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Japanese Rice Producers' Shift from High Yield to High Palatability and Quality —Characteristics of Highly Palatable Rice—

Youji Nitta*

College of Agriculture, Ibaraki University, Ami, Ibaraki, Japan

In 1962, Japanese people consumed 118.3 kg year^{-1} person^{-1} of rice. However, after decreasing continuously for four decades, consumption was only 61.9 kg year^{-1} person^{-1} in 2003. Since the 1980s, Japanese people have preferred highly palatable, high-quality rice products instead of quantity. We investigated some palatability properties and characteristics of rice products in different regions around Japan. Thicker brown rice and heavier brown rice were thought to have high palatability and quality, traits that have been associated with low percentages of protein and/or amylose. However, our results showed that these two characteristics were not related to palatability in the case of thicker brown rice. The surface and the interior ultrastructure of cooked rice also affect palatability. In highly palatable cooked rice, thin fibrous and mesh-like surface structures are well developed; mesh-like and spongy structures are also detectable inside. In contrast, the surface of cooked rice of low-palatability is covered with gel-like structures and has less-developed fibrous and mesh-like structures; fewer mesh-like structures are detectable inside. Different cultivars and environmental conditions also affect palatability and quality. The major conditions are the effects of high or low temperature, water status, and strong rain or wind during the ripening period. Currently we are analyzing the ripening process and how environmental conditions during ripening affect rice palatability and quality.

Key words: Environment, Paddy, Production

Introduction

Rice is an important cereal crop for the entire world in terms of its production and the nutrition it supplies. World production of rough rice was only 225 million tons when the first modern rice varieties were developed in the early 1960s (Fig. 1A) (Lampe, 1994). During the next 40 years, world rice production increased by about 350 million tons. Rice cultivation occupies about 153 million ha for 2000, with an average yield (productivity per unit growing area) of 3.9 ton ha^{-1} (Fig. 2) (IRRI 2005). Causal factors of the remarkable increase of rough rice production are (a) development of high-yielding varieties, (b) development of varieties with high resistance against pests and disease, (c) increase in irrigated area, (d) increased chemical fertilizer application, and (e) development of widely adaptable varieties.

More than 90% of the total area of rice production is in Asia (Fig. 1A). North and Central America, South America, Africa and Europe have each produced less than ten thousand tons/year of rough rice (Lampe, 1994). Among Asian countries, rice production is greatest in China, followed by India and Indonesia, with smaller amounts in other countries (Fig. 1B) (Lampe, 1994).

Since the 1960s, large increases in yield have been seen in Japan, Korea, China and Turkey (Fig. 2). However, only slight increases are apparent in Indonesia, Bangladesh and some other countries. These limited increases are attributable to the following: (a) because of limited irrigation, the water supply for most paddy fields is dependent on rain-

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* Corresponding author: College of Agriculture, Ibaraki University, Ami, Ibaraki 300-0393, Japan.
E-mail: nittay@mx.ibaraki.ac.jp

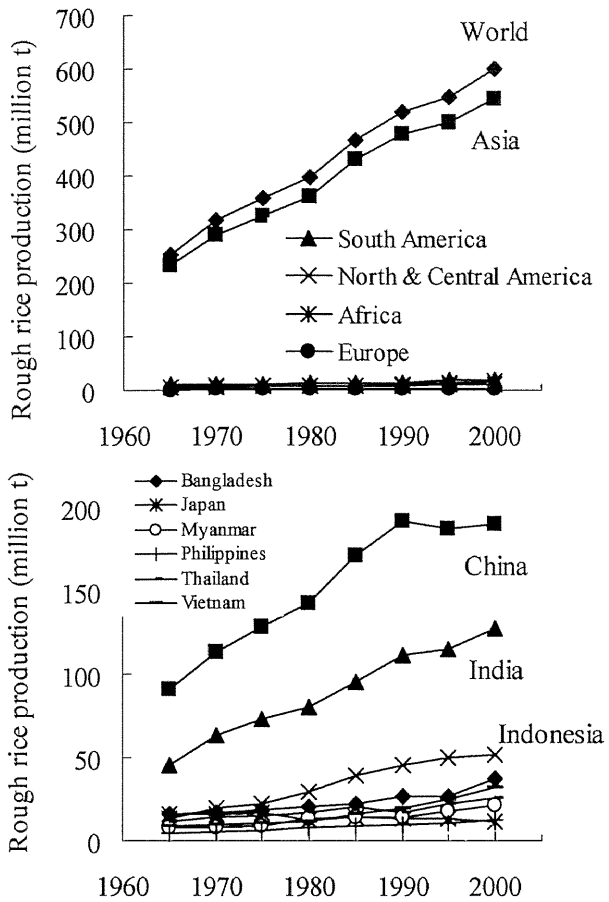

Fig. 1. Rough rice production in the world (A) and Asian countries (B).

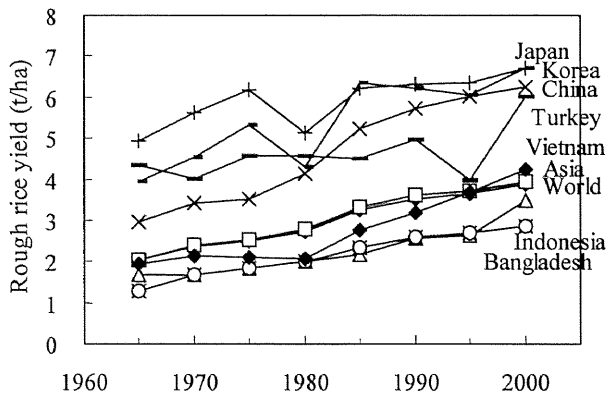

Fig. 2. Rough rice yield in Asian countries.

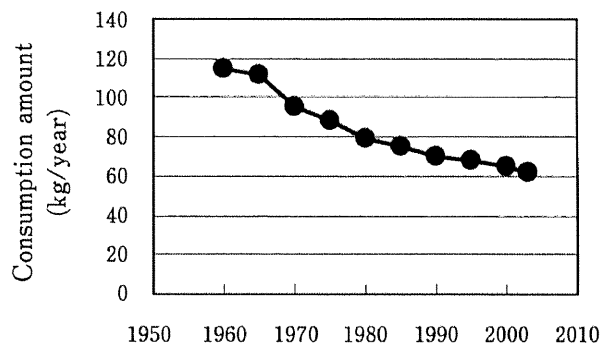

Fig. 3. Milled rice consumption in Japan.

fall, (b) intensive labor was not applied, and (c) the supply of chemical fertilizers was insufficient in those countries. Therefore, even within Asia, differences in farming practices result in very different agricultural output.

Consumption Trends of Japanese People

According to the Ministry of Agriculture, Forestry and Fisheries (2009), Japanese people consumed 118.3 kg year^{-1} person^{-1} in 1962. which has decreased continuously for four decades (Fig. 3). In 2003, only 61.9 kg year^{-1} person^{-1} was consumed.

There are many reasons for the decrease in rice consumption. One reason is thought to be related to food supply and Japanese people's preferences. (a) Since the 1960s, Japan has undergone cultural changes so that western foods, such as bread, eggs, meat, milk, coffee, and dairy products are widely consumed. (b) Japanese children prefer western food: hamburgers, curry with rice, and spaghetti have become popular with Japanese families. (c) Frozen, processed, and precooked foods are more readily available in supermarkets. (d) There are much greater opportunities to eat meals outside the home.

The other reason for the decrease in rice consumption is thought to be social changes. (a) In the past, workers would consume a homemade lunch. However, more recently, lunch is eaten in restaurants or convenience stores. (b) School lunch programs in elementary and junior high schools have been widely developed. (c) Meals have become more diverse: Japanese, Chinese, and western dishes are consumed at home and at restaurants.

On the other hand, Japanese people prefer to eat rice products of high palatability and quality. This trend has been evident since the 1980s. In general, soft and sticky cooked rice is preferred by Japanese people.

This preference has affected which varieties of rice are cultivated in Japan (Fig. 4). Before the 1980s, many varieties were grown. However, in the

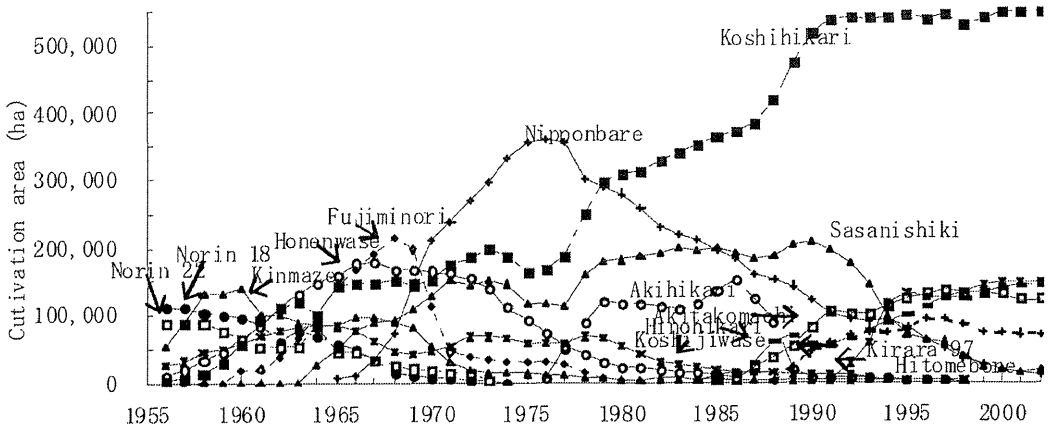

Fig. 4. Rice cultivation areas by varieties in Japan.

1980s, Japanese people began to prefer highly palatable rice. Consequently, Koshihikari, which is most famous for its high palatability, has become the most popular cultivar and is currently grown on 550,000 ha, which amounts to about one-third of all paddy fields in Japan (1.69 million ha)(2002). As a result, cultivars of high-yielding rice or rice with high-resistance against insects or diseases, including Kinmaze, Fujiminori, Akihikari, have vanished.

Characteristics of Palatability and Quality in Rice Products

We investigated some characteristics associated with palatability and quality of rice products derived from different regions around Japan. Brown rice thickness and 1000-grain brown rice weight are important markers for palatability and quality (Matsue *et al.,* 1994). Thicker brown rice and heavier brown rice are thought to have high palatability and to be of high quality. The physicochemical properties thought to be associated with palatability are the percentages of protein and/or amylose. As previously reported, brown rice of low protein and/or amylose content has high palatability (Matsue *et al.,* 2001). However, our results showed that in the case of thicker brown rice, these two properties were not related to palatability (Fig. 5).

Ultra Fine Structures of High-palatability Cooked Rice

Rice quality is evaluated not only by external properties such as grain size, or weight but also by the palatability of the cooked rice. A common method of evaluating this characteristic is to ob-

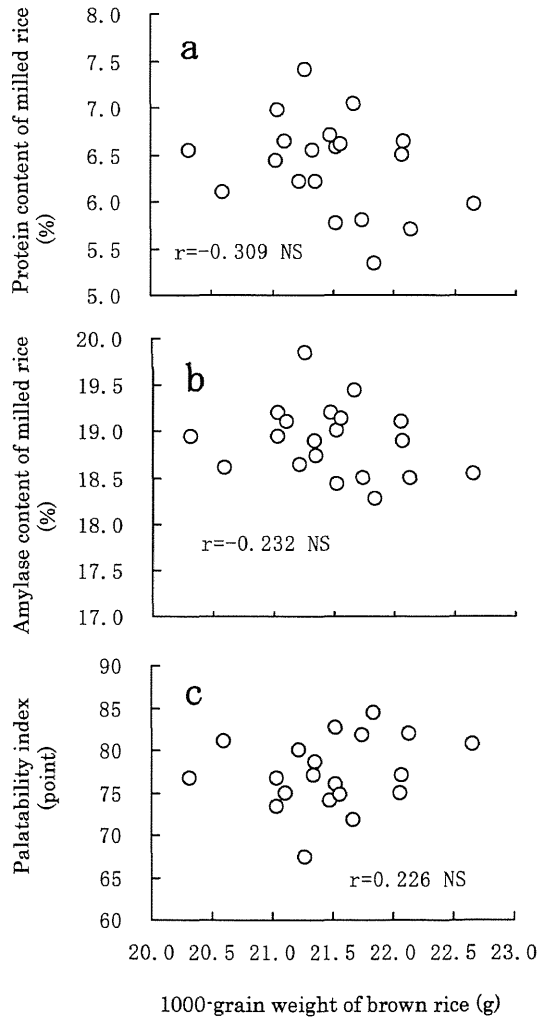

Fig. 5. Relations between 1000-grain weight or thickness of brown rice and protein or amylase content and palatability index of milled rice. NS: not significant.
(Nitta *et al.,* 2005)

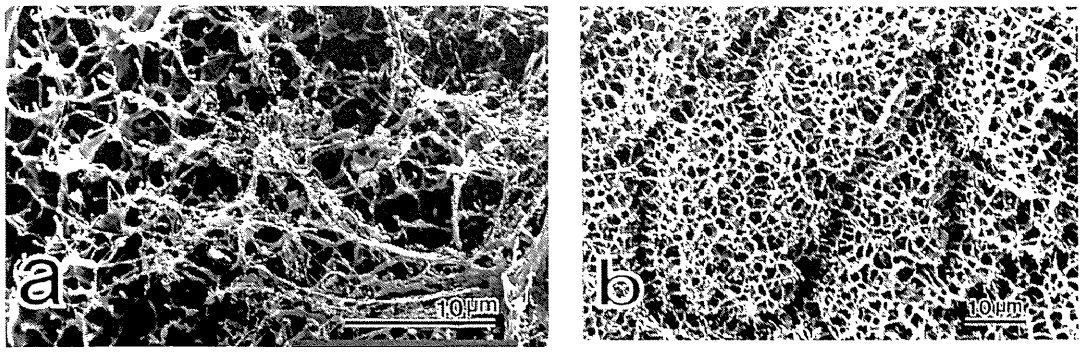

Fig. 6. Scanning electron micrographs of high palatability cooked rice (cv. Koshihikari). a: surface structure, b: inner structure.

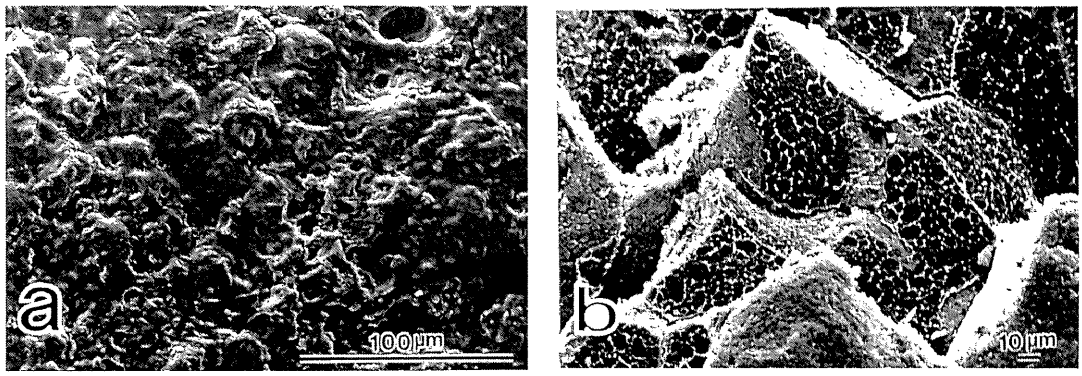

Fig. 7. Scanning electron micrographs of low palatability cooked rice (cv. Akihikari). a: surface structure, b: inner structure.

serve ultra fine structures by using a scanning electron microscope (Matsuda *et al.,* 1993). Figure 6a shows the surface view of highly palatable cooked rice (cv. Koshihikari). Developed fibrous and mesh-like structures are observed. Internally, there are well defined mesh-like structures and spongy tissues (Fig. 6b). These properties are thought to be related to weak hardness and strong stickiness when consumed. In Japan, people generally prefer softness and stickiness. In contrast, the low palatability cooked rice cv. Akihikari is covered with gel-like membranes and has a less developed fibrous or mesh-like surface structure (Fig. 7a); inside this cooked rice, less defined mesh-like structures are observed, similar to those of the surface (Fig. 7b).

Cultural and environmental conditions affect palatability. In addition, structural changes in amylopectin is also important for determining palatability. The relationship between the fine structure of cooked rice and molecular structures such as side chain length of amylopectin will be investigated for further research.

Conclusion

The amount of rice produced is different among countries. The problem is that the yield is different among countries due to cultural situations. Low yielding countries need to pay more efforts to increase rice yield in this century during which the population is expected to increase more and more. However, the standpoint for rice production is also different among countries. The most typical feature can be seen in Japan. Namely, rice consumption has decreased in Japan, while rice palatability and quality has become important since the 1980's. Rice palatability and quality are influenced by different cultivars as well as environmental conditions. Effects of temperature extremes, water status, and strong rain or wind during the ripening period are major factors. We evaluated rice palatability and quality by electron microscopic observations. Highly palatable cooked rice is characterized by fibrous

and mesh-like structures on the surface as well as by well defined mesh-like structures and spongy tissues inside. We are also analyzed the ripening process as affected by environmental factors.

References

IRRI 2005. Atlas of Rice & World Rice Statistics. http://www.irri.org/

Lampe, K., 1994. Foreword. In Breaking the Yield Barrier (ed. Cassman, K.). International Rice Research Institute, Los Baños, Philippines, 5.

Matsuda, T., H. Hara and N. Chonan, 1993. Fine structure and palatability of cooked rice. XII Characteristics of high palatability cooked rice. Jpn. J. Crop Sci. 62 (extra 2): 253–254. (in Japanese)

Matsue, Y., K. Odahara and M. Hiramatsu, 1994. Differences in protein content, amylase content and palatability in relation to location of grains within rice panicle. Jpn. J. Crop Sci. 63: 271–277.

Matsue, Y., H. Sato and Y. Uchimura, 2001. The palatability and physicochemical properties of milled rice for each grain-thickness group. Plant Prod. Sci. 4: 71–76.

Ministry of Agriculture, Forestry and Fisheries, 2009. Change of rice consumption. http://www.maff.go.jp/

Nitta, Y., Y. Ino, T. Matsuda, Y. Iida and S. Tsukamoto, 2008. Correlation of palatability properties with grain-weight and thickness of rice grain —Case of cv. Koshihikari cultivated in Ibaraki prefecture in 2005—. Jpn. J. Crop Sci. 77: 315–320. (in Japanese with English abstract)