Varietal Difference in Palatability of Stored Rice

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Abstract : Changes in the eating quality of nine cultivars of rice, including Koshihikari, Nipponbare, and some recently developed varieties, after storage for about one year at room temperature were studied. Though there was varietal difference, the palatability of all cultivars deteriorated with storage. The palatability of stored Koshihikari rice was almost the same as that of new-crop Nipponbare. The deterioration in palatability was due to the deterioration of the appearance, taste and stickiness of the cooked rice. Cultivars with a high palatable new crop showed a relatively high palatability for stored rice. The palatability of stored rice was generally poor for the cultivars with a high free fatty acid content. Changes in amylographic characteristics were not related to the deterioration of the palatability of stored rice.

Key words : Amylographic characteristics, Free fatty acid, Palatability, Rice of new crop, Stored rice, Varietal difference.

貯蔵米の食味特性の品種間差 : 松江勇次・水田一枝・吉田智彦* (福岡県農業総合試験場・*現九州大学農学部)

要 旨 : 福岡県における水稻主要 9 品種を用いて、玄米を 1 年間室温貯蔵した古米の食味および食味関連形質の品種間差を検討した。貯蔵後はいずれの品種も食味が低下し、コシヒカリの古米の食味は、新米の日本晴と同程度であった。古米での食味にも品種間差があり、新米で食味の良好な品種が古米の食味も比較的良好であった。古米での食味総合評価には、新米同様に外観、味、粘りの三つの要素が強く影響していた。古米の遊離脂肪酸の生成量は品種によって異なったが、概して古米の食味評価の高い品種は遊離脂肪酸が少なく、食味評価の低い品種は遊離脂肪酸が多かった。いずれの品種も古米の最高粘度が高くブレークダウンは大きくなり、その程度は品種によって異なったが、古米の食味との関係は明らかでなかった。

キーワード : アミログラム特性、古米、食味、新米、品種間差、遊離脂肪酸。

The palatability of stored rice deteriorates with the changes in various chemical or amylographic properties. Yasumatsu et al.^{10),11)} reported that the appearance, aroma, taste, cohesiveness and hardness of stored rice deteriorated during storage and the storage deterioration could be predicted by evaluating the changes in some chemical characteristics. Yasumatsu et al.⁹⁾ and Shibuya et al.⁷⁾ showed the roles of fatty acids on the deterioration during storage. Taira⁸⁾ suggested the introduction of Indica-type traits or early maturing to cultivars in order to lower the linoleic acid content and prevent the storage deterioration.

It is expected that good palatability cultivars are less affected by storage. But there are few reports focused on differences in the palatability deterioration of stored rice among cultivars and there is no report for recently-developed good palatability cultivars.

This study was conducted to find the palatability differences among cultivars stored for about one year at room temperature and the changes in some physicochemical properties.

Materials and Methods

Nine cultivars were used this experiment ; Koshihikari and Nipponbare (well-established excellent and good palatability cultivars), Kinuhikari, Mineasahi, Chubu No. 68, Hino-hikari, and Yumehikari (recently-developed good-excellent palatability cultivars), and Tsukushihomare and Minaminishiki (recently-developed moderate palatability cultivars). These cultivars of rice were both grown in 1988 and 1989 at the experimental field of Fukuoka Agricultural Research Center. All cultivars were transplanted in the middle of Jun., and harvested from late Sep. to late Oct. After harvesting, the plants were solar-dried. The moisture content of hulled rice of new and stored rice for the sensory was about 14%. Milling was done prior to the test to the extent of a 91% milling rate.

For storage, rice was hulled, packed in polyethylene bags one month after harvesting and then kept in a storage room at room temperature for about ten months.

Sensory tests on cooked rice were conducted in Nov. 1988 for a new crop harvested in 1988. For stored rice harvested in 1988, the test was

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conducted in Oct. 1989. For a new crop harvested in 1989, the test was conducted in Oct. 1989. The reference cultivar for the sensory test was newly cropped Nipponbare for both new and stored rice evaluation. It was assumed that the palatability values of Nipponbare harvested in different years were constant. The following five sensory attributes were evaluated by 15–20 panel members; overall eating quality, stickiness, appearance of cooked rice, taste and hardness. Other details of the evaluation were described in the previous paper⁵⁾.

Amylography¹⁾ and protein content analysis were conducted in Jan. 1989 for a new crop harvested in 1988, and in Oct. 1989 for stored rice harvested in 1988. Amylose, protein and free fatty acid content were measured in Jan. 1990 for new crop harvested in 1989 and in Oct.–Nov. 1990 for stored rice harvested in 1989. Methods of amylography, amylose and protein analysis were described in the previous paper⁵⁾. Free fatty acid content was measured by the method of AOAC²⁾.

Results and Discussion

1. Palatability of new and stored rice

Two kinds of comparison for new and stored rice were made and shown in Fig. 1 and Fig. 2. In Fig. 1, the relationship between overall eating quality among cultivars of new crop produced in 1989 and stored rice produced in 1988 is shown, where both of the sensory tests were conducted at the same time in 1989. In Fig. 2, the relationship between overall eating quality of new and stored rice produced in 1988 is shown, where the same rice was evaluated in new and stored condition, whereas, the sensory tests were conducted in different years.

Palatability of stored rice generally deteriorated. After ten months storage, overall eating quality of Koshihikari, which showed high value for new crop harvested in 1988 and 1989, was equal to that of Nipponbare of new crop. Fig. 1 and Fig. 2 showed that cultivars having good palatability of new crop also had good palatability of stored rice. The correlation coefficients between overall eating quality of new and stored rice in Fig. 1 and Fig. 2 were 0.74* and 0.76*, respectively (Correlation coefficient among cultivars between new crop harvested in 1988 and in 1989 was 0.95**).

In Table 1, the degree of palatability deterioration of each cultivar is shown. The mean value of deterioration was 1.06 or 1.03 compared with new crop produced in 1988 or 1989. Deterioration of Yumehikari was the highest, although that for Koshihikari, Mineasahi and Tsukushihomare was relatively low.

In Figs. 3–6, the relationships between new and stored rice for other sensory attributes (appearance, taste, stickiness and hardness) are shown. These figures also show that appearance, taste and stickiness of stored rice deteriorated during storage, and that cultivars having high values of appearance, taste and stickiness immediately after harvesting retained high values of appearance, taste and stickiness after storage. For hardness, however, the relationship between new and stored rice was not clear. The correlation coefficient between stored and new rice was 0.83** for appearance, 0.79* for stickiness, 0.74* for taste and 0.13 for hardness. Deterioration in appearance and taste for Yumehikari was relatively large compared to other cultivars.

Among cultivars of stored rice, coefficients of correlation between overall eating quality and appearance, taste, stickiness and hardness were 0.95**, 0.95**, 0.90** and 0.00, respectively. Therefore, overall eating quality of stored rice seemed to be closely connected to appearance, taste and stickiness but not to hardness as in the case of new crops reported by Matsue et al⁵⁾.

2. Protein and amylose content of new and stored rice

The mean protein content of new and stored rice was 6.9 and 6.7%, respectively (Table 2). The mean amylose content of new and stored rice was 20.6 and 20.0%. It seems that there was no difference in protein and amylose content during storage. Fluctuations in amylose content of new and stored rice might be due to experimental error. This consistency both in protein and amylose content during storage showed that palatability deterioration could not be attributed to the protein and amylose content.

3. Amylographic characteristics of new and stored rice

It was reported that breakdown and maximum viscosity values of good palatability cultivars were higher than those of ordinary cultivars in the case of the new crop^{3,4)}. In this

Fig. 1. Relationship between overall eating quality of new and stored rice (I). New and stored rice were produced in different years. Cultivar names in the Figure are as follows: 1: Koshihikari, 2: Kinuhikari, 3: Mineasahi, 4: Nipponbare, 5: Chubu No. 68, 6: Hinohikari, 7: Tsukushihomare, 8: Minaminishiki, 9: Yumehikari.

Fig. 2. Relationship between overall eating quality of new and stored rice (II). New and stored rice were produced in the same year. Numerals in the figure are the same as those in Fig. 1.

Table 1. Palatability deterioration incurred during storage.

Cultivar	Palatability*	Degree of palatability deterioration	
		I	II
Koshihikari	1.00	0.63	1.00
Hinohikari	0.93	1.24	1.53
Kinuhikari	0.74	1.23	1.47
Yumehikari	0.47	1.80	1.74
Mineasahi	0.39	0.93	0.62
Nipponbare	0.00	1.15	1.15
Chubu No. 68	0.23	0.90	0.77
Tsukushihomare	-0.64	0.59	0.23
Minaminishiki	-1.00	1.08	0.73
Mean	0.24	1.06	1.03
LSD (0.05)	0.518		

* Overall eating quality of new crop produced in 1989.

The degree of palatability deterioration (I) and (II) were calculated as, I: (overall eating quality of new crop produced in 1988) - (that of stored rice produced in 1988). II: (overall eating quality of new crop produced in 1989) - (that of stored rice produced in 1988).

report, although palatability was clearly deteriorated by storage, breakdown and maximum viscosity values of stored rice were higher than those of new crop (Fig. 7 and 8). Shibuya et al.⁶⁾ also reported the increase in breakdown and maximum viscosity values in stored rice.

Therefore, any relationship was not found between the increase in maximum viscosity or breakdown values and the palatability deterioration in stored rice.

Fig. 3. Relationship between appearance of new and stored rice.
New and stored rice were produced in different years. Numerals in the figure are the same as those in Fig. 1.

Fig. 4. Relationship between stickiness of new and stored rice.
Numerals in the figure are the same as those in Fig. 1.

Fig. 5. Relationship between taste of new and stored rice.
Numerals in the figure are the same as those in Fig. 1.

Fig. 6. Relationship between hardness of new and stored rice.
Numerals in the figure are the same as those in Fig. 1.

Fig. 7. Relationship between maximum viscosity of new and stored rice.
Numerals in the figure are the same as those in Fig. 1.

Fig. 8. Relationship between breakdown values of new and stored rice.
Numerals in the figure are the same as those in Fig. 1.

Table 2. Protein and amylose content of new and stored rice.

Cultivar	Protein content		Amylose content	
	Rice of new crop	Stored rice	Rice of new crop	Stored rice
Koshihikari	6.9	6.8	19.0	17.4
Hinohikari	6.5	6.2	19.9	20.1
Kinuhikari	7.0	7.0	19.3	18.2
Yumehikari	6.8	6.7	21.2	21.1
Mineasahi	6.6	6.3	19.4	18.5
Nipponbare	6.8	6.8	21.4	19.9
Chubu No. 68	6.6	6.5	20.6	18.7
Tsukushihomare	7.1	7.0	22.1	22.4
Minaminishiki	7.4	7.1	22.4	23.7
Mean	6.9	6.7	20.6	20.0

Values in the table were %dry weight basis for milled rice.

New and stored rice for protein analysis were produced in 1988.

Those for amylose analysis were produced in 1989.

Fig. 9. Relationship between free fatty acid content of new and stored rice.

New and stored rice were produced in the same year.

□ : rice of new crop, ■ : stored rice.

Numerals in the figure are the same as those in Fig. 1.

4. Free fatty acid content of new and stored rice

Free fatty acid content of new and stored rice is shown in Fig. 9. Free fatty acid content of milled rice (mg %) varied from 14.9 to 23.1 for new crop and from 19.1 to 38.9 for stored rice. Free fatty acid content of all cultivars increased and the variation among cultivars widened during storage. Free fatty acid contents in stored rice of Tsukushihomare, Minaminishiki and Yumehikari, which had low palatability values, were high, though those of Koshihikari and Mineasahi, which had relatively high palatability values, were low. The coefficient of correlation between

overall eating quality of stored rice and free fatty acid content of stored rice was -0.87^{**} . Therefore, palatability of stored rice can be partly evaluated by measuring the free fatty acid content of stored rice.

In conclusion, considerable variation among cultivars in eating quality of stored rice was found. Cultivars with high palatability of new crop had relatively high palatability of stored rice, though palatability of all cultivars deteriorated after storing about one year at room temperature. Because of the variation among cultivars, it may be necessary to evaluate stored rice at the breeding center or in the test for recommendable varieties at local experi-

mental stations.

Palatability deterioration was associated with the deterioration of appearance, taste and stickiness of cooked rice. Chemically, palatability of stored rice for cultivars with a high content of free fatty acid was generally poor. But changes in amylographic characteristics could not explain the palatability deterioration of stored rice.

Deterioration by storage is affected by environmental conditions. Shibuya et al.⁶⁾ reported that changes in the flavor and taste of milled rice during storage were greater than those of brown rice. Temperature and packing materials affected the palatability deterioration^{10,11)}. The effects of environmental conditions might be different among cultivars. Further studies will be needed to assess the interaction between the environmental conditions and palatability deterioration or the change in physicochemical properties of stored rice.

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** In Japanese with English Summary.