Effect of the Gamma-Ray Irradiation on the Removal of Astringeny in Kaki (Oriental Persimmons)*

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The effect of the gamma rays from Co^{60} on the removal of astringency in Kaki (Oriental persimmons) were observed. The astringency of mature Kaki fruits was removed completely by the irradiation of the gamma rays with dosage more than 150×10^4 r. As the radiation dosage increased, firmness and astringency decreased while soluble pectin increased. The fruit of which astringency removed by this treatment became soft like the overripe fruit. The gamma-ray irradiation seems to accelerate the ripening of the fruit. From the data obtained on firmness, and alcohol, acetaldehyde and water soluble pectin contents of the fruit and microscopic observation of its tannin cells after the irradition, it is concluded that the mechanism of removal of the astringency is the same as in overripe fruits.

INTRODUCTION

It is well know that there are two types of astringency in Kaki (Oriental persimmons): astringent and non-astringent. The non-astringent type of the fruit becomes non-astringent to the taste as it comes to maturity on the tree, while in the other type the fruit remains astringent until it becomes overripe. In our country the astringent Kaki is generally made edible by removing its astringency using some artificial treatments. On the removal of astringency of Kaki, several workers have published their studies. Kakeshita[1] has reported that the astringency disappears when the astringent substance is polymerized by acetaldehyde formed in the fruit as it matures. Kitagawa[2] has observed some difference between the tannin cells of both types in cell wall thickness, pit development and pectin contents, and pointed out a role of pectin in removal of the astringency. He has also found interesting facts that in the artificially treated fruit the astringent substance remains unchanged chemically before and after such treatments and the destruction of the astringency is found to be due to coagulation of pectin which makes the astringent substance insoluble in water. According to McArdle and Neheias[3], and Miura, and Mizuta[4] the treatments by gamma-ray irradiation for the fruits such as apples and oranges increase water soluble pectin in them.

The present work has been attempted to examine further the effect of the gamma-ray irradiation on the removal of astringency using astringent Kaki fruit

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and to clarify the mechanism of removal of the astringency.

MATERIALS AND METHODS

As the samples to be examined well matured Kaki fruit of the variety Hiratanenashi from our University Orchard were used. For each run of irradiation a couple of the fruits were irradiated in the Co^{60} gamma-ray facility of the Institute for Chemical Research, Kyoto University. The treatments were repeated three times. The dose rate in the irradiation chamber was about 136×10^4 r/hr when we used the facility. After the irradiation of the fruits, firmness was first measured by a hardness meter. Then the fruits were peeled and the juice was extracted by a juicer. Removal of the astringency was judged by tasting. The astringent substance in the juice was determined by titration with 0.1 N $KMnO_4$. alcohol, acetaldehyde and water soluble pectin contents in the juice were determined using by the colorimetric method[5], Ripper's method[5] and calcium pectate method[6], respectively.

RESULTS

Removal of the astringency. The dosage of Co^{60} gamma rays used for removal of the astringency in Kaki fruits were 0, 1×10^4, 10×10^4, 100×10^4, 200×10^4, and 300×10^4 r. The dose of the gamma radiation less than 10×10^4 r did not show any effect on astringency or on the appearance of the fruit. The fruits exposed to the dosage more than 100×10^4 r lost the astringency considerably. The ones exposed to 200×10^4 r and 300×10^4 r lost their atringency completely, but they became soft and the color became slightly dark. The effects of gamma rays observed are summarized in Table 1.

With an aim to clarify the mechanism of the removal of the astringency we observed the firmness, astringency, alcohol, acetaldehyde and water soluble pectin contents of the irradiated fruits exposed to the gamma radiation of various values of dosage. The effects observed are given in Table 2. For comparison, date on the fruits treated with alcohol and hot water are also presented in the table.

As the radiation increased, the astringency decreased. The fruit exposed to 150×10^4 r or more tastes non-astringent. Firmness of the fruit decreases almost constantly as the radiation dosage increases. On the other hand, water soluble

Table. 1. Effects of gamma radiation on the removal of astringency in Kaki (Variety : Hiratanenashi).

Radiation dosage	Astringency judged by tasting	Appearance of the fruits
0 × r	Quite astringent	No change
1 × 10^4 r	Quite astringent	No change
10 × 10^4 r	Quite astringent	No change
100 × 10^4 r	Slightly astringent	Slightly soft
200 × 10^4 r	Non-astringent	Soft, slightly dark
300 × 10^4 r	Non-astringent	Soft, slightly dark

Table. 2 Effects of gamma radiation on the firmness and chemical consituents of Kaki (Variety: Hiratanenashi).

Radiation dosage $\times 10^4$r	Firmness kg.	Astringency ml of 0.1 N $KMnO_4$ titrated to 1 ml of juice	Alcohol %	Acetaldehyde mg %	Water soluble pectin mg of Ca-pectate in 10 ml juice
0	2.87	2.11	0.00	0.33	45
25	2.92	2.09	0.00	0.44	52
50	2.16	1.64	0.01	0.40	52
75	1.76	1.26	0.01	0.51	71
100	1.41	1.00	0.02	0.58	89
125	0.98	0.47	0.02	0.65	96
150	0.90	0.19	0.05	0.64	106
Warm water treated	1.75	0.21	0.18	1.80	82
Alcohol treated	1.51	0.17	0.55	1.87	74

pectin contents increases. Alcohol and acetaldehyde contents show a tendency to increase as irradiation increases. It is noted that in the fruit exposed to 150×10^4 r the alcohol and acetaldehyde contents are several times lower than in that treated with alcohol or hot water.

Microscopic observation. In order to examine the mechanism of the removal of the astringency from the other standpoint, tannin cells of the fruit treated by gamma rays of 150×10^4 r were observed microscopically.

Protoplasm in the tannin cells of the irradiated fruits do not coagulate even though the fruit tastes non-astringent. However, it coagulates at once when plasmotysis of the tannin cell occurs or the cell is ruptured, as shown in Fig. 1. Moreover, all the fruit cells are macerated by the radiation and the plasmoptysis occurs readily. These observations are similar to those on the tannin cells of overripe fruits.[2)]

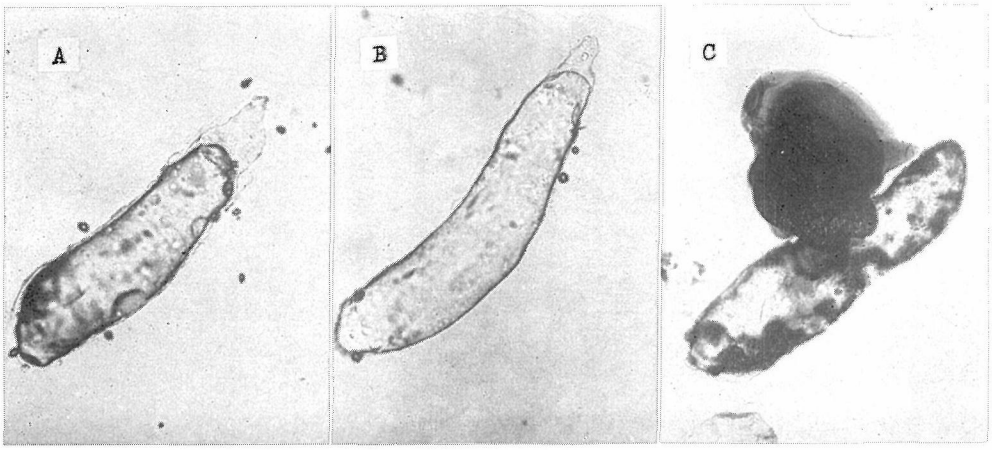

Fig. 1. Tannin cells of the fruit exposed to 150×10^4 r: A. Tannin cells in 0.5 N sucrose solution. The cell shows plasmolysis. B. Deplasmolysis of the same cell. C. When plasmoptysis occursed the protoplasm coagulates instantly. Dyed with ferric chloride.

DISCUSSION

The gamma radiation of more than 150×10^4 r removed the astringency from astringent Kaki fruit, but the irradiated fruit became soft like overripe fruit. As the radiation dosage increased firmness of the fruit decreased and water soluble pectin contents increased. These changes were similar to those observed by McArdle and Neheias[3] with apples and carrots. They concluded that these changes were due to depolymerization of the pectic substance by gamma-ray irradiation.

It is well know that ethylene promote the fruit ripening. This fact has been known to be due to depolymerization of the pectic substance.[7] Overholser[8] has reported that exposure of Kaki fruits to dilute concentrations of ethylene and its derivatives for periods of 15 to 25 hours results in a more rapid loss of astringency than for check specimens. The treated fruit, however, tended to soften so rapidly that he concluded this method for removal of astringency being of value only in preparation for local markets. He did not determine the changes in pectin in the fruit, nor did he observe the tannin cells involved microscopically. It seems that gamma rays and ethylene have a similar effect to ripen the fruit rapidly. From these facts mentioned above, as a practical method for removal of the astringency gamma radiation is not very favorable unless any method can be found to keep the irradiated fruit firm.

In the astrigent Kaki removal of the astringency by artificial treatment is due to coagulation of protoplasm in its tannin cells.[2] It is also known that when the astringent fruit becomes overripe the water soluble pectin increases.[3] Taking into consideration the data obtained on firmness, alcohol, acetaldehyde and water soluble pectin contents, the mechanism of removal of the astringency by the gamma-ray irradiation seems to be different from other artficially treated fruits but is the same as in overripe fruits. This was also co-nfirmed by the microscopic observation.

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