

Comparative Storage-Tolerance of Some Cereal Grains in Japan *

By

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I. Introduction

Numerous investigations on the storage of rice and wheat grains have been published by M. KONDO, T. OKAMURA, S. NAKAZAWA, and others, but little is known concerning the storage of naked barley and corn grains in Japan. It is of much importance and also of interest to find out what kind of cereal grains shows the highest storage-tolerance under the same storage conditions, and the changes in quality under different stored conditions. Comparative storage tests were, therefore, carried out, and the result showed that in these storage tests, there seems to be some differences in the storage-tolerance among different grains.

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II. Materials and Methods

Comparative storage tests were begun in January 1942 using corn, wheat, naked barley, and rice grains as the material. Each sort of grains harvested in the previous year and almost equally dried to about 12 per cent moisture content, was packed in two types of vessel, that is, Japanese rice straw bags and air tight tins, and they were placed in a granary of this institute. In the experiment thus begun, the changes both in the physical as well as the biochemical properties were examined several times during the storage until when it was finished in September 1943.

III. Results

1. Comparison of the storage-tolerance among four kinds of cereal grains stored in Japanese rice straw bags

It has already been demonstrated that the quality of stored cereal grains is mainly influenced by the original moisture content of the grains, temperature and relative

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humidity of the air, and also by the rate of insect damages during storage. When the rice straw bag is used as a container, the cereal grains absorb the moisture rather freely from the air, and also are subjected to the invasion of the noxious insects. Comparison of the properties of grains stored in rice straw bags may, therefore, be regarded as a means of revealing the differences in the storage tolerance under a condition not so favorable for the storage.

(1) Changes in moisture content

The moisture content of stored grains was determined by using Hoffmann's moisture tester. The results are as shown in Table 1.

Table 1. The changes in moisture content of four kinds of grains stored in rice straw bags (%)

| Date of test | Corn | Naked barley | Wheat | Rice |
|--------------|------|--------------|-------|------|
| Jan. 1942 | 11.8 | 11.7 | 12.3 | 11.9 |
| May " | 11.8 | 11.8 | 12.4 | 12.0 |
| Sept. " | 11.9 | 11.9 | 12.4 | 12.1 |
| June 1943 | 14.6 | 13.6 | 14.0 | 14.3 |
| Jan. 1944 | 14.8 | 15.7 | 15.7 | 16.1 |
| Sept. " | 14.6 | 15.6 | 16.1 | 16.1 |

From the data given in Table 1, after two years, the moisture content of these grains attained their maximum by absorbing moisture from the surrounding air, but the value of the equilibrium was slightly varied with different grains; wheat and rice showed the highest hygroscopic moisture. Naked barley contained appreciably lower percentages of hygroscopic moisture than wheat and rice, while corn showed the lowest value.

(2) Damage of insects

Each kind of grains was, more or less, injured by insects, especially two species of weevils, *Calandra oryzae* L. and *C. sasakii* TAKAHASHI. The percentages of injured grains investigated at the end of the test were 45.8 in corn, 34.3 in rice, 17.1 in wheat, and 15.3 in naked barley, respectively. According to this result it is recognized that corn is apt to be heavily damaged by weevils, rice slightly infested, while wheat and naked barley are least injured among these grains.

(3) Decrease in volume weight

It is general that every kind of grains gradually decreases their volume weight by the cause of absorbing moisture from the air and damages of insects when they are stored under the usual condition. The weight per one-Sho (about 1.8 L.) of the grains investigated is given in Table 2.

Table 2 shows that there was a gradual decrease in the volume weight of grains during the time of storage, and the change was also marked in all samples at the end of the experiment. The degree of diminution of volume weight was, however, somewhat different with grains. In wheat and rice the decrease was less than in naked barley and corn.

(4) Germinating capacity

Table 2. Changes of one-Sho weight of the grains stored in straw bags (kg. / 1.8 L.)

| Date of test | Corn | Naked barley | Wheat | Rice |
|--------------|------------|--------------|------------|------------|
| Jan. 1942 | 1.37 (100) | 1.37 (100) | 1.30 (100) | 1.52 (100) |
| May " | 1.37 (100) | 1.37 (100) | 1.30 (100) | 1.52 (100) |
| Sept. " | 1.37 (100) | 1.37 (100) | 1.30 (100) | 1.52 (100) |
| June 1943 | 1.34 (98) | 1.31 (96) | 1.28 (98) | 1.44 (95) |
| Jan. 1944 | 1.25 (91) | 1.25 (92) | 1.25 (96) | 1.41 (93) |
| Sept. " | 1.20 (88) | 1.22 (89) | 1.19 (91) | 1.39 (91) |

Remark. The values in parentheses show the indices of weight.

The germinating capacity of these grains was investigated, but in this test the grains injured by insects were, of course, eliminated from use. The results obtained are shown in Table 3.

Table 3. Changes in percentages of germination of grains stored in rice straw bags

| Date of test | Corn | Naked barley | Wheat | Rice |
|--------------|------|--------------|-------|-------|
| Jan. 1942 | 88.8 | 100.0 | 98.7 | 100.0 |
| May " | 86.8 | 100.0 | 97.5 | 100.0 |
| Sept. " | 83.2 | 94.8 | 96.4 | 94.5 |
| June 1943 | 72.0 | 82.0 | 77.0 | 0 |
| Jan. 1944 | 0 | 1.0 | 0 | 0 |
| Sept. " | 0 | 0 | 0 | 0 |

Table 3 shows that although the germinating power of rice could scarcely be preserved for even one year, other grains retained about 80 per cent of the original ability to germinate at the beginning of the second year, and lost entirely two years after. The difference among these three grains was hardly sufficient to be of significance.

(5) Diminution in vitamin-B₁

The results of vitamin-B₁ content determined by using Thiochrome method are given in Table 4.

Table 4. Decrease of vitamin-B₁ content of grains stored in rice straw bags (γ/100g.)

| Date of test | Corn | Naked barley | Wheat | Rice |
|--------------|----------|--------------|----------|----------|
| May 1942 | 324(100) | 243(100) | 285(100) | 267(100) |
| Sept. " | 312(96) | 230(96) | 278(98) | 261(98) |
| Sept. 1944 | 257(76) | 257(105) | 274(96) | 235(88) |

Remark. The values in parentheses show the indices of vitamin-B₁ content.

According to Table 4, there was a small increase over the original vitamin-B₁ content in naked barley, wheat showed slight decrease, while rice and corn decreased to some degree. From this result it appears that naked barley and wheat show little or

no change in vitamin-B₁ content for at least three years even when stored in straw bags.

(6) Catalase activity

Percentage of hydrogen peroxide decomposed by the catalase was determined by titration with potassium permanganate, and compared with those in May 1942. The results obtained are shown in Table 5.

Table 5. Comparison of decrease in catalase activity of grains stored in straw bags

| Date of test | Corn | Naked barley | Wheat | Rice |
|--------------|------|--------------|-------|------|
| May 1942 | 100 | 100 | 100 | 100 |
| Sept. " | 87 | 79 | 81 | 84 |
| Sept. 1944 | 18 | 35 | 27 | 4 |

As given in Table 5, all grains stored in rice straw bags greatly reduced their catalase activity during the time of storage; but the changes were not uniform, naked barley retained the most, followed by wheat. Corn was next to wheat, and rice the least among the four grains.

Summarizing the results of tests on physical and biochemical properties of the grains stored in rice straw bags mentioned above, it may be concluded that naked barley showed the highest storage-tolerance in both quality and quantity, and it was followed by rice with a slight loss in quantity; wheat was next to rice owing to quantitative loss, corn was the poorest in both.

2. Results of storage experiment in air tight tins

When cereal grains are stored in air tight tins, they will be free from the invasion of noxious insects and free from the changes of atmospheric moisture, and the quality of the grains is mainly affected by the original moisture content of the grain, and the temperature.

Results of tests on both physical and biochemical properties of grains stored in air tight tins are shown in Tables 6 and 7.

Table 6. Changes of some physical properties and germinating power of grains stored in air tight tins

| Date of test | Moisture content (%) | | | | Volume weight (kg./1.8 L.) | | | | Germinating power (%) | | | |
|--------------|----------------------|--------------|-------|------|----------------------------|--------------|-------|------|-----------------------|--------------|-------|-------|
| | Corn | Naked barley | Wheat | Rice | Corn | Naked barley | Wheat | Rice | Corn | Naked barley | Wheat | Rice |
| Jan. 1942 | 11.8 | 11.7 | 12.3 | 11.9 | 1.37 | 1.37 | 1.30 | 1.52 | 88.8 | 100.0 | 98.7 | 100.0 |
| May " | 11.8 | 11.7 | 12.3 | 11.9 | 1.37 | 1.37 | 1.30 | 1.52 | 88.0 | 99.5 | 100.0 | 100.0 |
| Sept. " | 11.8 | 11.7 | 12.4 | 11.9 | 1.37 | 1.37 | 1.30 | 1.52 | 88.2 | 100.0 | 100.0 | 99.7 |
| June 1943 | 12.4 | 12.4 | 12.8 | 12.2 | 1.38 | 1.36 | 1.29 | 1.48 | 83.5 | 96.0 | 84.5 | 89.5 |
| Jan. 1944 | 13.4 | 12.6 | 12.7 | 13.3 | 1.35 | 1.36 | 1.31 | 1.52 | 85.3 | 92.8 | 83.8 | 64.0 |
| Sept. " | 13.2 | 12.7 | 12.3 | 13.3 | 1.36 | 1.35 | 1.32 | 1.51 | 82.0 | 78.0 | 82.3 | 9.2 |

Table 7. Decreases of vitamin-B₁ content and catalase activity of grains stored in air tight tins

| Date of test | Vitamin-B ₁ content (γ /100g.) | | | | Catalase activity (indices) | | | |
|--------------|---|--------------|----------|----------|-----------------------------|--------------|-------|------|
| | Corn | Naked barley | Wheat | Rice | Corn | Naked barley | Wheat | Rice |
| May 1942 | 324(100) | 243(100) | 285(100) | 267(100) | 100 | 100 | 100 | 100 |
| Sept. " | 322(99) | 240(99) | 280(98) | 255(99) | 100 | 96 | 95 | 100 |
| Sept. 1944 | 282(87) | 250(102) | 283(99) | 254(95) | 73 | 151 | 39 | 25 |

Remark. The values in parentheses show the indices of vitamin-B₁ content.

In this series of experiment, all kinds of grains showed no difference in the physical properties but some deterioration in the biochemical properties was observed in different degree. The vitamin-B₁ content and catalase activity in naked barley were highly maintained, and in wheat grains it was slightly inferior to naked barley only in the catalase activity. Corn was found inferior to wheat with respect to all of the characters analysed. Rice grain lost its germinating power rapidly and its catalase activity markedly, making it take the lowest rank among the four grains as to its biochemical properties.

IV. Summary and Conclusion

In comparative storage tests of cereal grains, wheat, corn, naked barley and rice grains dried to 12 per cent moisture content were held for storage in containers consisting of Japanese rice straw bags and air tight tins.

Periodic analyses on the conditions of the grains revealed that in all cases, deterioration of the grains proceeded at a much rapid rate in the straw bag than in the tin container. There were changes not only in the physical properties but also biochemically of different degrees. The naked barley was highly storage-tolerant, showing least changes, followed by rice and wheat. Corn was found to be least suitable for storage in the rice straw bags.

Under the sealed condition in the tin containers, all grains were preserved with less changes, particularly this was true on many of the physical properties. Biochemically, however, the order of deterioration was naked barley least affected, wheat and corn slightly affected, while the rice ranked lowest among the four grains tested.

It may be concluded that the quality of naked barley can be maintained in a good condition, while corn and rice least suitable for storage. To keep corn grains, it is advisable to conserve corn grains free from the noxious insects.

Literature Cited

- (1) ALBERTS, H. W. (1926): Moisture content of corn in relation to relative humidity and temperature of the atmosphere. *Jour. Amer. Soc. Agron.* 18: 1029-1034.
- (2) COLEMAN, D. A. and FELLOWS, H. C. (1925): Hygroscopic moisture of cereal grains and flaxseed exposed to atmospheres of different relative humidity. *Cereal Chem.* 2: 275-287.
- (3) KONDO, M. and OKAMURA, T. (1929): Storage of rice II. On the effect of air-tight and carbon dioxide upon the storage of rice. *Ber. Ohara Inst. Landw. Forsch.* 4: 1-18.

- (4) KONDO, M. and OKAMURA, T. (1930) : Storage of rice III. Germinating power, analyses and vitamin-B₁ of hulled rice stored during 4 years either air-tight or in carbon dioxide. Ber. Ohara Inst. Landw. Forsch. 4 : 343-348.
- (5) ————— (1933) : Storage of rice VI. Physical and biochemical studies of hulled rice stored in straw bags. Ibid. 5 : 395-405.
- (6) UICHANCO, L. B. and CAPCO, S. R. (1933/34) : Effect of various methods of storing corn on the degree of damage due to weevils. Philipp. Agriculturist 22 : 653-668.
- (7) ROBERTSON, D. W., LUTE, A. M., and GARDNER, R. (1939) : Effect of relative humidity on viability, moisture content and respiration of wheat, oats and barley seed in storage. Jour. Agr. Res. 59 : 281-291.