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Quality Evaluation of Rice in Japan

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Abstract
Quality evaluation of rice in Japan can be carried out by the application of sensory test and physico-chemical determinations. The former is a basic method although it requires a large amount of samples and many panellers. The latter is an indirect method to estimate the eating quality based on the chemical composition, cooking quality, gelatinization temperature and/or the physical properties of cooked rice. Although it is impossible to estimate accurately the eating quality by only one physico-chemical determination, if a rapid, simple and more accurate method to evaluate rice quality could be developed, it would be very useful for both the producer and the consumer of rice.

Discipline: Food/Postharvest
Additional key words: amylose, physico-chemical determination, sensory test

Introduction

Rice is one of the most important crops in the world in addition to wheat and maize. In 1988-1989 rice covered about 147 million ha with a production of 506 million t worldwide. As De Datta[2] pointed out, rice is indispensable in terms of importance as a food crop because it provides more calories per ha than any other crop. As a staple food in Japan, in 1989, rice was cultivated over more than 2 million ha of paddy fields with a production of 12,934 thousand t per year. Along with the changes in the dietary habits of the Japanese people associated with the improvement of the economic situation, the consumption of rice has decreased rapidly. As a result, the demand for high-quality rice has increased. Also, the Japanese government has been promoting rice consumption to cope with the domestic surplus of rice. For the increase of rice consumption, breeding of new varieties with various characteristics, development of low-cost cultivation technology and of new processed rice foods are essential. Under these circumstances, quality evaluation of rice aims at two objectives: first, to select high-quality rice easily and accurately, and second, to characterize the processing suitability of the newly bred high-yielding rice varieties.

General considerations relating to rice quality

(1) Basic requirements

Rice quality involved various aspects, for example, safety, price level, palatability, nutrition, appearance, etc. As we eat rice every day, safety and high nutritive value are indispensable factors. Furthermore, as rice is the economical base for the farmers and it is prepared, milled and traded by wholesalers and retailers, the yield and price are very important. Consumers ask for more palatable rice because they have become more affluent recently.

(2) Inspection standards of rice in Japan

In Japan rice is graded based on standards depending on the weight per volume, moisture content, appearance, and the ratio of head rice, damaged rice, dead rice, colored rice, foreign grain and foreign matter. Official inspectors belonging to the National Food Agency evaluate rice mainly by the appearance and classify it into first, second, third, sub-standard grades and non-standardized.

(3) "Meigara", five grades depending on the varieties and the producing districts

Classification of rice, except for the inspection standards, takes place at the Meigara Committee.

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Table 1. Price of graded rice in Japan (produced in 1989)

(Yen/60 kg brown rice)

Grade	Meigara				
	1st	2nd	3rd	4th	5th
1st	17,015	16,865	16,615	16,265	15,865
2nd	16,695	16,545	16,295	15,945	15,545
3rd	-	-	15,295	14,945	14,545

The main commercial rice varieties are grouped into five classes based on the amount of rice produced, price, rate of free market rice, etc. This classification leads, along with the inspection standards, to differences in the price of rice (Table 1). In 1990, trading areas for free market rice were established in Tokyo and Osaka. This system reflects the demand for rice and the evaluation by the food industry and dealers of the price at which rice is traded.

(4) Factors and weight in relation to the eating quality of rice

According to the report of the National Food Research Institute[9], the most important factors for the eating quality of rice were as follows: variety > producing district, climate, cultivation methods, storage, milling > harvest conditions, soaking, cooking, or keeping warm.

Relation between eating quality and chemical, physical or spectrophotometrical properties of rice

(1) Organoleptic test

The members of a trained panel (16 to 24 members) eat cooked rice and give scores for the appearance, flavor, taste, hardness, stickiness and general evaluation on a sensory basis. The results depend on the preference, circumstances and time. This test requires rice samples of at least 300 to 600 g and 16 panel members. Nevertheless, this sensory test is the basic or the standard method for the evaluation of rice quality. The cooking conditions, order of eating, environment of the test and the composition of the panel members are important factors for the accuracy of the test. The results are expressed as numerical values and treated statistically.

(2) Physico-chemical determinations

It is possible to estimate the rice quality based on physical determinations, such as rheological measurements of cooked rice, or chemical determinations, such as protein or amylose contents. These objective tests do not fully agree with the results of the sensory tests at present, and sometimes a very expensive equipment is required. The advantages of these tests are that the measurements are objective and the results can be compared among different districts and at different time.

Amylose content: The main component of rice is starch (about 72% of brown rice), which consists of amylose, 1,4-glucoside-bonded single chain, and amylopectin, 1,4- and 1,6-bonded branched chain. It has been reported that the higher the amylose content, the harder and non-sticky cooked rice becomes. At present, the amylose content is measured by the iodine colorimetric method of Juliano or with an autoanalyzer, by the amperetitration method, or chromatography after debranching by several enzymes.

Protein content: Rice contains about 5 to 15% of crude protein. It has been reported that cooked rice with a higher protein content tends to be hard and non-sticky. Protein content has been measured by the Kjeldahl method. Recently, an automatic system for the Kjeldahl method (digestion and titration) has been developed, and the near infrared reflectance (NIR) method has been introduced[3]. The latter method is preferable because it is a simple, rapid and accurate non-destructive method, although the former method is necessary for the calibration of the latter one (Fig. 1).

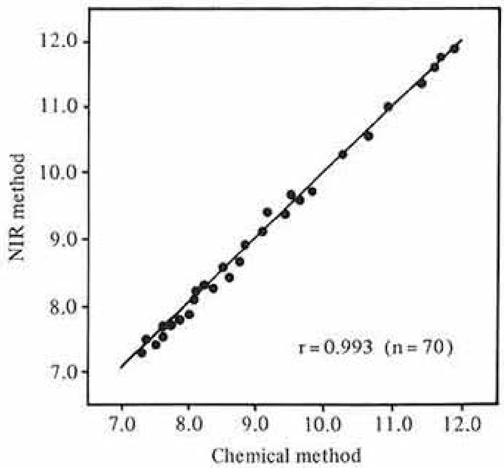

Fig. 1. Comparison of protein content determined by chemical and NIR methods[3]

Miscellaneous components: Moisture content (105°C, oven dry method), fat content (acid hydrolysis method or ether extraction method) and the contents of some inorganic components, such as Mg or K, are reported to influence the eating quality of rice.

Amylography: Amylography enables to analyze the gelatinization characteristics and amylase activity of cereal materials such as wheat or rice. The gelatinization temperature, maximum viscosity and "breakdown" were reported to be suitable indices for the eating quality of rice. Rice with a high maximum viscosity and "breakdown" is, in many cases, highly graded in Japan. However amylography is time-consuming (2 hr for each sample) and a large quantity of rice flour (40 to 50 g) is required.

Cooking quality test: Based on Batcher's method, the cooking quality test is carried out using 8 g of milled rice. After cooking in a cage hung in a tall beaker which contains 160 ml of water, the expanded volume (EV), water uptake ratio (WUR), content of solid substances in cooking solution (iodine blue value, IBV) and pH of the cooking solution are determined. The IBV was reported to be highly correlated with the amylose content, while EV, WUR an IBV are good indices for rice quality. Many of the rice varieties with a high quality in Japan show a low IBV and small EV and WUR values.

Determination of physical properties of cooked rice

After cooking, three grains or the mass of cooked rice are subjected to the determination of physical properties such as hardness, stickiness, using a Texturometer, a Tensipresser or an Instron tester, etc. Among the various parameters of the measurements, hardness, stickiness and their ratio (-H/H) are often used for the evaluation of rice quality. However, it is necessary to repeat the measurements at least 5 to 10 times because the texture of the rice

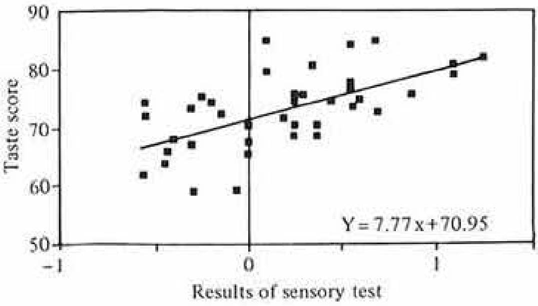

Fig. 2. Relationship between the results of the sensory test and taste score using a taste analyzer[10)]

Table 2. Changes in cooking qualities of the newly bred varieties at HNAES during storage

Varieties	Storage[a)]	EV	WUR	IBV	SS	IBV/SS
Koshihikari	B	36.4	334	0.118	0.361	0.327
	A	40.2	368	0.184	0.567	0.325
Kinuhikari	B	35.2	335	0.170	0.467	0.364
	A	38.9	358	0.248	0.663	0.374
Akichikara	B	37.7	355	0.192	0.536	0.358
	A	44.0	392	0.254	0.666	0.381
Ochikara	B	36.4	304	0.222	0.610	0.364
	A	37.7	340	0.232	0.661	0.351
Habataki	B	36.4	354	0.140	0.430	0.325
	A	37.7	375	0.172	0.605	0.284
Hokuriku 142	B	40.2	362	0.190	0.431	0.441
	A	45.2	387	0.300	0.655	0.458

a): A; 4°C storage for 70 days, B; 30°C storage for 70 days.
EV: Expanded volume, WUR: Water uptake ratio, IBV: Iodine blue value, SS: Solid substances in residual solution.

grains changes remarkably. In Japan, soft and sticky rice is preferred.

Taste analyzer: "Taste analyzer" is an apparatus for physico-chemical measurements of rice quality, consisting of a micro-computer, a display device, and a software. Its primary function is to convert various physico-chemical parameters of rice grains into "taste scores", based on correlations between physico-chemical values and the scores derived by sensory tests.

These "taste analyzers" were developed by several private companies based on the principles of NIR and multi-variance statistics. These systems are currently used by the agricultural cooperatives, rice milling industry or rice traders in Japan, because "taste scores" can be rapidly and easily obtained. Some reports have pointed out the need for the improvement of the system in terms of accuracy[10] (Fig. 2).

Miscellaneous subjects: The role of the cell wall or enzyme activities, the effect of harvest, drying or storage conditions, changes in the microstructure of the rice grains during cooking are major research subjects in Japan (Table 2).

Changes in rice quality from production to consumption

(1) Varieties

The rice varieties produced in the Hokkaido district (northernmost island of Japan) had been ranked as the worst ones in Japan due to their low quality for the past decades. However since the breeders in Hokkaido succeeded in developing new varieties with a low amylose content, the eating quality of Hokkaido rice varieties such as Kirara 397 markedly improved[7] (Fig. 3).

(2) Fertilizer application and eating quality

Application of an excessive amount of nitrogen

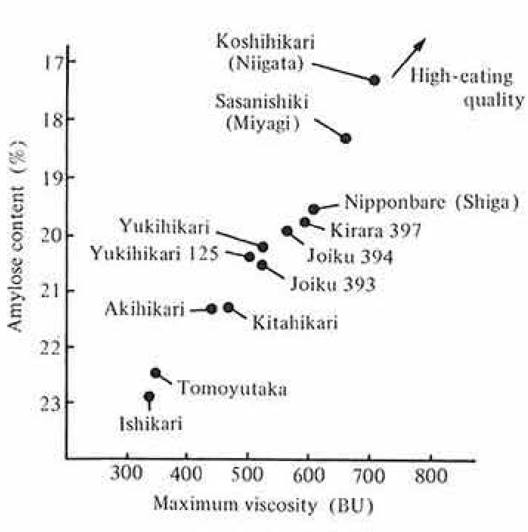

Fig. 3. Improvement of Hokkaido rice quality[7]

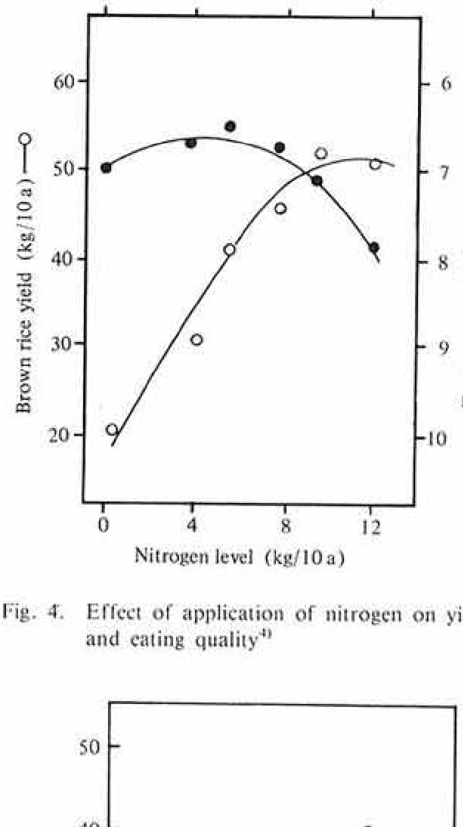

Fig. 4. Effect of application of nitrogen on yield and eating quality[4]

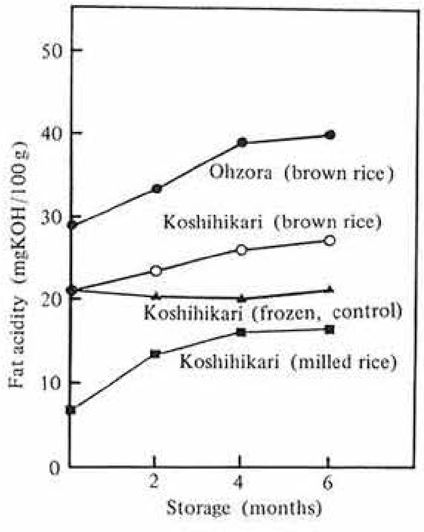

Fig. 5. Changes in fat acidity during storage[5]

fertilizer, particularly after heading, lowers the eating quality of rice, although it leads to high yield. Proper choice of the amount and timing of nitrogen application is necessary from the viewpoint of yield and quality[4] (Fig. 4).

(3) Drying and eating quality

Drying at a high temperature leads to the rapid deterioration of the eating quality of rice.

(4) Storage and eating quality

Storage at a high temperature and high humidity severely impairs the eating quality of rice. Low temperature storage is very effective to prevent the deterioration of the eating quality. Colorimetric measurement of the fat acidity is useful for evaluating the changes in the rice quality during storage[5] (Fig. 5).

Recent topics relating to research on rice quality in Japan

(1) Rapid and simple measurements of rice quality

NIR system has been found to be useful for rapid and simple determinations of the contents of rice components, such as protein, moisture, fat, etc. The use of multi-variance statistics and computer with some improvement of the software may lead to the development of a simple and rapid quality evaluation system in the future.

(2) Improvement of the accuracy of quality evaluation

Chikubu et al.[1] developed a new equation for the estimation of the eating quality of rice using a multiple regression analysis based on physico-chemical determinations, such as amylography, protein assay and IBV measurements (Fig. 6).

(3) New physical measurement system

Sugiyama et al.[8], National Food Research Institute, developed a new physical measurement system, "Rheolograph micro", which was based on the conductive characteristics of vibrations of cooked rice grains (Fig. 7).

(4) Breeding of new rice varieties with various characteristics

To expand the rice market in Japan, new rice varieties with various properties, including low or high amylose content, scented taste, large grain, giant embryo, pigmentation, sugary taste, are now being bred by the Ministry of Agriculture, Forestry and Fisheries, under close cooperation with universities or the food industry.

(5) Grouping of rice varieties

Ohtsubo et al.[6] have attempted to classify the rice varieties into several groups based on their properties, such as amino acid composition, IBV and 1000 kernel weight, with the use of cluster analysis (Fig. 8),

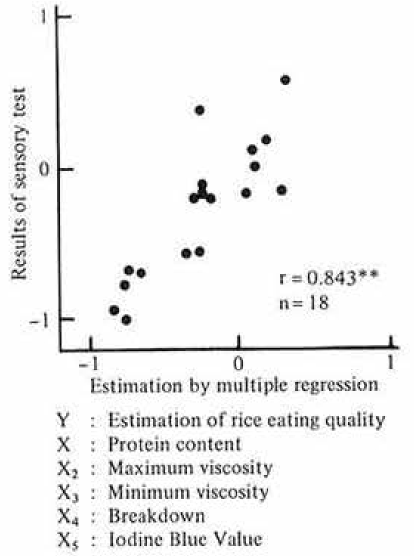

Fig. 6. Multiple regression for estimation of rice eating quality[1]

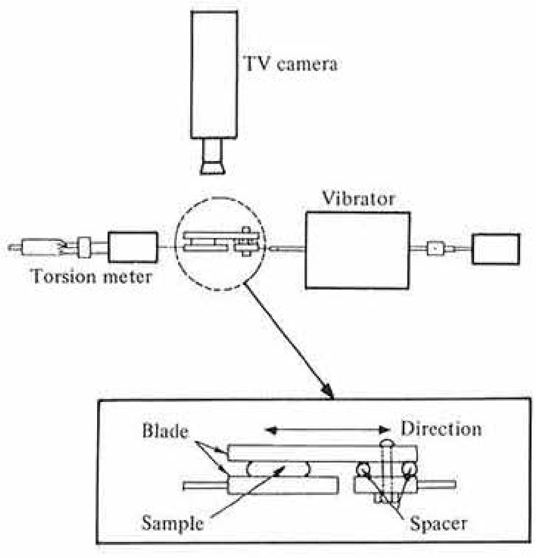

Fig. 7. Diagram of Rheolograph-micro[8]

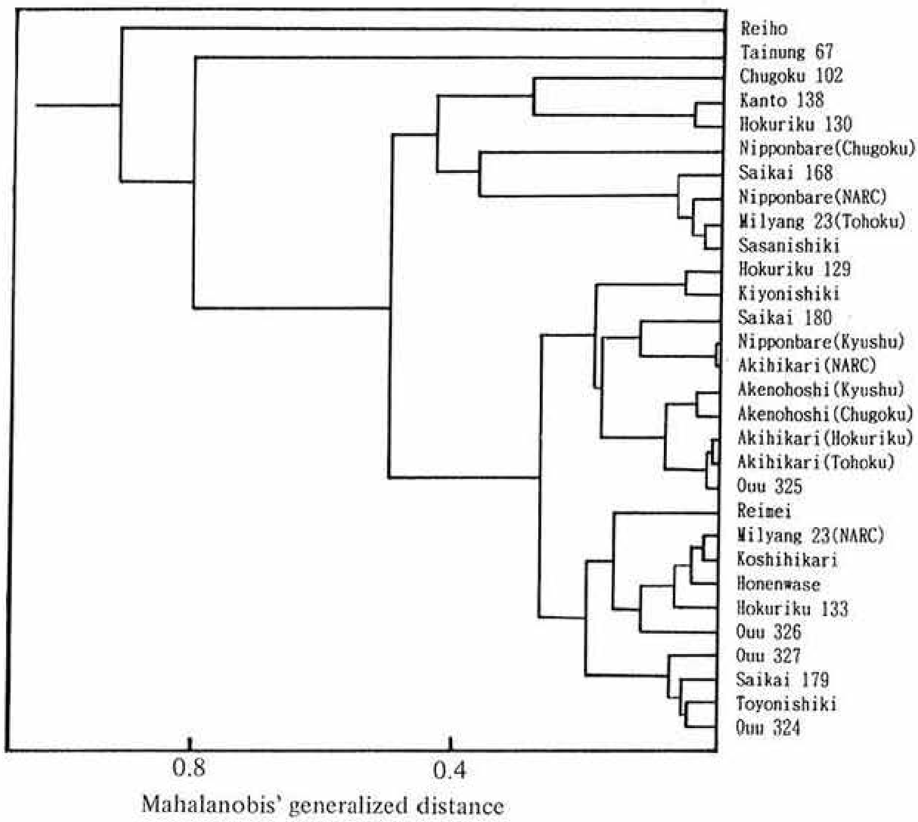

Fig. 8. Cluster analysis of rice based on physico-chemical data

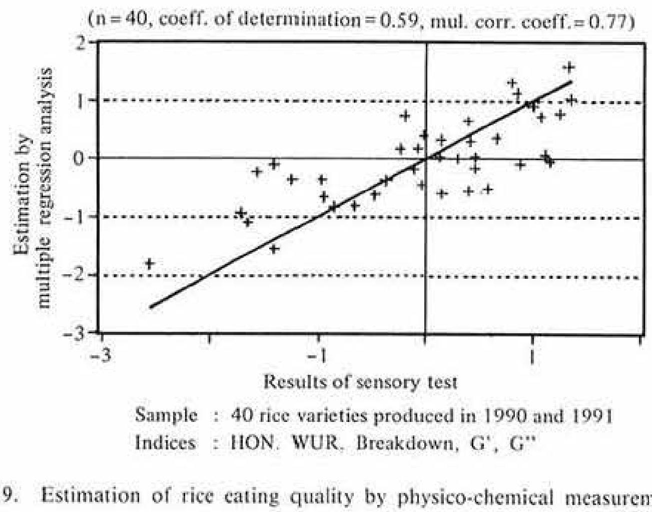

Fig. 9. Estimation of rice eating quality by physico-chemical measurements

not for ranking or grading purposes but for analyzing the characteristics of each variety of the same level.

(6) Quality evaluation at Hokuriku National Agricultural Experiment Station (HNAES)

At HNAES, quality evaluation of rice is carried out by applying the sensory test, cooking quality test, physical measurement with Rheolograph-micro, and spectrophotometric measurement with an NIR system centered on the characteristics of the newly bred rice varieties (Fig. 9).

(7) Problems of quality assessment

It is necessary to standardize the methods and indices for the assessment of the eating quality of rice in Japan. For example, sample preparation (milling, removal of residual bran, moisture content, flouring, etc.), cooking conditions (soaking, water addition, cooking apparatus, etc.), measuring methods, and their conditions, as well as the calibration samples must be standardized in order to compare the various data measured at different experiment stations in Japan.

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