Storage of Rice. XX.
Studies on Unhulled Rice Stored about One Hundred Years in a Granary.

By

M. Kondō and T. Okamura.

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Introduction.

In an earlier paper[1] the authors reported the results of their studies on four lots of unhulled rice stored 46, 49, 62 and 82 years respectively in granaries. After that, they again had an opportunity to continue the work, employing unhulled rice stored about 100 years. The rice was stored in a small granary specially constructed for the storage of unhulled rice in anticipation of a bad harvest. The investigation extended from May to July, 1936.

I. Method of Storage.

The granary, in which the rice was stored, was owned by a farmer named NAKASHIMA, and was located in the Province of Saga, in the southern part of Japan. It is a small wooden building surrounded by woods. (Plate III.) The rice was stored in a loose state, that is not packed in bags.

II. General Quality of Rice.

At the outstart of the investigation the authors studied the general quality of the unhulled rice, as well as the corresponding hulled rice. The unhulled rice was awnless, brown coloured and contained plenty of empty hulls. A species of insect, *Rhizopertha dominica* FAB. had damaged the kernels seriously, invading the hulls. The insects were all dead, but it was observed that they had at some times increased greatly during storage, thus causing the deterioration, notwithstanding the protection of the hulls. (Plate IV, Photo. 2, 3.) From the above facts it is obvious that the rice was kept for a longer time, but its condition was inferior to that of the lots of unhulled rice from Kanonko, which were studied in the earlier investigation[1].

The hulled rice was light brown, somewhat lusterous and had a slight, peculiar odour. The embryo was shrunken and coloured dark brown. A few red kernels were present.

III. Physical Properties of Hulled Rice.

The unhulled rice under investigation was hulled and the physical properties of its kernels were studied. The results are given in Table 1.

Table 1.

Physical Properties of Hulled Rice.

Properties	Results
Moisture content	15.6%
Size of hulled rice — length	5.4 (5.1—5.6) mm.
Size of hulled rice — width	2.9 (2.5—3.0) mm.
Size of hulled rice — thickness	2.0 (1.7—2.1) mm.
Weight of 1,000 grains	22.50 g.
Weight of one hectoliter	80.7 kg.
Specific gravity	1.408
Hardness of rice, resistance to — breaking	5.07 kg.
Hardness of rice, resistance to — crushing	6.49 kg.
Water absorbing capacity of grains	21.0%
Swelling capacity of grains	27.5%
Polishing loss	11.9%
Time required for polishing	40 minutes
"Kamabue"	151.9%
Viscosity of rice-paste	1.32
Percentage of the corresponding hulled rice to unhulled rice — in weight	76.1%
Percentage of the corresponding hulled rice to unhulled rice — in volume	42.3%

Note: 1) Water absorbing and swelling capacity was determined after soaking the rice in water at 25—28°C. for 48 hours.

2) Viscosity of 5% rice-paste was determined at 40°C., the viscosity of water being set at 1.

3) "Kamabue" is the percentage of increase in volume of boiled rice compared to the original volume of uncooked rice.

Table 1 brings out the following facts:— The moisture content of the rice was fairly large, because the outside moist air could easily enter into the granary during the time of storage.

Judging from the size of the kernels as well as the weight of a thousand grains, the rice under investigation belongs to the middle sized class cultivated in Japan at the present time.

The physical properties of the rice, such as the volume-weight, specific gravity, hardness, water absorbing capacity and swelling capacity, and the viscosity of rice-paste were more or less inferior to those of the new rice.

The polishing loss was very large and the time required for polishing longer than usual.

The percentage of hulled rice corresponding to the unhulled rice was very small, because of the great damage by insects. An admixture of 19 per cent of empty chaffs was present.

The "Kamabue" (increment in volume of boiled rice) was larger than that of new rice.

As stated above, all of the physical properties had been altered more or less, by the ageing during the storage.

IV. Analysis of Rice.

The old rice under investigation was analysed and compared with a new rice. The results are given in Table 2.

Table 2.

Composition of Rice.

Composition / Lot of rice	In the dry substance						
	Ash	Crude fiber	Crude fat	Crude protein	Starch	Glucose	Dextrin
Old rice	1.421	1.524	2.437	8.391	81.298	0.502	1.532
New rice	1.324	1.215	2.884	8.683	83.847	0.880	2.520

According to Table 2, fat, glucose and dextrin in the old rice had decreased in a great degree, protein and starch also in a certain degree.

V. pH value of Rice.

Ten grams of the rice powder under investigation were added to 50 cc. of distilled water and the mixture was kept one hour at 25°C. After filtering, the pH value, as determined by the quinhydron electrode, was found to be 6.49, i.e. faintly acid. In the preceding paper[1] the authors reported that the lots of the old rice from Kanonkō were also faintly acid. Such a formation of acidity is correlated in some degree with change in quality during the time of storage.

VI. Enzymes.

The authors determined the activity values for lipase, catalase, protease and diastase in the old rice and made a comparison with those of the new rice, the

activity values for these enzymes in the new rice being set at 1. The results are given in Table 3.

Table 3.

Comparison of Activities of Several Kinds of Enzymes in the Old and New Rice.

Lot of rice	Lipase	Catalase	Protease	Diastase
Old rice	0.67	0.14	0.24	0.32
New rice	1.00	1.00	1.00	1.00

According to Table 3, the lipase activity of the old rice was 67 per cent of that of the new rice. It shows that lipase activity can be preserved well during a hundred years. In the preceding paper[1] it is reported that in the four lots of 46 to 80 years old rice, lipase was present in amount equal to that of new rice.

The catalase activity of the old rice was 14 per cent of that of the new rice. It appears that the catalase activity decreased in a great degree but never entirely. In the preceding experiment[1] it was found that in some lots of old rice the catalase was nearly lost, but in the other lots it was present in somewhat higher amount. It was stated therefore that in general a decrement of catalase is a result of ageing, but that there is no regular decrement.

The protease activity of the old rice was 24 per cent of that of the new rice. It decreased, but the amount remaining was about one-fourth that of the new rice.

The diastase activity of the old rice decreased in a great degree, yet an amount equivalent to one-third that of the new rice. This coincides with the results of the preceding study of the lots of old rice.

Summarizing the facts, it may be said that, with the exception of lipase, the activity of the three kinds of enzymes in the old rice was reduced in a great degree and that these facts entirely agree with those given in the preceding publication[1] on the enzymes of the old rice.

VII. Vitamin-B_1.

The content of vitamin-B_1 in the hundred years old rice was determined. White Leghorn fowls served as experimental animals, a set of two or three fowls having been used for each lot. For comparison, the rice of the 1935 crop was also fed to fowls. In this experiment 25 per cent of the powdered rice under investigation was mixed with 75 per cent of the powdered clean polished rice. The latent period of beri-beri illness of the fowls during the experiment was recorded and the comparative value of vitamin-B_1 in the rice was calculated on the basis of 100 for the content of vitamin-B_1 in the new rice. The results are summarized in Table 4.

Table 4.

Results of Feeding Experiment with Fowls.

Lot of rice	Latent period of beri-beri illness			Average of latent periods	Comparative value of vitamin-B_1 content
	days	days	days	days	
100 years old rice · · · ·	9	10	—	9.5	8.2
New rice · · · · · · · ·	30	26	—	23	100
Clean polished rice only	9	9	9	9	0

According to Table 4, the old rice under investigation had largely lost its vitamin-B_1, only 8.2 per cent having been retained. In their earlier paper[1], the authors reported that in the unhulled rice stored 46 to 80 years, the vitamin-B_1 content was only 7—15 per cent of that of new rice. The results of both experiments agree quite well.

VIII. Germinating Power.

Examination of the old unhulled rice under investigation showed that the germinating power had been entirely lost.

IX. Quality of Boiled Rice.

Finally the authors determined the taste, odour, colour and other qualities of the boiled rice prepared from the rice in question, after hulling and polishing. The boiled rice was light brown, around the embryo much darker, less sticky and rougher on the tongue than that of new rice, and had a disagreeable odour. The taste was not good and the general quality showed much deterioration during storage. Nevertheless, the rice would be edible in time of need. The results agree with those on the old rice studied in the preceding experiment[1].

It may be concluded from the above that, if unhulled rice is stored during a long time, such as a hundred years, the general quality of the hulled rice, as well as the boiled polished rice, shows a great deterioration ; nevertheless, the rice can be used not only as coocked rice in times of short harvest, but also as puffed rice, rice flour, miso, soy etc.

X. Discussion.

Generally it is believed that unhulled rice can be preserved for a long period without appreciable loss, because the glumes protect the kernels from insects and vermin. However, it was found that the unhulled rice under investigation was damaged heavily by a species of insect, *Rhizopertha dominica*. Empty chaff amounting to 19 per cent of the material was present. The insect thrives in a warm locality like Saga, where the granary is situated. Of course, the glumes

furnish a good protection against insects, but it is not a perfect protection. In the storage of rice, it is highly important, whether or not protected by glumes, to guard against the incursion of insects. The granary in question is thin walled and not air-tight. As a consequence the insects found ready access and thrived therein. The moisture content of the rice was rather high. Farmers' granaries for unhulled rice are usually of the simple construction, of the one here described. In such a granary the underdried rice would be gradually dried to some extent during storage, but the deterioration of the quality of the rice is unavoidable. The rice must be thoroughly dried and stored in a well constructed granary to insure perfect keeping.

A comparison of the results of the earlier studies on four lots of unhulled rice stored forty-six to eighty-four years with those of the present investigation on rice stored a hundred years shows a perfect agreement. Deterioration occurred in a great degree during storage, but the rice was still edible and could be used in several ways in an emergency.

Summary.

1) The authors had an opportunity to study a lot of old unhulled rice stored about one hundred years in a granary of a farmer named NAKASHIMA in Saga Province in the southern part of Japan. The investigations extended from May to July, 1936.

2) The unhulled rice was awnless, brown coloured, and much damaged by *Rhizopertha dominica*. The corresponding hulled rice was light-brown, much darker than normal about the embryo and had a peculiar odour. Some deterioration of quality occurred during storage.

3) The moisture content, polishing loss and "Kamabue" (increment in volume of boiled rice) increased, but the percentage of hulled rice to unhulled rice, volume-weight, specific gravity, hardness, water absorbing capacity of the hulled rice and the viscosity of rice-paste decreased during storage.

4) Fat, glucose and dextrin decreased during storage.

5) pH value of the water extract was 6.49: It shows that the rice was faintly acid.

6) With the exception of lipase, the enzyme activity (catalase, protease and diastase) was reduced in a great degree. The lipase activity was about 67 per cent of that of the new rice.

7) Only 8.2 per cent of the vitamin-B_1 was retained in the old rice.

8) The germinating power of the rice was entirely lost.

9) The boiled rice prepared from the polished kernels was light-brown, less sticky than normal, rough on the tongue, and had a disagreeable odour. The taste was unpleasant; however, the rice would be edible in times of need.

Literature.

1) M. KONDO and T. OKAMURA: Storage of rice X. Studies of four lots of unhulled rice stored forty-six to eighty-four years in granaries. Ber. Ōhara Inst., Bd. VII, Ht. 2, 175—185, 1934.

PLATE III.

Photo. 1. The granary, in which the rice was stored about 100 years, located in the Province of Saga.

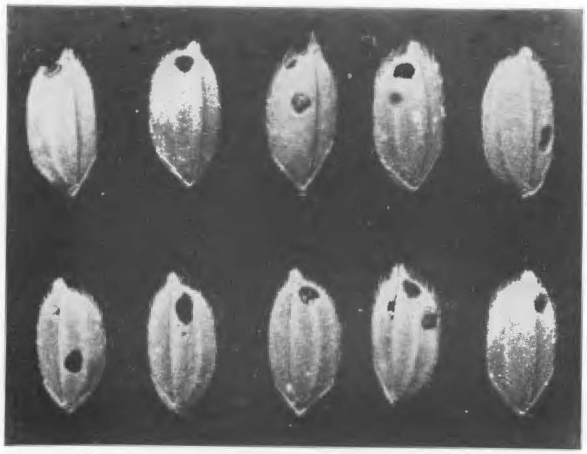

Photo. 2. A species of insect, *Rhizopertha dominica* FAB. had damaged the rice kernels seriously, invading the hulls.

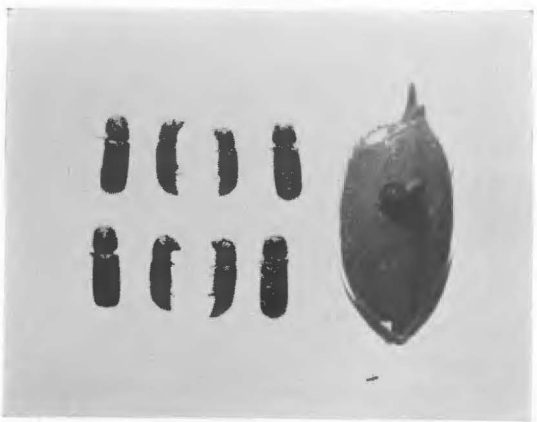

Photo. 3. *Rhizopertha dominica* FAB.