▶ 특별강연 - Ⅳ

Post-harvest Technology for High Quality Rice in Japan

KENICHI OHTSUBO

NATIONAL FOOD RESEARCH INSTITUTE,
TSUKUBA SCIENCE CITY, IBARAKI, 305-8642 JAPAN

1. Abstract

Rice is one of the most important cereals in the world. Japanese people use about 9 million tons of rice per year. We use rice for cooked rice as staple foods and for processing, such as rice wine (sake), rice crackers and miso fermentation,etc. Palatability, eating quality, of rice is evaluated by the sensory test and various kinds of physicochemical measurements.

Japanese National Food Agency started the storage of 1.5 million tones of rice in 1996. We carried out the storage test using high quality rices since 1995 until 1996. As indices for the quality deteriorations of rice grains during the storage, germination ratio, enzyme activities, fat acidity, physical properties of cooked rice were clarified to be useful. We applied colorimetric method for the measurements of fat acidities in the place of titration method.

Processing suitabilities of rice differ depending on the products. Low amylose rice is more suitable for soft rice crackers and high amylose rice is preferred more for rice noodle. Pre-cooked rice products, such as frozen cooked rice, retort-pouched rice and aseptic rice, are increasing recently in Japan. In addition to above-mentioned physico-chemical tests, NIR spectroscopy, "Midometer" and "Taste sensor" are novel and useful to evaluate eating quality and processing suitabolities.

Recently, rice wholesalers and retailers have been obligated to display the name of cultivar, location of cultivation and the year of prioduction of rice grains which they sell by the Japanese Agricultural Standard Law (JAS). In order to detect the dishonest labeling of rice cultivars, we developed new cultivar identification method based on DNA polymorphism.

2. Sensory test and physico-chemical measurements of palatabilities of rice

1) Sensory test

Palatability, that is eating quality, of rice is evaluated by the sensory test and the various kinds of pjhysicochemical measurements. For sensory test, appearance, taste, aroma, hardness, stickiness were evaluated in addition to the general evaluation. Japan Grain Inspection Association has been carried out the

sensory test for all the dominant rice cultivars in Japan cultivated more than 2,000 ha and publicated the results, such as "Special A", "A'", "A" and "B".

2) Chemical components

Moisture contents of rice grains produced in Japan, Korea and China (Northern region) are rather higher (14-15%) and those in U.S.A., Thailand and Australia are lower (12-13%). Amylose contents of rice grains in Japan, China (Northern), U.S.A. and Australia and a part of Thailand are low (15-22%), and many rice grains in Thailandand some in U.S.A. and Australia show rather higher values (23-36%). Protein contents of rice grains show the negative correlations with the results of sensory tests.

3) Gelatinization properties

Gelatinization properties of milled rice flours were evaluated using a Rapid Visco Analyser. All of samples in Japan, China (Northern) and most of those in U.S.A. and some of Australia and Thailand revealed low final viscosities(lower than 300 RVU) and many samples in Thailand and some of Australia and a part of U.S.A. samples showed rather higher final viscosities (higher than 300 RVU).

4) Physical properties of cooked rice grains

Japanese breeders try to develop new varieties of which properties are diversified, such as high-quality rices, big-grains, long-grains, indica-japonica hybrids, aromatic rices, for the enhancement of rice utilizations in Japan. Those rice grains were subjected to the measurements of physical properties with a Tensipresser. A single grain method (low-compression/high-compression continous measurement) was found to be useful for the classifications of each group (high-quality rice, medium-quality rice, hard rice, indica-japonica hybrid rice).

5) Taste sensor

In the field of production, distribution and utilization of rice grains, objective and accurate method to evaluate their eating qualities is indispensable. For the purpose of evaluation of the palatability of rice grains, we investigated on (1) reaction of each sensor against the salty, sour or tasty substances, (2) conditions for the preparation of rice samples, and (3) selection of the conditions to stabilize the measurements by the use of "Aji Sensor", a kind of electric taste sensor system developed by Professor Toko, Kyusyu University. Sensory test in each National Agricultural Experiment Station, chemical component analyses, such as protein and amylose, physical property measurements, such as hardness/stickiness and pasting properties, and storage test were carried out using rice grain samples produced in 1997 and 1998. It was clarified that (1) "Aji sensor" is reactive to salty, sour or tasty substances, (2) cooking liquid is suitable as its sample, and (3) it is useful to detect the change in qualities during the storage of rice grains.

3. Detection of quality deteriorations during the storage of rice grains

1) Low temperature storage of rice grains

Quality of rice grains deteriorates during the storage. It proceeds rapidly under the higher temperature and high humidity. Therefore, rice grains are mainly stored in the air-conditioned wharehouses in Japan. The temperature is maintained under 15 degrees and RH is 70 to 75%. The capacity of governmental air-conditionede wharehouses are about 4.9 million tones.

2) Fat acidity

Fat acidity increases during the storage of rice grains (Figure 4). In our laboratory, colorimetric method for the fat acidity measurement was developed (Ohtsubo et al.,1987).

3) Change in eating quality during the storage of rice grains

Storage test of various rice cultivars were carried out since 1995 until 1996 in our laboratory. Sensory test of cooked rice showed that the low-temperature storage was effective to maintain the eating quality well. The eating quality of grains stored under the low temperature (l.t.) for one year was about at the same level with that of those stored under the natural temperature until befor the summer season.

The degree of deterioration differed depending on the cultivars. The eating quality of Koshihikari was maintained well compared with other cultivars.

4. Processing of rice grains in Japan

Rice is one of the most important cereals in the world in addition to wheat and corn. Rice is produced more than 500 million tons (as paddy/ per year) in the world and especially about 90% of it is produced and consumed as a major staple food in the densely-populated Asian countries.

Rice is processed and utilized as various kinds of foodstuffs besides direct food use. We can mention parboiled rice, fermented rice wine, rice noodle, rice cracker, rice cake, rice snack, rice flour and other fermented rice products as examples of processed rice products.

Processed rice products in Japan are shown in figure. According to Ministry of Agriculture, Forestry and Fisheries of Japan, 9,115,000 tons of rice are used for staple food as cooked rice, 490,000 tons of rice are used for Sake wine fermentation, 233,000 tons for rice cracker and rice flour, 100,000 tons for Miso fermentation in 1995.

In the present paper, I will introduce some convenience foods manufactured from rice.

1) Traditional rice based convenience foods in Japan

One of the most famous traditional rice based convenience foods in Japan is "Sushi". Sushi originated as preservative foods of fish using natural fermentation ("Narezushi"). In this case, cooked rice was used as a

substrate with salt for lactobacillus bacteria. Nowadays, "Nigirizushi" was invented as easy-preparative rice dish by pressing cooked rice ball manually and topped with sliced raw fish in Tokyo in 1800's. Cooked rice becomes more tasty by the addition of salt, sugar and vinegar after cooking. Soy sauce and grated horse-radish ("wasabi") are necessary to enjoy the original taste of "Sushi".

"Onigiri" or "Omusubi" is another traditional rice based convenience food in Japan. These cooked rice balls wrapped with bamboo leaves were used as a box lunch for many years.

2) Breakfast cereals from rice

The breakfast rice cereals are made from rice grains, milled rice flours or the cooked rice dough. These rice materials are precooked, dried, flaked, then expanded or puffed and toasted. These examples are puffed rice, rice flakes and shredded rice cereals. Various kinds of breakfast cereals were developed and consumed in USA, China, Korea, Thailand, Vietnam and many other Pacific countries.

3) Retort Rice

Retort rice was developed early in 1970's in Japan. Rice and water are packed in laminated plastic container and pasteurized at 120Ä. Consumers soak it in hot water for 15 min or heat it in a microwave oven for a couple of minutes. Its shelf-life is more than half a year without refrigeration. The price is reasonable. Their problems are off-flavor by the excess heating and texture of cooked rice grains. Retort rice is produced 22,000 tons in Japan (1996).

4) Canned rice

Canned rice has long history more than 50 years.. Milled rice and water are placed in tin cans, steamed for 30 min and sealed and sterilized in a retort at 112Ä for 80 min. Consumers heat it in hot water for 15 min before eating. Canned rice can be stored for several years under natural condition.

5) Pregelatinized rice

Cooked and dried rice, or pregelatinized rice is prepared by usual cooking followed by abrupt drying. As its moisture content is very low, it can be preserved for several years under natural condition. It is easy to cook as its starch is pregelatinized and prevented from retrogradation due to low moisture content.

Instant rice, such as "Cup Rice", is a kind of high-quality pregelatinized rice. Consumers can eat it by only adding hot water and keeping warm for several minutes.

Recently, pregelatinized and packaged rice without excess drying has been developed in Japan ("Hayadakimai" or "Quick cooking rice"). Its production procedure is shown in figure. Consumers only have to add the enveloped tasty cooking soup or water and cook for about 15 minutes. They can omit time-consuming washing of rice, soaking, and warm keeping after cooking. Compared with "Instant rice", quick cooking rice is improved in terms of taste and texture. Although its moisture content is more than 35%, it can be stored for several months without refrigeration by pasteurization or by the oxygen absorber.

Quality evaluation of these various kinds of quick cooking rice, sensory test, gelatinization properties test and physical properties measurement were carried out in our laboratory as a collaborative research with a food industry, QP Co. ltd., (in figures).

6) Frozen cooked rice

The market of frozen cooked rice in Japan has expanded to 138,000 tons in 1996. Frozen cooked rice is convenient to prepare with a microwave oven at home and its high quality is preserved in a freezer for a long period. Its price is rather high compared with the other processed rice, but frozen roasted cooked rice ball or frozen pilaf is very popular among Japanese consumers.

The typical procedure to manufacture the frozen cooked rice is shown in figure. In cooperative research work with a manufacturer of freezer system, Mayekawa Co. ltd., we developed the new freezing technic, "medium rate freezing", for frozen cooked rice ball. Frozen cooked rice ball prepared at the medium rate revealed better palatability compared with those frozen at the slow rate or the quick rate (shown in figure). And its physical properties, hardness and stickiness, were maintained better than the others (in figure).

7) Aseptic cooked rice

Aseptic cooked rice was developed within one decade in Japan. Rice grains are washed well to remove the bacteria followed by cooking and packaging in a clean booth. Because the contamination of microorganisms are very low, it can be stored for half a year under natural condition. As rice is not heated excessively like a retorted rice, its eating quality is very good.

8) Cooked rice distributed at low temperature

Cooked and packaged rice in plastic container are sometimes shipped and distributed under low temperature (lower than 18Ä). It is recommended from the viewpoint of sanitation but the problem is the retrogradation of rice starch. Its market is expanding year by year.

9) Rice cracker

There are two kinds of rice crackers, which are glutinous rice cracker (arare, kakimochi) and non-glutinous one (senbei). In case of high quality rice cracker, arare, waxy rice is steamed, pounded(or kneaded), refrigerated, cut and baked packaged. The quality is affected by the variety of the material rice, kneading condition and refrigeration procedure.

The results of the research by Dr.Watanabe are shown in figures.

10) Pre-germinated brown rice

Pre-germinated broen rice has becoming popular in Japan. It is believed in that pre-germinated brown rice is good for health. It was reported that the content of gamma aminobutylic acid (GABA) in pre-germinated brown rice is higher than those in ordinary milled rice or ungerminated brown rice.

11) Utilization of pressurization on rice processing

High pressure treatment was applied to the manufacturing of the rice cracker, rice cake. It is well known that the rice crackers are made by the many processing steps. High pressure treatment made it possible to simplify the manufacturing procedure. According to Dr. A. Yamasaki, starch of non-glutinous rice was gelatinized by the high pressure treatment of 700 MPa at 35 C. He also succeeded in developing the low-allergenic rice which is useful for the preparation of "low allergenic bread" and "low allergenic cooked rice". These rice products are promising because there are many people who are suffering from allergy.

12) "New characteristic rice" research project

Ministry of Agriculture, Forestry and Fisheries, Japan, supported the research project named of "New characteristic rice" since 1990 until 1995. For the purpose of enhancement of rice consumption, Japanese breeders tried to develop various kinds of new rice varieties, such as big-grains, long-grains, aromatic, pigmented, low-amylose, etc. In addition to the national institutes, many universities, prefectural research institute and private companies took part in the project for the basic and practical research program.

5. Cultivar identification of rice grains

The Food Control Law was enforced, trade and distribution of rice grains in Japan were deregulated. Producers, traders and consumers tend to prefer to the famous brand rice eagerly due to the needs by the consumers. According to the Food Control Law, cultivars, producing locations and the year of production should be displayed on the bag of the milled rice grains. Therefore, the technology to identify the rice cultivar is indispensable for the purpose of judging whether the label is right or not.

Various kinds of techniques, such as one by the crossing/ripening or plant figure by Matsuo (Matsuo, 1952) isozyme pattern method by Nakagahra et al. (Nakagahra, 1978), or the grain shape method by Matsunaga (Matsunaga and Tamura, 1989) to identify the rice cultivar have been reported. As these methods were limited to the use to rice plant or the appearance of the rice grain, it was impossible to identify the rice cultivar of the different milling condition and the different storage condition, based upon only the information of the milled rice grains.

Random Amplified Polymorphic DNA (RAPD) method we adopted in the present paper, was developed by Williams et al. (Williams et al., 1990). DNA was amplified with the random primers by the Polymerase Chain Reaction (PCR) Method and the difference was detected by the electrophoresis. RAPD method has been utilized for the potatoes, barley and juvenile leaves of rice plant. In case of rice plant, detection of retreaver gene of male-sterility or the desease resistant genes was carried out by this method. Using shoot of rice plant, research on classification of 18 cultivars of long grain rices, 7 cultivars of medium grain rices and 1 cultivar of short grain was reported (Cao and Oard, 1997). Classification among the comparative distant cultivars of Australian rices (Ko et al., 1994) and classification among the sub-families of rices, such as indica, japonica and javanica, were reported (Makill, 1995).

As an example for the application to the rice grain classification of RAPD Method, distant rice grains for

sake-brewery could be classified but it was impossible to classify closely-related rice grains for cooked rice.

The present authors tried to distinguish the 10 closely-related high- quality rice cultivars for cooking which are dominant rice cultivars sharing about 67% of the paddy field in Japan and succeeded in selecting the suitable random primers for the RAPD Method using milled rice grains as samples (Ohtsubo et al., 1997).

6. Conclusions

1) Rice is one of the most important cereals and food materials in Japan.
2) There are various kinds of characteristic rice in Japan.
3) Eating quality is evaluated by sensory and physicochemical tests.
4) Rice quaity deteriorates during the storage.
5) Processing technology promotes the consumption of rice grains.
6) Cultivar identification method for rice grains was developed in Japan.

7. References

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