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ABSTRACT

THE TEXTURAL AND BIOCHEMICAL CHANGES IN IRRADIATED APPLES (*Malus pumilla*). The purpose of this study was to investigate some textural and biochemical changes in irradiated apples. The apples were irradiated with doses of 0; 0.25; 0.5 and 1.0 kGy and stored at 10±2°C with relative humidity (RH) of 80 - 85 % . The changes in texture pectin content, juice viscosity, peroxidase (POD) activity, and POD isoenzymes banding pattern were evaluated periodically after 0, 1 and 2 months of storage. The result showed that irradiation with a dose of 0.25 kGy had no significant effect on texture, pectin content and juice viscosity; while POD specific activity decreased significantly. Irradiation doses of 0.5 and 1.0 kGy had significant effects on texture, pectin content, juice viscosity, POD activities and POD isoenzymes banding pattern. During storage the texture, pectin content and POD activities tended to decrease in all samples, while juice viscosity increased remarkably. Organoleptic examination showed that physiological damage occurred after 2 months of storage. Irradiation doses of 0.5 and 1.0 kGy seem to be too high for the preservation of apples.

ABSTRAK

PERUBAHAN TEKSTUR DAN BIOKIMIA PADA APEL (*Malus pumilla*) IRADIASI. Penelitian ini bertujuan untuk mempelajari perubahan yang terjadi pada tekstur dan sifat biokimia apel yang diiradiasi dengan dosis 0; 0,25; 0,5 dan 1,0 kGy dan disimpan pada suhu 10±2°C dengan RH 80 - 85 %. Perubahan pada tekstur, kadar pektin, viskositas jus, aktivitas spesifik enzim peroksidase (POD), dan pola pita isoenzim POD diamati setelah penyimpanan bulan ke-0, 1 dan 2. Hasil penelitian menunjukkan bahwa iradiasi dengan dosis 0,25 kGy tidak menyebabkan perubahan pada tekstur, kadar pektin dan viskositas jus, sedang aktivitas POD menunjukkan penurunan. Iradiasi dengan dosis 0,5 dan 1,0 kGy sangat nyata berpengaruh baik pada tekstur, kadar pektin, viskositas jus, maupun pada aktivitas POD. Selama penyimpanan, tekstur, kadar pektin dan aktivitas pod menunjukkan penurunan, sedang viskositas jus menunjukkan kenaikan. Iradiasi dengan dosis 0,5 dan 1,0 kGy nampaknya terlalu tinggi untuk pengawetan apel.

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picked one day before starting the experiment, and were carefully selected for uniformity in size and colour.

Irradiation. Irradiation was done in a Panoramic Batch Type Irradiator using ^{60} Co source with a dose rate of 3 kGy/hr, and irradiation doses of 0.25; 0.50 and 1.0 kGy. A part of the samples were kept in same condition as the control. All of the samples were stored at 10±2^{o}C.

Analytical Methods.The texture of irradiated as well as non-irradiated apples was measured using Tensil tester at 10 scale load, and the viscosity was measured using Viscometer. The pectin content of the samples was determined based on the weight of pectin extracted with 10 % acetic acid and 10 % calcium chloride.

Enzyme Assay. All samples were extracted with 0.02 M sodium phosphate buffer pH 6.5. The homogenates were centrifuged for 1 hr at 3000 rpm. The resulting supernatants were used for POD activity determination. Aliquots (0.2 ml) of the extract were incubated with 0.01 M o-phenilenediamine as H-donor and 0.03 % hydrogen peroxide as oxidant. The oxidation of o-phenilenediamine was measured using a Hitachi U-200 Spectrophotometer at 430 nm. The specific activity was expressed as unit activity per mg of the enzyme protein, whereas the protein content was determined by Lowry method with bovine serum albumin (BSA) as protein standard.

Polyacrylamide Gel Electrophoresis. Disc electro-

according to the method described by DAVIS (6). Electrophoresis was carried out in Tris-glycine buffer, pH 8.3 with a constant current of 2 mA per tube. The POD isoenzymes banding patterns were detected by amino-9-ethylcarbazole and 0.7 % hydrogen peroxide followed by dipping the gels in 7 % acetic acid which developed orange coloured bands.

RESULTS AND DISCUSSIONS

In this study, the experiments were done in three replications, and the parameter values illustrated in Figures 1 to 5 were the average values.

The changes in texture of unirradiated and irradiated apple tissue during storage are shown in Figure 1.

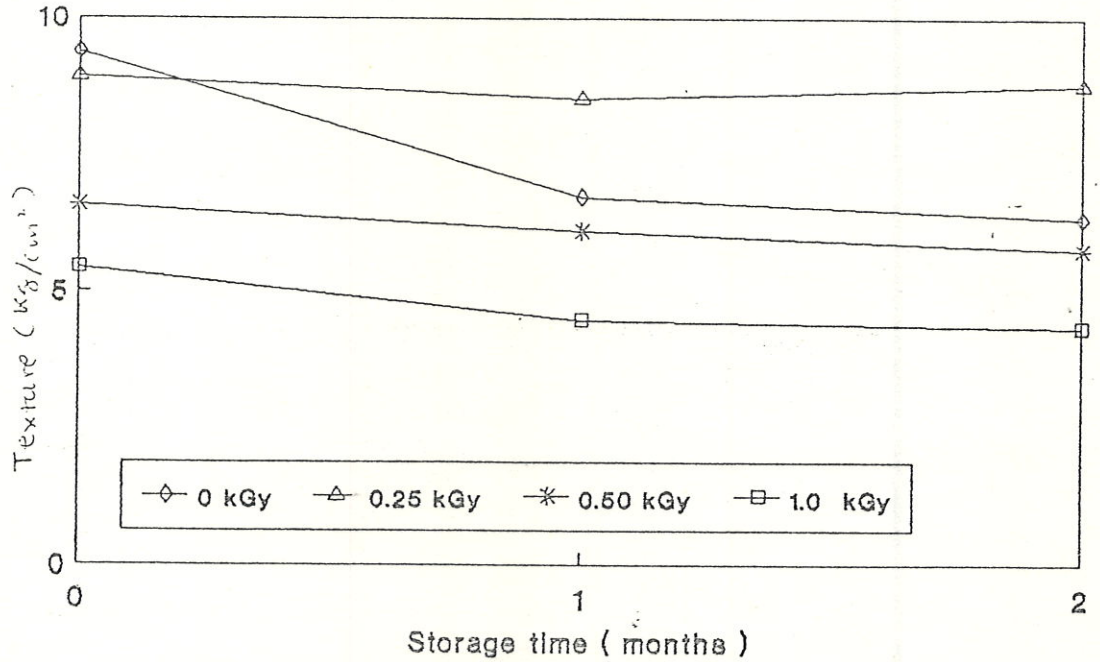

Figure 1. Texture changes in unirradiated and irradiated apples (0 - 1.0 kGy) after 0,1 and 2 months storage at 10° C.

It is clear that irradiation at a dose of 0.25 kGy has no effect on apple texture immediately after irradiation. However, the texture of apples was affected significantly ($P < 0.05$) by irradiation with the doses of 0.5 and 1.0 kGy. The hardness of texture tended to decrease during storage. MAXIE et al. (5) concluded that immediate softening occurred in some varieties of apples irradiated at doses above 1 kGy, but after long period of storage, the irradiated fruits were firmer than control. Furthermore he pointed out that the effects of irradiation on texture of a tissue must be considered from two points of view, i.e direct and immediate effect on the firmness of the tissue, as well as a delayed, secondary effect on ripening of the fruit. There is an immediate loss in texture during irradiation. If irradiation inhibits ripening, the loss in firmness of the tissue will be retarded following the initial loss. If irradiation does not inhibit ripening, the loss in texture following the direct and immediate effect will follow closely to that of unirradiated ones. The third possibility is radiation-stimulated ripening as noted in nectarines and peaches by MAXIE et al. (5), where an unexpected post-irradiation stimulation of softening occurs. However, the direct and immediate effects of irradiation on the texture of these species are so profound that the fruits are about as soft immediately after irradiation as fully ripened fruit even though they are physiologically unripe. CLARKE (7) found

that there was an immediate effect of gamma irradiation on apple texture and subsequent changes during storage at 3°C. According to HULME and RHODES (8),the texture of apples in biochemical terms derives from pectin, hemicellulose, cellulose, pentosan and hexosan and their interactions and interconections. Texture is also affected by changes in the turgor of the cells and by changes in cell elasticity and adhesion. Cell elasticity is influenced by changes in the composition of the cell wall and in lipoprotein membranes bordering the cells. It is generally thought that pectins and their combinations play a central role in the softening process of the tissue during ripening.

Pectin contents of gamma irradiated apples and control are shown in Figure 2.

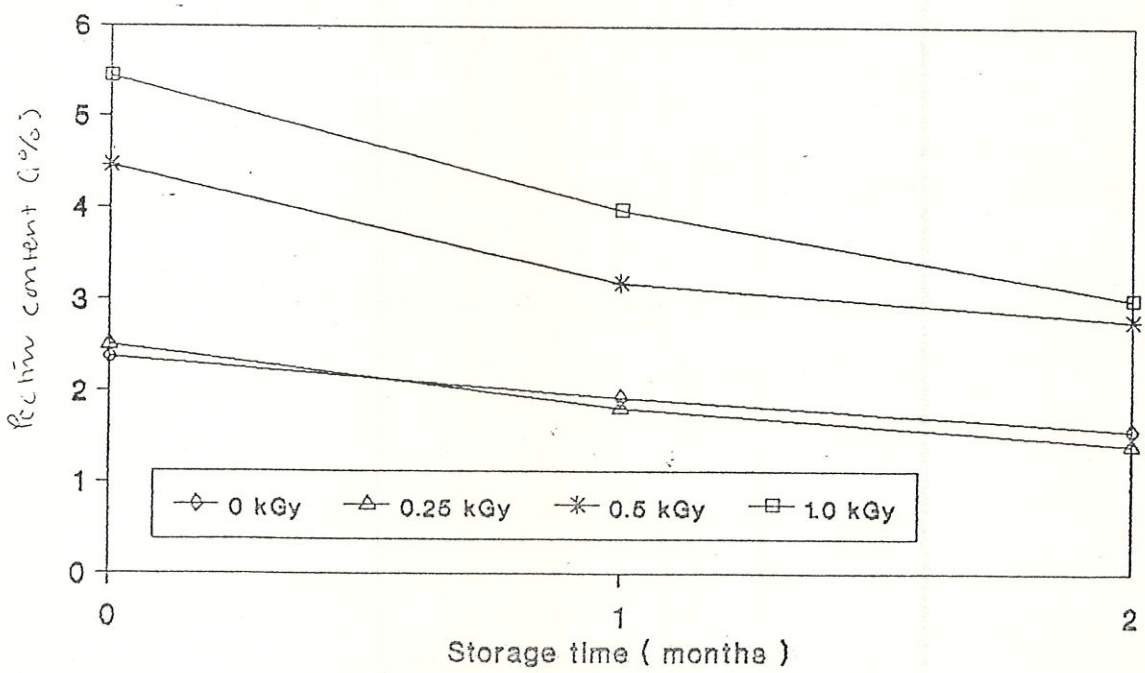

Figure 2.Pectin content of unirradiated and irradiated apples (0 - 1.0 kGy) after 0,1 and 2 months storage at 10± 2°C

Significant changes in pectin content appeared in samples irradiated with doses of 0.5 and 1.0 kGy ($P<0,05$). It can also be associated with a reduction in molecular weight of the pectic substances,with a consequent increase in water soluble pectin during ripening, thus causes softening. When fruits ripen, one of the most striking changes occurred is the conversion of insoluble protopectin to soluble pectin. This change is a logical one to study with respect to the softening associated with irradiation.

Figure 3 illustrates the significant effect ($P<0,05$) of gamma irradiation with doses of 0.5 and 1.0 kGy on juice viscosity of apples and its increase during storage.

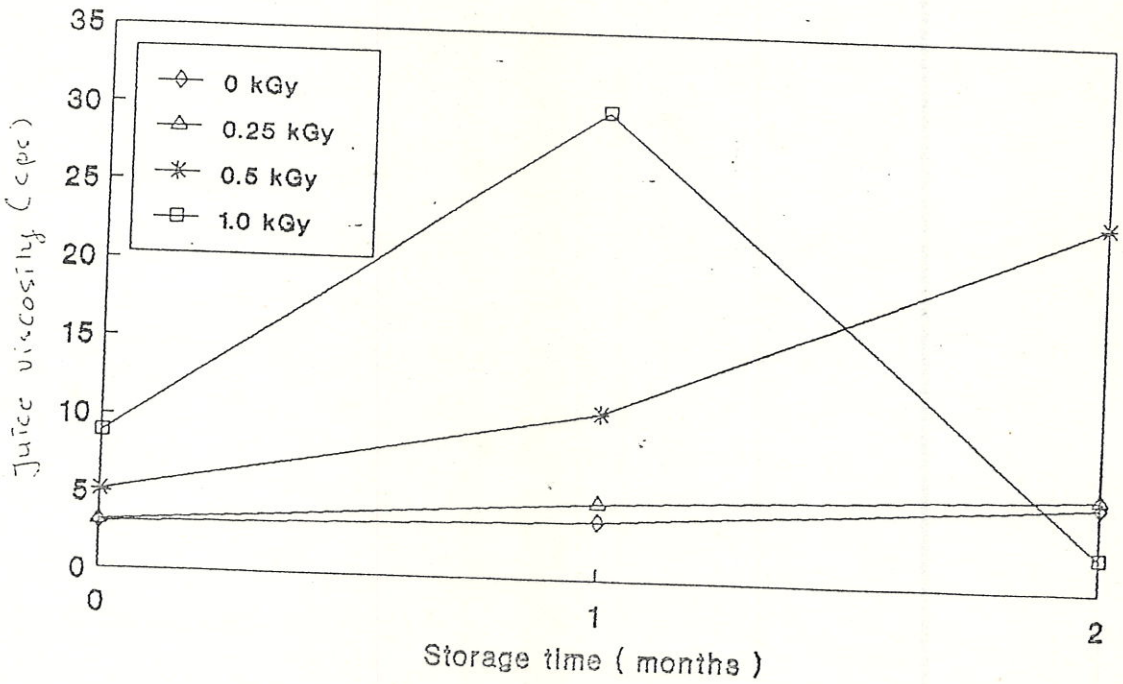

Figure 3. Juice viscosity of unirradiated and irradiated apples (0 - 1.0 kGy) after 0, 1 and 2 months storage at 10°C

It shows also a nonsignificant increase by the dose of 0.25 kGy. MITCHEL ***et al*** (4) noted that juice viscosity of apples irradiated with a dose of 0.75 kGy increased four times higher than that of control. The increase in juice yield attributed to one or more irradiation induced changes including the increase in permeability of cell wall of the skin, weakening of the skin, breakdown of protopectin in intermediate layers which weaken bonds between the cells, and softening of the tissue due to enzymatic breakdown of protopectin.

Ascorbic and dehydroascorbic acids, hesperidin as well as many enzymic systems such as ascorbic acid oxidase, catalase and peroxidase are responsible for the breakdown disorder of fruits. Specific activity of apple peroxidase is illustrated in Figure 4.

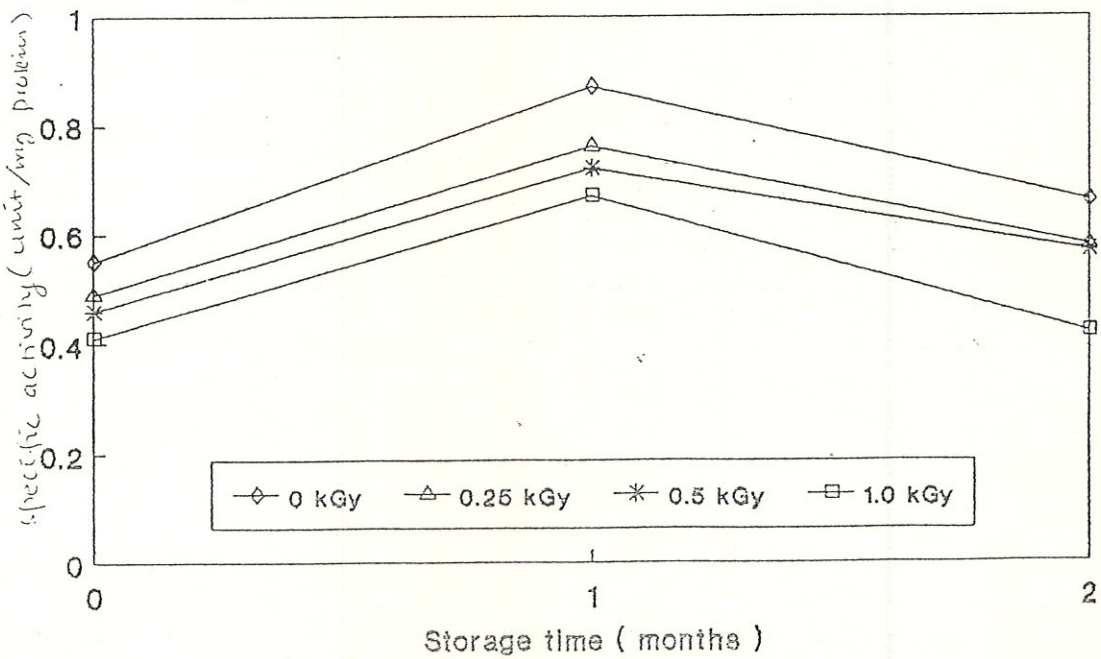

Figure 4. Specific activity of peroxidase in unirradiated and irradiated apples (0 - 1.0kGy) during 2 months storage

The result showed that specific activities of POD enzyme decreased by increasing irradiation dose. Irradiation doses of 0.25; 0.5 and 1.0 kGy were able to inactivate the POD's specific activity by about 10.91 % ; 16.36 % and 24.45 %, respectively. The specific activity tended to decrease at the end of storage.

GANTHAVORN *et al*. (9) found that POD in peas could regenerate at -18°C. It was detected that the POD activity increased 7 % higher than the original activity after 15 days of storage. Irradiation with a dose of 0.75 kGy led to a significant decrease in apple pectinesterase. According to FARAG *et al*. (10) pear fruits irradiated with doses of 1 and 2 kGy tended to soften. In samples irradiated with the dose of 2 kGy, more than 50 % of lipoxygenase was inactivated. It indicates that lipoxygenase activity relates to physiological breakdown disorder.

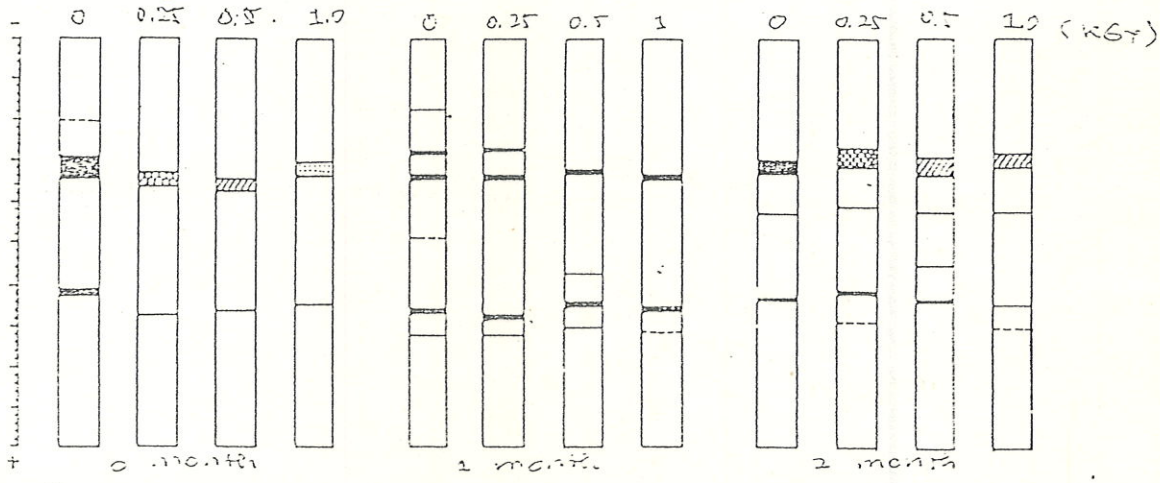

Figure 3. POD isoenzymes banding pattern of unirradiated and irradiated apples with doses of 0; 0.25;0.5 and 1 kG, during 2 months storage at 10±2°C
The peroxidase isoenzyme banding pattern of irradiated and

Figure 5. POD isoenzymes banding pattern of unirradiated and irradiated apples with doses of 0; 0.25;0.5 and 1 kGy during 2 months storage at 10±2°C

The peroxidase isoenzyme banding pattern of irradiated and unirradiated samples, before and after storage at 10±2°C are shown in Figure 5. It was found that the intensity of isoenzyme A in control remained constant until one month storage, while isoenzyme B broke into three bands, and isoenzyme C split into two bands. At the end of storage, the POD isoenzyme of control broke into three bands.

The intensities of isoenzymes B and C of 0.25 kGy samples were similar to those of the control after 1 month storage. It was found also that in samples irradiated at 0.5 and 1.0 kGy, the POD- isoenzymes banding patterns were different with those of the control. Irradiated samples of 0.5 kGy had four bands, while samples irradiated at 1.0 kGy had three bands after one month of storage. At the end of storage, the intensities of isoenzyme A in irradiated samples was weaker than control. PRABHA and PATWARDAN (11) noted that isoenzyme bands were more intense in the case of apples harvested at a later stage of maturity than in the earlier stages. It was noticed that enzyme activity in the post-climacteric period was much higher than that in the pre-climacteric period in apples harvested at early maturity.

CONCLUSION

It could be concluded that there was no changes in textural properties of apples caused by irradiation at a dose of 0.25 kGy, while the peroxidase activity decreased by about 10.91 % and POD isoenzyme A disappeared. Irradiation doses of 0.5 and 1.0 kGy led to significant effect on texture, juice viscosity, pectin content; and hence were not recommended for the preservation of apples. With doses of 0.5 and 1.0 kGy, POD activity decreased by about 16.36 and 24.45 %, respectively. During storage, the firmness of texture and pectin tended to decrease, while juice viscosity increased remarkably. Organoleptic examination showed that physiological damage occurred after 2 months of storage.

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