

Storage of Rice. VIII.
Studies on Hulled Rice Stored Air-tight
26 and 28 Years.

By

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Introduction.

The present authors¹⁻³⁾ have often reported that air-tight storage of thoroughly dried rice is the safest method for preventing spoilage. For instance, according to the authors' experiment³⁾, hulled rice stored 4 years in hermetically sealed containers retained perfectly its germinating power, vitamin-B and nutrients. It was practically equal to new rice.

Recently authors had an opportunity to get valuable samples for studying the effect of air-tight storage during 26 and 28 years upon the quality of rice through the cooperation of a landlord named FURUHASHI residing in a mountain village in Aichi Prefecture. The locality produces only half of the local demands, the remaining half being imported from another region. The landlord FURUHASHI has been accustomed, therefore, for a long time to store rice in anticipation of a bad harvest, which often happened there. In earlier times FURUHASHI stored unhulled rice, but for 30 years he has stored hulled rice in tin containers hermetically sealed. Today he has in storage rice harvested many years ago. Since the properties of rice stored hermetically for so long a time are a matter of great scientific and practical interest, the following investigation was undertaken.

1. Material.

The authors secured two samples of thoroughly dried hulled rice, namely of the 1904 and 1906 harvests. Mr. FURUHASHI said that at the harvest time it was dried at 50—55°C for 10 hours, cooled, packed in tin containers, sealed hermetically and stored upstairs in a granary.

2. Physical Properties of Rice.

A. Weight and Volume.

At the beginning of storage, the weight and volume of the rice had been determined. Examination by us on removal from storage showed that there had

been no loss in weight or volume, the storage having been in perfectly sealed containers. There was also no damage by insects which, as is well known, is usually the case when the grain is stored in straw bags.

B. General Qualities.

On January 28 1932, the tin containers were opened and first the general quality of the rice was determined. The authors observed that the original quality must have been rather bad, since red rice, unripe grains, green rice, etc. were present and some of the grains had already germinated before drying and storage. The color of grains changed to light brown, but the fact that green grains had not lost their color is inductive that no great change had taken place during storage. It had an oily smell. From the above data it can be said that the quality as determined by the senses was not good, but it looked like rice harvested only 3—4 years ago. Nobody would believe that it was 26 or 28 years old. The green coloured grains show that the quality changed only a slight degree.

C. Physical Properties.

Some of the physical properties of the rice of 1904 and 1906 were determined and compared with those of the crops of 1926—1929, which had been stored only 1—4 years in straw bags, in a granary of the Department⁴. The results are given in Table 1.

Table 1.
Physical Properties of Hulled Rice.

Physical Properties	Rice of 1904	Rice of 1906	Rice of 1926—9, in a granary of the Department
Moisture content of hulled rice, %	12.72	10.60	13.20
Weight of 1000 grains, g.	24.06	21.14	24.69
Weight of one hectolitre, Kg.	81.04	85.00	85.56
Specific Gravity	1.402	1.417	—
Germinated grains before storage, %	2.8	0	0
Green coloured grains, %	15.3	7.7	—
Cracked grains, %	18.7	47.7	—
Hardness against breaking, Kg.	8.94	11.71	8.81
" " crushing, Kg.	9.93	12.21	9.50
Swelling ability of grains in water, %	30.84	38.07	31.36
Water absorbing capacity, %	23.54	28.23	22.52
Material lost by polishing, %	10.4	8.9	8.1
Increment in volume of boiled rice, %	119.7	121.1	143.0
Viscosity of rice paste	1.28	1.34	1.55

The physical properties of the rice were determined by the methods which were used by the authors in the preceding experiments.

The percentage of increment in volume of boiled rice compared to the original volume of white rice is called "Kamabue".

The viscosity of distilled water at 40°C was taken as 1 (standard). The rice paste had a density of 5% (water 100 cc. rice powder 5 g.), and its viscosity was measured at the temperature of 40°C.

From the above table it can be seen that the rice of 1904 and 1906 was well dried. During storage its properties changed only slightly, since, in comparison with rice of 1926—1929 of the Department, there is no distinct difference. Although the increment in volume of boiled rice and the viscosity of rice-paste of the old rice were smaller and the material lost by polishing larger than in the case of rice of the Department, it is not right to attribute these differences to deterioration during storage, because the original quality of the rice was very bad, as already described.

3. Analyses of Rice.

The rice stored during 26 and 28 years air-tight was analysed in February 1932 and the results compared with those on the new crop of 1931. The composition of the rice was as follows :

Table 2.
Composition of Rice.

Constituents		New rice	Rice of 1904	Rice of 1906
In the dry substance	Crude fiber	% 1.607	% 1.024	% 1.082
	Ash	1.528	1.451	1.509
	Starch	89.936	87.350	88.845
	Crude fat	2.764	2.476	2.508
	Crude protein	8.843	9.119	8.859

Strictly speaking, the new and old rice can not be compared with each other, because both are not of the same variety ; nevertheless from the above table, it is clear that no remarkable chemical change occurred during 26 and 28 years.

4. Analyses of Gas in the Containers.

The gas in the containers was analysed by the ordinary process, using HALDANE's apparatus. The results are as follows :

Table 3.
Composition of Gas.

Kind of gas	Common air	Gas in tin container with rice of 1904	Gas in tin container with rice of 1906*
CO ₂	% 0.05	% 0.21	% 0.11
O ₂	20.88	20.69	20.80
N	79.07	79.11	79.09

Note. * This container was slightly damaged during transportation.

The above table shows that CO₂ increased only a little during storage. The authors expected that the composition of the gas in the containers would be much changed, but in reality it was not so. This must be attributed to the fact that the rice was thoroughly dried and dead, owing to the heating.

5. Enzymes.

The authors studied the activities of peroxidase and catalase in the rice of 1904 and 1906, and made a comparison with those of the new rice of 1931. The activities of both enzymes in the new rice of 1931 were set equal to 1, and the activities of the enzymes in the old rice were compared with them. The results are as follows :

Table 4.
Comparison of Activities of Peroxidase and Catalase
in Old and New Rice.

Kind of rice	Activity of Peroxidase	Activity of Catalase
Rice of 1931	1	1
Rice of 1904	0	0.34
Rice of 1906	0.27	0.74

According to Table 4, the activity of peroxidase in the rice of 1904 was lost entirely and that in the rice of 1906 decreased to 27%. The activity of peroxidase in rice, therefore, was not preserved well during storage. The activity of catalase in the rice of 1904 and 1906 decreased respectively to 34% and 74%, but it was retained much better than that of peroxidase.

The content of vitamin-B in the rice of 1904 and 1906, stored during 26 and 28 years air-tight, is respectively just equal to that in the rice stored 2 and 3 years in straw bags. It shows how well vitamin-B was retained in the rice stored air-tight during many years. If the rice be of good quality at first, its vitamin-B should be perfectly preserved during 30 years.

7. Germinating Power.

The germinating power of rice of 1904 and 1906 was determined and it was found that it was entirely lost.

In a preceding paper²⁾ (Storage of Rice III) the authors reported that hulled rice stored air-tight during 4 years retained its germinating power perfectly and suggested that rice could retain its germinating power even longer than 4 years.

The investigated rice in the present experiment was dried by heating before storage. Moreover it was found that, before drying, some of the grains had already germinated. Such a bad condition must have caused to some extent the loss of the germinating power.

8. Qualities of Boiled Rice.

The authors investigated the taste, smell, stickiness and colour of the boiled rice. In February 1932, the rice of 1904 and 1906 was clean polished and boiled. The boiled rice had a slight undesirable smell and was less sticky, but it was fairly good for eating. The rice of 1904 was faint brown; but that of 1906 was clean white.

In a preceding paper²⁾ (Storage of Rice II), the authors reported that the taste of the boiled rice was already somewhat impaired, after the rice had been stored only one year in straw bags in the granary of the institute; after two years the taste, smell, colour etc. of the boiled rice became very bad and the rice could scarcely be eaten; after three years it became still worse and could not be eaten at all.

The original quality of the rice used in the present investigation was rather bad, but it could still be eaten after 26 or 28 years storage. The authors have demonstrated that rice can be preserved well, without change of taste about 30 years if thoroughly dried and stored air-tight.

9. Conclusion.

Compared with rice at the present time, that used in the above experiment was of very bad quality. Thirty years ago the rice was not so purely bred as at the present time. Several kinds of inferior grains—red, green, unripe and

germinated—were contained therein. Nevertheless it was observed that no distinct deterioration of quality had occurred during the storage of 26 or 28 years. Vitamin-B was retained fairly well and the rice after boiling was edible. Accordingly if rice of good quality be thoroughly dried, packed in air-tight containers, and stored in a cool place, it should keep perfectly without any deterioration for 30 years.

Summary.

1) The authors secured two samples of hulled rice 1904 and 1906, which had been stored respectively 26 and 28 years in tin-containers hermetically sealed. Before storage the rice was thoroughly dried by heating. The moisture content was respectively 12.7% and 10.6%. In January 1932 the containers were opened and the quality of the rice was investigated.

2) Notwithstanding the original quality of the rice which was not good and the fact that it was off colour and of rather bad odour, its physical properties changed little during storage. The rice looked like that of the harvest of only 3—4 years since.

3) According to the gas analyses, CO_2 increased a little in the tin-containers.

4) There occurred no chemical change of the nutrients during air-tight storage of 26 or 28 years.

5) In the rice of 1904 peroxidase was lost entirely, but in the rice of 1906 a little was retained.

6) In the rice of 1904 34% of the catalase was retained and in that of 1906, 74%.

7) In the rice of 1904 the vitamin-B content was 54.1% of that of new rice and in the rice of 1906 it was 83.8%. The content was just equal to that of rice stored in straw bags for 2—3 years after harvest.

8) The boiled rice had a slight undesirable smell and was not very sticky, yet its taste was fairly good and its culinary characters on the whole were quite satisfactory.

9) From the above data it is clearly evident that hulled rice of good quality dried to a moisture content of 11—13% in the sun and packed in air-tight containers may be stored safely 30 years.

Literature.

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