Physiological Studies on the Winter Storage of Ginger and Potato in Central Japan*

By Takeyosi Hori**

Introduction

In this part of central Japan it is very easy to store potatoes in winter, but with the ginger it is so difficult technically that farmers often fail in making a success of it. The purpose of this paper is to present the results of some observations on the physiological changes of these two crops when they are stored in order to find out the exact nature of the difference in their adaptability for winter storage.

Water Content: The water content is found always 8% less in the potato than in the ginger. Practically no seasonal change of water content is observed in either throughout the period of winter storage. Table 1 shows the results obtained.

<table>
<thead>
<tr>
<th>Date</th>
<th>6/XII 1949</th>
<th>25/1 1950</th>
<th>27/II</th>
<th>10/III</th>
<th>10/IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato</td>
<td>80.98</td>
<td>80.73</td>
<td>80.72</td>
<td>80.69</td>
<td>80.59</td>
</tr>
<tr>
<td>Ginger</td>
<td>89.02</td>
<td>88.99</td>
<td>88.98</td>
<td>89.10</td>
<td>89.06</td>
</tr>
</tbody>
</table>

Water Evaporation: When the rhizomes of ginger are left in the open air, they soon dry up. The rate of evaporation is enormously high on the first and second day of exposure, so that they wither to death within several weeks. With the potato, on the other hand, the evaporation is imperceptibly small from the beginning. The results obtained are shown in Fig. 1.

* Aided by the Ministry of Education with a Grant from the Scientific Research Expenditure.
** Biological Laboratory, Gifu University, Gifu, Japan.
**Freezing Point**: The freezing point as well as the supercooling point the extracted juice is always lower in the potato than in the ginger, as indicated in Table 2.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Date</th>
<th>5/XI</th>
<th>12/XII 1949</th>
<th>14/I</th>
<th>25/II</th>
<th>17/III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato</td>
<td>F. P.</td>
<td>-0.35°C</td>
<td>-0.35°C</td>
<td>-0.68°C</td>
<td>-0.71°C</td>
<td>-0.50°C</td>
</tr>
<tr>
<td>Ginger</td>
<td>F. P.</td>
<td>-0.21°C</td>
<td>-0.22°C</td>
<td>-0.22°C</td>
<td>-0.25°C</td>
<td>-0.24°C</td>
</tr>
<tr>
<td>Potato</td>
<td>S. C. P.</td>
<td>-2.25°C</td>
<td>-2.30°C</td>
<td>-2.43°C</td>
<td>-2.46°C</td>
<td>-2.48°C</td>
</tr>
<tr>
<td>Ginger</td>
<td>S. C. P.</td>
<td>-1.67°C</td>
<td>-1.85°C</td>
<td>-1.90°C</td>
<td>-2.01°C</td>
<td>-1.96°C</td>
</tr>
<tr>
<td>T. F. M.</td>
<td></td>
<td>-9°C</td>
<td>-10°C</td>
<td>-11°C</td>
<td>-12°C</td>
<td>-12°C</td>
</tr>
</tbody>
</table>

F. P.—Freezing point  S. C. P.—Supercooling point  
T. F. M.—Temperature of the freezing mixture

In the case of potato, both the freezing and the supercooling temperatures are lowest in January and February, while the giner such a seasonal change can scarcely be observed.

**Starch and Glucose Content**: With potatotubers the starch content decreases and the glucose content increases with the advance of storage period. With the ginger, however, practically no seasonal change is observed in the content of either constituent. The data obtained are presented in Table 3.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Date</th>
<th>6/XII</th>
<th>27/I</th>
<th>27/II</th>
<th>16/IV</th>
<th>9/IV 1950</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato starch</td>
<td></td>
<td>59.51</td>
<td>55.58</td>
<td>49.56</td>
<td>45.83</td>
<td>44.89</td>
</tr>
<tr>
<td>Ginger starch</td>
<td></td>
<td>21.10</td>
<td>19.14</td>
<td>16.73</td>
<td>17.21</td>
<td>16.52</td>
</tr>
<tr>
<td>Potato glucose</td>
<td></td>
<td>0.67</td>
<td>0.87</td>
<td>1.37</td>
<td>1.33</td>
<td>1.26</td>
</tr>
<tr>
<td>Ginger glucose</td>
<td></td>
<td>1.45</td>
<td>1.48</td>
<td>1.64</td>
<td>1.65</td>
<td>1.65</td>
</tr>
</tbody>
</table>

Dry weight % in starch and glucose contents.

**Actual Climatic Conditions of Storage Places**: In central Japan potatoes are stored customarily in a room of the farmer’s house, placed directly on the earthen floor. In this room the air temperature often lowers as low as -2°C. The optimum relative humidity of the air is generally found to be 70% in all weathers and temperatures. The ginger, on the other hand, cannot be stored under such simple
conditions. They are stored in a hole excavated in and with a cover of earth. But
the hole must be climatically conditioned with the greatest care. The temperature
is observed to be always above 9°C and the moisture to be nearly 90% in relative
humidity. Table 4 gives the temperature of a ginger storage-hole in Gifu prefecture,
the hole in which the storage is always successful.

Table 4. Temperature of a ginger-hole always successful.

<table>
<thead>
<tr>
<th>Month</th>
<th>Average temperature</th>
<th>The lowest temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov.</td>
<td>15.5°C</td>
<td>15.2°C</td>
</tr>
<tr>
<td>Dec.</td>
<td>13.7°C</td>
<td>11.0°C</td>
</tr>
<tr>
<td>Jan.</td>
<td>10.2°C</td>
<td>9.8°C</td>
</tr>
<tr>
<td>Feb.</td>
<td>9.8°C</td>
<td>9.1°C</td>
</tr>
<tr>
<td>Mar.</td>
<td>9.8°C</td>
<td>9.2°C</td>
</tr>
</tbody>
</table>

Discussions

It may be said from the results of our observations mentioned above that the
difference between potato and ginger in their storability in winter is attributable to
a difference in their susceptibility to the cold and to the withering. It is found that
the hardiness of ginger is much smaller than that of potatoes. This may safely be
derived from the comparison of the two in the freezing point as well as the
supercooling temperature of the cell-sap. The higher freezing point observed in the
ginger is caused by a higher percentage of water content of its cell-sap. Water
content does not decrease even in the midst of winter. The ratio between the starch
and glucose contents may also be responsible for the difference in hardiness. In the
potato the content of glucose, which is more osmotically active than starch, increases
during the winter months. But in the ginger this increase does not take place. As
regards the withering, the ginger is extraordinarily weak in the resisting power.
It dies of withering within several weeks even in the low temperatures of winter.
In the potato the epidermis of the tubercle naturally drops off soon after harvesting,
and the outer surface thickens greatly by the formation of a thick corked layer of
cells, which prevents the loss of water from passing through the surface of the
tubercle. In the ginger, on the other hand, the epidermis of the rhizome is a one-
celled layer and the membrane of cells is always very thin in the period of winter
storage. It is without doubt that the far greater rate of evaporation observed in
the ginger is caused by such a thin surface structure. Thus the conclusion may
safely be established that the difference of the two crops in their storability in
winter is caused by a difference in their hardiness due to the different physiological
nature of the cell sap and also by a difference in their resisting power to drying
due specifically to the different morphological structure of the epidermis.

Conclusions

The causes which make the potato storage easy and the ginger storage difficult
are explained experimentally, basing on the resisting power to the cold and to the
withering, which is greater in the former than in the latter. The lower water
content and the higher glucose content in contrast to starch content are responsible
for the lower freezing and supercooling temperatures of the cell sap in the potato as
compared with those in the ginger. The thicker and stronger structure of the
epidermal surface prevents the water evaporation from the surface more effectively
in the potato than in the ginger, in which the epidermis is too thin and delicate to
prevent evaporation.

Literature