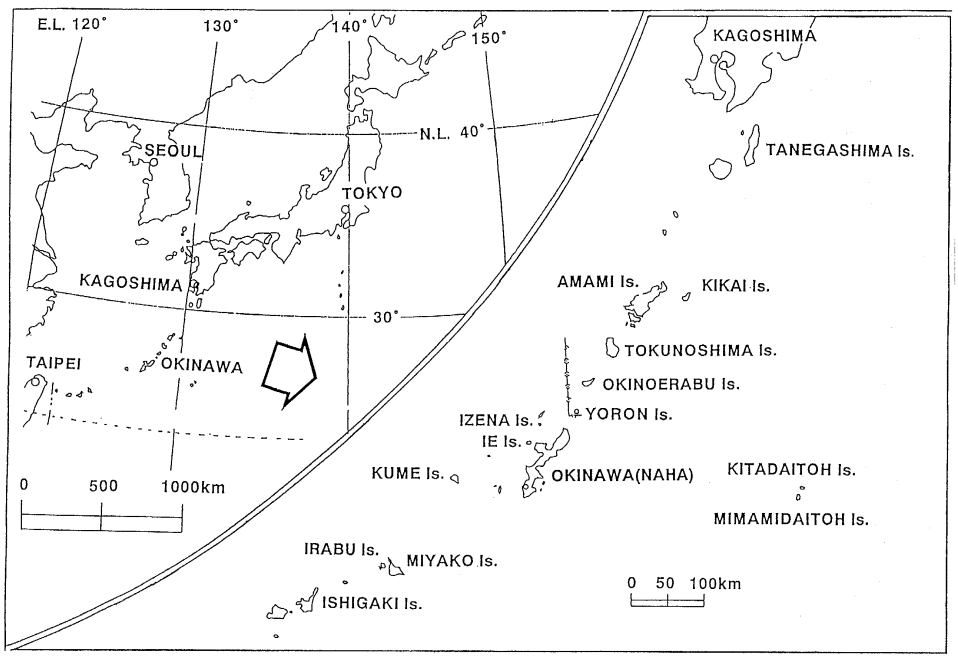

Figure 3. Located areas in the Sugarcane Quality Inspection (SQI) network.

Maintenance and management of SJAA

Impartiality

To ensure impartiality in the quality inspection in sugarcane manufacturing factories and to enhance its reliability, JFRL has entered into a contract with every sugarcane manufacturing factory concerning the management of the SJAA.

Constants in the SJAA calibration have been locked so as to prevent them from any changes by someone from outside.

Accuracy

To grasp the measurement accuracy of the SJAA of each sugarcane manufacturing factory, samples analyzed by the SJAA of the factory are regularly sampled and delivered to JFRL in a frozen state. JFRL measures these samples again with an SJAA (Master Analyzer) corrected with data analyzed by the conventional method and records the difference between the factory's data and the JFRL's data.

In routine analysis during the sugar manufacturing period from 1994 to 1995, the difference among the factories' data and the JFRL's data each falls within the allowable range of error, which indicates that the measurement accuracy is not a problem.

Examination of contamination of liquid sample holder with standard solution

To examine contamination of the liquid sample holder and ensure the stability of the SJAA, an aqueous solution of sugars, which is similar to the sugarcane juice in sugar composition but can be easily stored, is employed as a substitute for the sugarcane juice which spoils easily. This aqueous solution of sugars is called the "Standard Solution ". Before starting the routine analysis, the measurement accuracy is examined daily in a sugarcane manufacturing factory by using this standard solution. After confirming that the data of the component of the standard solution falls within a definite range, the measurement of the sugarcane juice pol is started.

Remote control of SJAA in factory in case of the occurrence of bias

To continuously maintain the SJAA in every sugarcane manufacturing factory in the best condition, a computerised network has been introduced wherein the SJAA in each sugarcane manufacturing factory is connected to the SJAA of JFRLvia telephone lines. The SJAA in JFRL is connected to the SJAA's in 21 factories via telephone lines. The SJAA instruments in each sugarcane manufacturing factory are inspected and the bias, if any, of the calibration is corrected by the computer in JFRL.

Countermeasure to abnormal contamination of the liquid sample holder

The liquid sample holder is washed with two cleansing liquids as described above. However, there is a risk of abnormal contamination of the liquid sample holder, since tens of thousands of samples are measured in the routine analysis. Thus, each sugarcane manufacturing factory is provided with another liquid sample holder as a spare.

Measure to deal with troubles

When the SJAA suffers from some problem, the person in charge communicates with JFRL and then takes appropriate measures to cope with the situation under JFRL's instructions.

Problems to be discussed in the future

The following problems must be discussed further.

1. Development of a cleansing liquid with improved washing performance.
2. Development of calibrations for analyzing main factors other than juice pol (for example, sucrose content, Brix etc.)

Conclusions

After the establishment of the Sugarcane Quality Inspection (SQI) Network, NIR routine analysis of sugarcane qualities was started in the sugar producing period from 1994 to 1995.

Sugarcane Quality Inspection (SQI) Stations consisting of core sampler, shredder, oil hydraulic press and sugarcane juice automatic analyzer were introduced into all sugarcane manufacturing factories (21) in Kagoshima and Okinawa.

JFRL has served as a quality control center responsible for the maintenance and management of the SJAA provided in the SQI station in every factory with a computerized network via telephone lines.

By using this SJAA, juice pols of sugarcane juice samples can be measured at 1 minute intervals.

During the sugar producing period from 1994 to 1995, SJAAs were operated for 40 to 130 days in the sugarcane manufacturing factories. As a result, no serious problem occurred except that some variations in the analytical data due to the contamination of liquid sample holders were observed in a few factories.

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