EFFECT OF GAMMA IRRADIATION ON CELL WALL POLYSACCHARIDE MODEL SYSTEMS

By

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ABSTRACT

EFFECT OF GAMMA IRRADIATION ON CELL WALL POLYSACCHARIDE MODEL SYSTEMS. (H.M. Aman Wirakartakusumah as chairman, A.G.J. Voragen, Soewarno T. Soekarto, Dedi Fardiaz, and Anton Apriyantono as members of committee).

Irradiation is an alternative preservation method which can be utilized to extend the shelf life of agricultural products by eliminating number of insects, and decreasing microbial growth effectively. Irradiation at low dose can inhibit some physiological and biochemical changes of certain fruits, resulting in a delay of the ripening stage, and of their senescence. However, irradiation of fresh fruit at pasteurization dose might create an adverse effect on the fruit texture by loosing their tissue integrity.

Cell wall polysaccharides which mainly consist of pectic substances, hemicellulose and cellulose, play a major role on the immediate softening of irradiated fruits. Their degradation mechanism can be elucidated by studying degradation products resulting from irradiation of cell wall or from cell wall components.
Cell wall polysaccharides were isolated from mango flesh by ethanol insolubilization prior to low dose radiation exposure. A sequential extraction using Na2CyDTA was applied to the irradiated materials followed by further isolation steps to obtain pectin, hemicellulose, and cellulose fractions. These fractions were then analyzed to determine their neutral sugars, uronic acid and cellulose contents, elution behaviour of the charge polysaccharides, and molecular weight distribution.

The result revealed that ionizing radiation at a dose of 10 kGy subjected to isolated cell wall polysaccharides could degrade the macromolecules into smaller components. Some of the glycosidic bonds were split by irradiation as resulted by increasing some solubilized of sugar components and the reduced of molecular weight. However, such information was insufficient to obtain an explicit data on degradation mechanism of irradiated mango fruit due to the complexity of the substrates. Therefore, it is advantageous to carry out experiments with polysaccharides model systems to elucidate specific feature of degradation by irradiation.

Studies on irradiation of isolated apple pectins, alginates and arabinans as the model systems induced degradation were carried
out. Pectins and alginates were first purified then both irradiated either in solid or in solution state. Effect of gamma irradiation at 15-30 kGy on these treated materials was conducted by analyzing some changes using chemical, physical, and different chromatography methods.

The results show that medium and high doses gamma irradiation could reduce the viscosity of pectin and alginates, while irradiation did not cause β-elimination in the ester groups of pectin as confirmed by titration and ion exchange chromatography methods. The formation of 4,5-unsaturated uronosyl residues as a product of cleavage of the pectin backbone via β-elimination was not found in irradiated pectin as measured by thiobarbituric acid (TBA) test. HPSEC/GPC analysis for all irradiated polysaccharides model systems revealed that the average number of molecular weight showed a decrease by increasing radiation dose. Storage condition in 2 different relative humidities affected significantly the degree of polymerization of pectin and alginates irradiated in solid state.

A most detailed insight on the degradation mechanism of irradiated polysaccharides can be seen clearly by irradiating the
lower molecular weight fragments prepared from the same model systems.

Polygalacturonic acid (PGA) consists of a galacturonan backbone with free methoxyl groups, was fragmented into lower molecular weight components via an enzymic degradation. PGA is the best substrate for endopolygalacturonase which specifically hydrolyze the glycosidic linkages next to free carboxyl groups.

Low molecular weight fragments of PGA obtained by enzymic degradation, as well as low molecular weight fragments of pectin (methyl esterified polygalacturonic acid), and alginates obtained by mechanolysis have been used to study the mechanism of radiation-induced degradation.

By means of high-performance anion-exchange chromatography (HPAEC), the degradation of specific entities induced by irradiation and the formation of new compounds were measured. The low molecular weight fragments of PGA, pectin, and alginates show an increasing reduction in the degree of polymerization upon exposure to increasing irradiation doses. An alginate with high ratio of mannanuronic to guluronic acid appeared to be more sensitive towards irradiation than an alginate having a low ratio. Degradation of polygalacturonic acid fragments by
irradiation can be ascribed to hydrolytic cleavage of glycosidic bonds, although HPAEC analysis revealed that other unknown products were also released during the irradiation process. Storage at -20°C of various irradiated PGA fractions did not affect significantly their average molecular weight and had no effect on their HPAEC elution pattern. A phenomena can be postulated from the whole results that gamma irradiation of cell wall polysaccharides both in solid and solute states are likely more degradation than cross linking. The mechanism seems to be a hydrolysis in random by splitting glycosidic bonds, but does not create neither β-elimination reaction nor new double bonds on high methoxyl pectin. Irradiation induced degradation of the oligomers in solute state could produce some new fragments, and considered as intermediate radiolytic products.

*Key words: alginates, cell wall, irradiation, mango, oligomers, pectin.*
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Zubaidah Irawati was born on August 15, 1950 in Pekalongan, Central Java. She spent her childhood with her parents, in Semarang until she graduated from senior high school in 1969. She went to Bogor Agricultural University to pursue her study on the faculty of technology and mechanization on agriculture and graduated in 1977.

Since 1979 she has been working for food preservation group at radiation processing division National Atomic Energy Agency in Jakarta. From 1981 to 1982 she participated a International Facility for Food Irradiation Technology (IFFIT) fellowships sponsored by IAEA for 6 months in Wageningen, The Netherlands. Prior to her PhD programme from September 1986 to July 1988 she studied on the degradation of cell wall polysachharides of tropical fruits using various commercial enzymes at the Department of Food Science/Food chemistry and Microbiology Division, Wageningen Agricultural University, Wageningen the Netherlands sponsored by Netherlands Government as a grant scholarship. In September 1988
she officially admitted as a PhD student from the same university. Starting from September 1989 - August 1992 she worked for her PhD research on cell wall polysaccharides as substrates to elucidate their degradation mechanism induced by gamma irradiation using various chromatography methods. She transferred her credit points to Bogor Agricultural University under food science post graduate programme on February 1996 to finish her study. She is married, and having 2 children.