Effects of Postures of Vegetables and Fruits in Storage on Keeping Post-Harvest Freshness

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As the technology how to maintain freshness of harvested products in storage seems not to be so much progressed, it is desired to promote studies of post-harvest physiology as an important task.

When fresh vegetables such as garland chrysanthemum are kept in a horizontal posture after harvest, the top of their leaves curves upwards, and their stems bend upwards. The occurrence of such curvatures, that depend on negative geotropism, is considered to be associated with definite physiological and biochemical changes in the plants, not only inducing simple deformation.

The authors studied, at first, effects of the postures of post-harvest products in storage on their physiological activities, such as ATP content, chlorophyll content, TTC reducing activity, photosynthetic activity, and total sugar and starch contents. Asparagus, spinach and sweet corn, which are difficult to be kept fresh in storage, were used as the experimental materials. Secondly, ethylene production as related to different postures of apple fruit in storage was examined, because apple fruit is known to produce a large amount of ethylene, which is a plant hormone having physiological activity to promote fruit maturity. The results obtained are presented in this paper.

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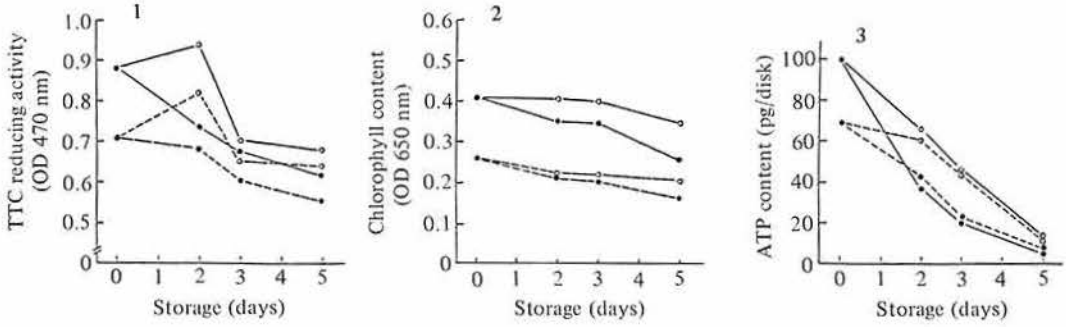
Materials and methods

1) *Asparagus*

Harvested asparagus obtained from Okunakayama Agricultural Cooperative of Iwate Prefecture was used in the next day of the harvest. Using the plants selected for uniformity, plant samples with 22 cm of stem length were prepared. Two groups, each made of 15 bundles, were packed with polydichloroethylene film. Then, one group was stored in an erect posture, while the other group in a horizontal posture in a dark room at constant temperature of 20°C. Tissue layers of 1 mm in depth from epidermis were taken from the actively elongating portion (4–6 cm below the stem tip), and from the basal portion where elongation had ceased (16–19 cm below the stem tip). Then, tissue disks, 1 mm in diameter were prepared from both tissue layers for the measurements of photosynthetic rate,[3] chlorophyll content,[8] ATP content,[5,6] TTC reducing activity,[1] and sugar and starch content.[4]

2) *Spinach*

Ten bunches of plants of uniform size, obtained from Shiobara Agricultural Cooperative of Tochigi Prefecture were packed



Twenty tissue disks were placed in 1% TTC solution for 20 hr at 28°C in darkness, and formazan produced was extracted with 10 ml of acetoethyl for colorimetry.[1]

Chlorophyll was extracted with 5 ml of 80% ethylalcohol from 20 tissue disks for colorimetry.[8]

Twenty tissue disks were heated in boiling water for 20 min to extract ATP, which was then measured with ATP photometer.[5]

Fig. 1. Changes in TTC reduction, chlorophyll content, and ATP content of asparagus during storage

vertically in a cardboard box. Another 10 bunches were packed horizontally in the other box. The boxes were stored at constant temperature of 20°C. To simulate the vibration given to the plants during their transportation, shaking treatment (horizontal shaking: 60 times/min, with 7 cm of amplitude) was given for 20 hr before the storage. The portion of plants where wilting or yellowing is apt to occur (4–8 cm below the leaf-tip) was used for the measurements.

3) Sweet corn

Uniform-sized ears of sweet corn obtained from San-ei Agricultural Cooperative of Iwate Prefecture were cut longitudinally into two parts and immediately packed with polydichloroethylene film. They were stored in a vertical posture and in a horizontal posture (hereafter referred to vertical storage and horizontal storage, respectively) in respective cardboard boxes at 20°C. The measurements were made, using grains on the 15–20th rows counted from the base of the ear.

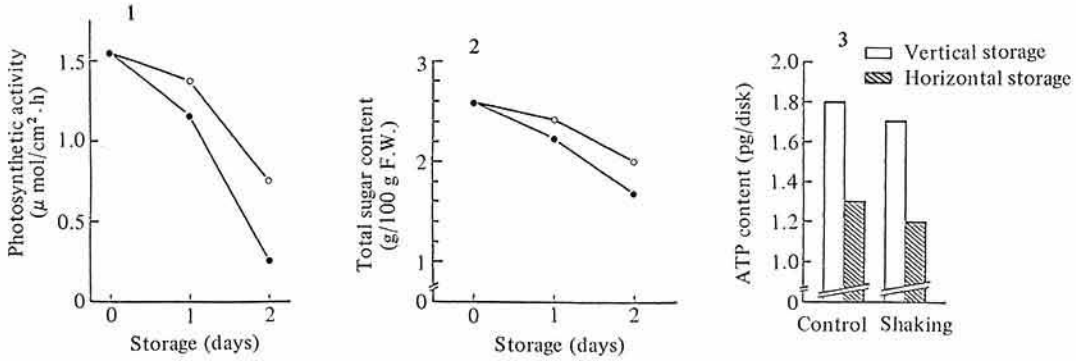
4) Apple fruit

In the next morning of the harvest in Nagano Horticultural Experiment Station, healthy fruit of uniform size and weight were selected to prepare 3 groups, each composed of 15 fruits. The first group (5,201 g) was stored in the natural posture, i.e., fruit with its peduncle on the top of it, just like growing fruit on the mother tree. The second group (5,286 g) was in the reversed position, and the third one (5,283 g) was treated with the alternation of natural and reversed postures (each 1 week). Ethylene was measured with the ethylene monitoring system,[7] developed by the authors. ATP content was measured by the conventional method,[5,6] using tissue disks of 5 mm in depth and 3 mm in diameter, obtained by punching from the top part and equator part of the fruit.

Experimental results

1) Asparagus

The vertical storage showed higher TTC reducing activity at the elongating portion and the basal portion than the horizontal storage, particularly after 2 days of storage the difference was remarkable (Fig. 1–1). The former also gave higher chlorophyll content than the latter, showing a tendency of increasing difference between them with the storage period (Fig. 1–2). Although ATP content decreased rapidly in both storages, particularly in the elongating portion with high physiological activities, the vertical stor-



Photosynthesis under light intensity of 6,000 klux was measured[3] with 15 tissue disks.

ATP content measured after shaking treatment for 1 day

Fig. 2. Changes in photosynthetic activity, ATP content, and total sugars content of spinach during storage
Legends are the same as in Fig. 1.

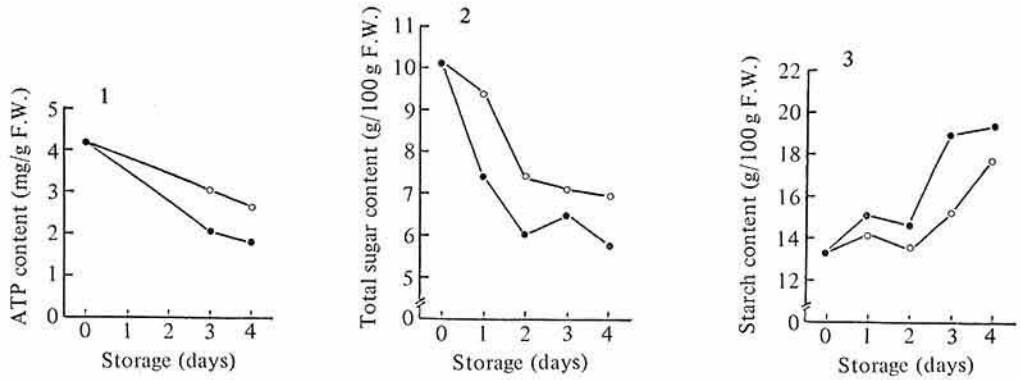


Fig. 3. Changes in ATP content, total sugar content, and starch content of sweet corn during storage
Legends are the same as in Fig. 1.

age showed apparently higher ATP content than the horizontal storage (Fig. 1–3). This result suggests that more ATP was consumed in the latter by geotropic response of plants.

2) Spinach

Although photosynthetic activity of leaves decreased in both storages, it was apparently higher in the vertical storage than in the horizontal storage. Particularly on the second day of storage, the activity in the former was about 3 times that in the latter (Fig. 2–1). ATP content (Fig. 2–3) showed the same trend as the case of asparagus, indicating an energy-rich status of plants in the vertical storage. The decrease of total sugar content was less in the vertical storage than in the horizontal storage (Fig. 2–2). Chlorophyll content was apparently higher in the vertical storage than in the horizontal one, like the case of asparagus. After the second day of storage, difference in yellowing of low leaves was recognized by the naked eye.

3) Sweet corn

Although ATP content decreased in storage, the decrease was slower in the vertical storage than in the horizontal one. The

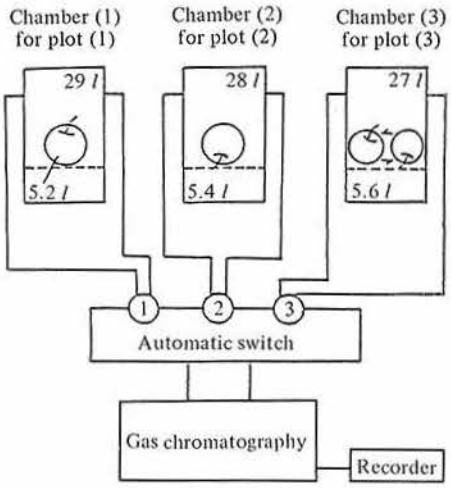


Fig. 4. Ethylene monitoring system
Ethlene concentration in each chamber is analyzed every 15 min and is recorded as shown in Fig. 5.

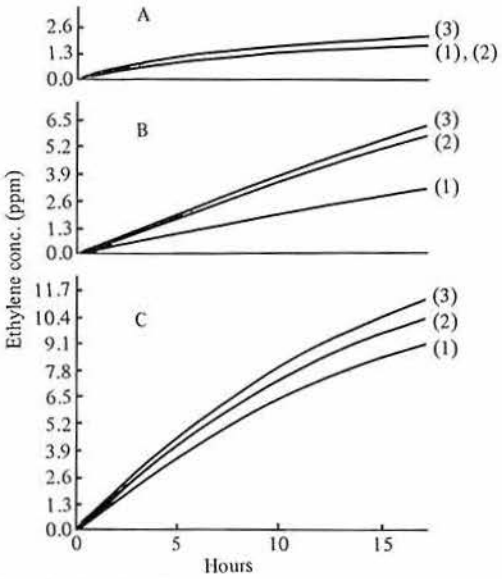


Fig. 5. Production of ethylene from apples stored in three different postures, (1) natural (2) reversed, and (3) alternated postures of (1) and (2).
A : At the start of storage. 15 apples showed 5202, 5286, and 5283 g of fresh wt in plots (1), (2) and (3), respectively.
B : After 1 month of storage. 15 apples showed 4994, 5084 and 5079 g of fresh wt in (1), (2) and (3), respectively.
C : After 2 months of storage. 7 apples showed 2193, 2196, and 2212 g of fresh wt in (1), (2) and (3).

former showed 50% higher value of ATP content than the latter (Fig. 3–1). Total sugar content decreased rapidly in 2 days and then slowly after that, but it was always higher in the vertical storage than in the horizontal one (Fig. 3–2). Starch content began to increase rapidly after the second day of storage, but its increase was slower in the vertical storage than in the horizontal one (Fig. 2–3) in contrast to the changes of total sugar content.

4) Apple fruit

Production of ethylene measured with the ethylene monitoring system (Fig. 4) is shown in Fig. 5. At the start of the storage, no significant difference was observed among three treatmental plots, i.e. (1) natural posture, (2) reversed posture, and (3) alternation of natural and reversed postures. After 1 month of storage, the plot (1) showed apparently less ethylene production than other plots. After 2 months of storage, the amount of ethylene production showed a great increase in all plots, but that in the plot (1) was less than in the others. The ratio of the amount of ethylene produced in the plot (2) to that in the plot (1) is shown in Fig. 6. The

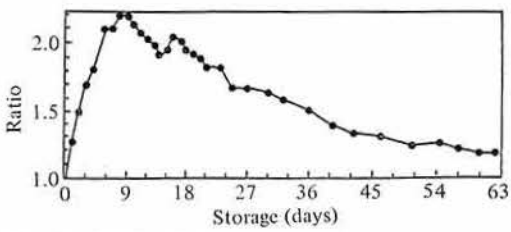


Fig. 6. Ratio of ethylene concentration in chamber (2) to that in chamber (1)

ratio increased rapidly after the start of storage, reaching a peak value about 2.2 after 1 week, and then gradually decreased. Thus, it was clearly shown that the amount of ethylene production of apples was greatly influenced by their posture during a period of about 1 month in storage.

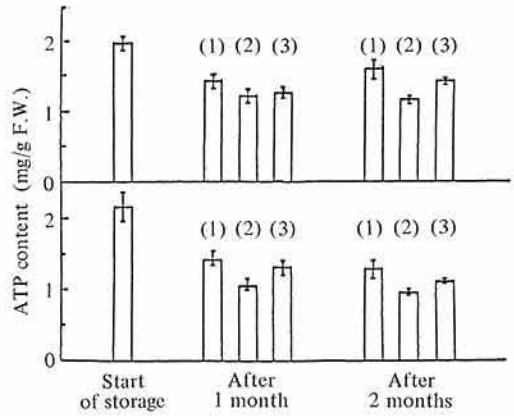


Fig. 7. Change in ATP content of apples during storage in different postures
(1), (2), (3) are the same as in Fig. 5.

Loss of moisture from the apples examined after 1 month of storage showed no difference among plots: 207.4 g, i.e. loss of 4.0%, in the plot (1) 201.2 g, loss of 3.8% in the plot (2) and 203.5 g, loss of 3.9%, in the plot (3). ATP content, which is utilized as an indicator for the degree of freshness of fishes, is given in Fig. 7. Contrary to the ethylene production, ATP content was higher in the plot (1) than in other plots at both portions of fruit (top portion and equator portion). These results indicate that more energy was consumed during the storage when apples were kept in the posture reverse to the natural posture on the mother plants. As a matter of fact, 3 rotten fruits and 8 rotten fruits were found after 1 month and 2 months, respectively, only in the plot (2).

Conclusion

The present study found out the fact that the posture of vegetables and fruit in storage exerts a great effect in keeping post-harvest freshness. For keeping freshness of apples for long; it is quite effective to store them in the natural posture, i.e., the posture of fruit on their mother plants (peduncle at the top of fruit). This effect was remarkable during a period of about 1 month of storage. As the period from harvest to retail of apples is long, such post-harvest technology is quite important.

Fresh vegetables, which are liable to lose their freshness within a short period after harvest, such as asparagus and garland chrysanthemum, cause the curvature when stored in a horizontal posture, resulting in reduced marketing value. In addition to the occurrence of such deformed shape, it was found out that physiolgical activities such as TTC reduction, ATP content, chlorophyll content, etc. were lowered to a greater extent as compared with those of the plants stored in a vertical posture. Thus, it can be concluded that the storage with the posture similar to the natural posture during the growth is effective in preserving post-harvest freshness.

These results have come to be applied by farmers or marketing systems. Packing and display of harvested products in the vertical posture are becoming popular recently. Further studies are needed to be done with other kinds of vegetables and fruit.

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(Received for publication, October 23, 1985)