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Effects on the Quality of Fresh Cucumber (*Cucumis sativas* L.) Treated with Ionizing, Non-ionizing Radiations and their Combined Treatments

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ABSTRACT— ***Postharvest loss of fresh produces is one of the major concerns in many countries, specially where climate is hot and humid. Ionizing radiation is used as phytosanitary treatment (PI) for many fresh produces. However, some variety of fresh produces can not tolerate high ionizing radiation dose which is required for PI treatment. We evaluated the possibility of using non-ionizing radiation alone or in combination with ionizing radiation for fresh cucumbers to minimize post-harvest loss. Gamma radiation of 100 Gy, Microwaves generated from 180 watt for 10 seconds, and their combined effects on cucumbers were analyzed. External colour, firmness and percent storage loss of treated cucumbers were compared with untreated control group. External colour analysis of L*a*b* parameters showed a gradual increase of L* (lightness) and b* (blue to yellow) with the storage time. We did not observe any significant changes of L* and b* values between the treated and untreated cucumbers. However, values of a* (green to red) were changed significantly (p=0.0001). During the 15-day storage period we did not observe any significant differences of firmness of cucumber among the treated and untreated ones. At the end of the 15-day storage period, the cumilitive percent losses of treated and untreated cucumbers were 13.3% (combined ionizing and non-ionizing radiation), 16.6 % (only ionizing radiation), 20.0 % (only non-ionizing radiation) and 30.0 % (no treatment).***

Keywords— Cucumber (*Cucumis sativus* L.), Gamma Radiation, Ionizing, Non-Ionizing, Microwave Energy, Quality.

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1. INTRODUCTION

The external appearance of Cucumber (*Cucumis sativus* L.*)* such as colour and texture are the major important attributes of quality that determine consumer preference and purchasing decision. Low temperature effect like 3°C and safe storage temperature like 12°, 20° and 25°C on various enzymes of stored cucumber was reported (Van Dijk *et al.*2006). Combination of hot water and radiation treatment was also applied on tomato to control fungal decay (Barkai-Golan *et al.* 1993). Ionizing radiation is an economically viable technology for reducing post harvest losses and extending shelf-life of perishable commodities and maintaining hygienic quality of fresh produce (Mitcham, 1999; Boylston *et al*., 2002; Cheour and Mahjoub, 2003; Gonzalaz-Aguilar *et al*.,2004). According to Naqvi, (2005) about 20-30% post harvest losses of cucumber fruits are observed every year in Bangladesh which creates considerable gap between the gross production and net availability. In 1987, the Food and Drug Administration (FDA) approved use of irradiation up to 1000 Gy for fresh commodities (Paull and Armmstrong, 1994).

The cucumber (*Cucumis sativus* L.*)* is a widely cultivated plant belonging to the family cucurbitaceae. It is usually grown throughout the tropical and subtropical countries. World's cucumber production is over 40,000 tonnes, China being the leading producer (FAO, 2005). Cucumber having a short storage life, about 10 to 14 (2 to 3 weeks) days at 10-12°C and 80% RH (Snowdon, 1990). It is harvested at immature stage having extremely high metabolic activity (Kader, 1983). The temperature effect is directly related to effect on lowering fruit respiration, ethylene production and metabolism in general (Hardenburg RE, 1986).

Heat treatments e.g. hot water dip, vapor heat, hot dry air or combinations of these have been increasingly used as quarantine treatment in several studies to retard post-harvest fungal damage to fruits and vegetables (Mansur, FE., 2006). Vapor heat was developed to kill insect eggs and larvae specially as a quarantine treatment (Le TN., 2010) but hot water has been used for both fungal and insect control. According to Bard and Kaiser (1996) the heat treatment in a selected fruit have been disinfesting of fungal and bacterial rots; desensitizing fruit to chilling injury; reducing incidence of post-harvest physiological disorders; decreasing rate of ripening and prolonging the shelf life. However, only few studies had been conducted on the effect of non-ionizing radiation to fresh produces. Microwave energy may provide an alternative non-chemical quarantine treatment against colding moth in export cherries (Ikediala JN., *et al*. 1999). Giese, J. 1992, reported on the advancement of microwave for food processing. Halverson, SL., *et al*. 1996, Bedi, SS., and Singh, M. 1992 reported that microwave and high-power microwave radiation act as an alternative insect control method for stored products. The quality standards of fresh cucumber in EU include, for example, minimum requirements of sound, intact fruit, in fresh appearance and firmness, and a classification of fruit in to three classes depending on fruit shape, defects in colouration, etc. (Commission Regulation 1677/88). Skin colour is a harvest index also used as the best quality index in cucumber (Gnanasekharan *et al*. 1992; Schouten *et al*., 1997, 2002).

The aim of this work was to determine whether the combination of both ionizing and non-ionizing radiation could be used to reduce the post-harvest loss when stored at 25°C.

2. MATERIALS AND METHODS

2.1 Cucumber collection and storage

Locally available variety of Hybrid cucumber, (*Cucumis sativus* L.*)* was collected from local farmers at the day of harvest. After collection, cucumbers were washed with normal water and wiped with soft clean cloth and then packaged in perforated polythene bag each with 10 cucumbers. A total of such 12 bags were prepared among which six bags were used for ionizing gamma irradiation and three bags for non-ionizing radiation generated from microwave and three bags for unirradiated (control) cucumbers.

2.2 Storage conditions

All the treated and untreated fresh cucumbers were stored at 25°C and 80-90% RH during the entire period of experiments. Cucumber used for treatments were selected by uniform size and free from any blemishes, physical damage and fungal decay.

2.3 Ionizing Irradiation Treatment

Cucumbers were irradiated using gamma-rays emitted from Co^{60} irradiator at dose of 100 gray (Gy) on the following day of collection at the Institute of Food and Radiation Biology, Atomic Energy Research Establishment , Savar, Dhaka, Bangladesh.

2.4 Non-ionizing irradiation Treatment

Non-ionizing irradiation Treatment: Microwave generated non-ionizing radiations generated from 180 watt for 10 seconds were applied to each fresh cucubmer individually.

2.5 Quality analyses

All the treated and untreated cucumbers were subjected to analyses of external colour, firmness and storage loss for the period of 15-day. Data were recorded 5 times during the storage period. First data were recorded immediately after the treatments and 2^{nd}, 3^{rd}, 4^{th} and 5^{th} data were recorded at 5^{th}, 9^{th}, 12^{th} and 15^{th} day of post-treatments. The data on colour and firmness were generated from 30 (10 from each replica) cucumbers from each experimental condition respectively. Therefore, in total 120 cucumbers for colour and firmness were used. During each measurement only the edible quality of cucumbers were used while non-edible fruits (cucumbers with black spot/mold/damaged etc.) were discarded for further analysis.

2.6 Colour analysis

External colour measurements of cucumbers were made using a chroma meter (Cr-410, Konica Minolta, Sensing Inc., Japan). A standard white reference tile was used for calibration. Readings were taken at four different points externally. Colour measurements were recorded as $L*$, $a*$ and $b*$ ($L*$ = lightness, $a*$ = ranging from green to red and $b*$ = ranging from blue to yellow).

2.7 Firmness analysis

A fruit texture analyzer (GS-20, Serial No. 2003-FTA-109, version 6.63) was used to measure the whole fruit firmness of each cucumber at four different positions.

2.8 Data analysis

All data obtained was subjected to analysis of Variance (ANOVA) using Minitab statistical software 13.20.

3. RESULTS AND DISCUSSION

3.1 Effect of ionizing, non-ionizing and combined treatment on the external colour of fresh cucumber

Different parameters of colour i.e. L* (lightness), a* (green to red) and b* (blue to yellow) of external surface of treated and untreated cucumbers were recorded and analyzed (Table 1) . Both L* and b* values were found to increase with the storage time. No significant changes of L* and b* values were recorded among treated and untreated fresh cucumbers. However, significant changes (p=0.0001) of the values of a* were recorded.

Table 1: Changes of External Colour of treated and untreated cucumbers during 15-day storage period.

Dose (Gy/MW)	1st days of treatment			5th days of treatment			9th days of treatment			12th days of treatment			15th days of treatment		
	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*
0	48.15	-14.54	27.80	50.88	-14.55	30.85	56.65	-13.02	35.44	59.59	-12.57	38.67	64.33	-10.23	43
180MW	47.31	-14.03	26.32	51.44	-14.18	30.61	57.29	-12.50	36.33	61.42	-11.12	41.99	63.84	-9.48	44.19
100Gy	50.46	-14.45	30.65	56.35	-13.87	34.61	62.09	-11.58	41.25	65.79	-8.72	43.71	68.64	-5.80	46.74
100Gy +180MW	52.11	-14.45	29.53	56.56	-14.00	34.31	62.74	-10.90	40.59	65.58	-8.45	42.89	68.26	-6.30	45.19

L*=lightness (white L=100 to black L=0)
a*=ranging from red (+) to green (-), positive a is red and negative is green
b*= yellow (+) to blue (-); positive b is yellow and negative b is blue
Individual values are means of chromameter measurements of 22 to 30 cucumbers (4 observations/cucumber).

In tomatoes, similar pattern of colour changes were reported which was suggested that this change of colour spectrum was related with their ripening (Alba *et al*., 2000). Increasing fruit temperature from 21°C to 26°C may enhance red fruit and chlorophyll degradation in off-vine fruits (Gautier *et al.*, 2008). Studies on the microwave-treated cherries showed comparable colour properties of control fruits (Ikediala *et al.*, 1999). However, L* and a* values of Hunterlab parameters were increased significantly to microwave-treated cherries with storage time. On the otherhand, it appeared that the microwave treatments gave lower stem a* (greenness) values as storage period increased (Ikediala *et al.*, 1999). The authors also expressed that the stem dryness may be occurred due to the use of hot air during their microwave treatment procedures.

Our experimental results indicated that either ionizing or non-ionizing or a combination of these two types of radiation has no significant effect on fresh cucumbers which were stored for 15 days at 25°C.

3.2 Effect of ionizing, non-ionizing and combined treatment on the firmness of fresh cucumber

Firmness is one of the criteria of fruit quality determined by different researchers and is one of the components of texture which is a complex sensory attribute that also included crispiness and juiciness (Konopacka, D. 2003). The firmness of all the treated and untreated cucumbers was found to increase initially (Figure 1). However, gradually the fireneness of cucumbers were decreased with storage time and reached to a close level that we observed on the first day of storage.

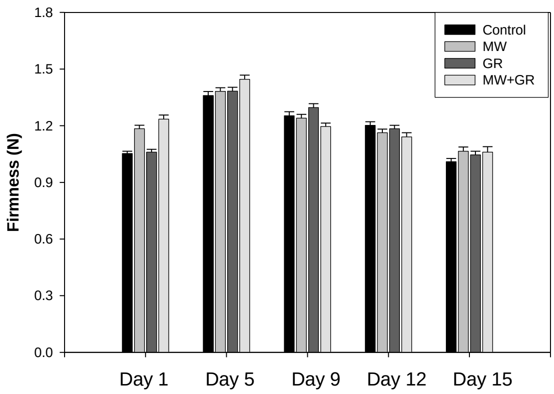

Fig.1. Firmness of treated and untreated cucumbers during the 15-day storage period

Irradiation has an immediate effects of decreasing firmness in vegetables (Glegg *et al*., 1956) including cucumber the softening of which is typically evident within hours following treatment, even for mature green fruit (Ahmed et al. 1972; Bramlage and Lipton 1965). However, firmness of diced cucumber does not decrease with storage time (Prakash et al., 2002). According to Ikediala *et al.* (1999) chrrry fruit firmness after microwave treatment apparently was either higher or similar to that of the control samples. In our experiment, regardless of the treatment, the firmness of all the groups was increased upto 5 days. Our this observation may be related to the maturity stage of cucumbers rather than the effects of irradiation or other treatments.

Storage loss of irradiated and unirradiated cucumber

When no treatment was applied to cucumbers, a total cumilitive loss of 30% was recorded during the storage period of 15 days. While the total cumilitive loss of cucumbers treated with non-ionizing radiation, ionizing radiation and combination of both ionizing and non-ionizing radiations were 20, 16.66 and 13.33 % respectively (Fig.2).

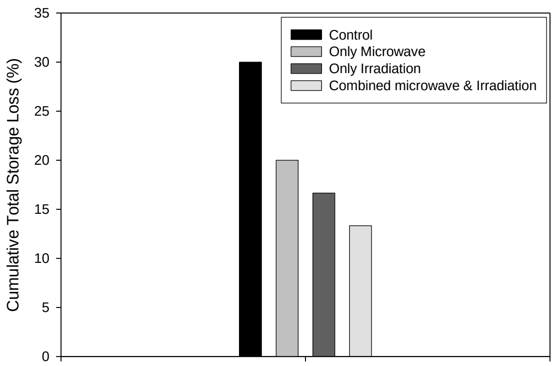

Fig. 2. Total cumulativepercent loss of treated and untreated cucumbers during the 15-day storage period

The treatments like gamma radiaion, microwave treatment or their combination treatments have beneficial effect in reducing the storage loss of cucumbers when kept at 25°C for the period of 15 days. Irradiation treatment extends the shelf life of minimally processed cabbage, cucumber and bitter gourd (Khattak, A. B. *et al.* 2005, Khattak, M. K.. *et al.* 2005 and Kader, A A., 1986, 2002). Prakash *et al.* 2000 also reported that low dose gamma irradiation increased shelf life of diced celery. Being a perishable produce, the loss of cucumber during storage was brought to only 13.3 % when both ionizing and non-ionizing radiations were applied in this present study.

4. CONCLUSION

Some studies showed that microwave generated non-ionizing radiation could be used to retain the quality of fresh produce (Ikediala et al. 1999) and also this technique could be used against stored product pests (Steven et al. 1996). This study also showed that microwave-generated non-ionizing radiation along with gamma ionizing radiation both could be used combinedly to retain the quality of fresh cucumbers and also to reduce the storage loss to a minimum level if stored at 25°C for the period of 15 days. Hence, this combined approach may reduce the gamma radiation dose. However, further detail studies would be required with commercial microwave generator.

5. REFERENCES

1. Ahmed, E. M., Fluck, E. C. and Dennison, R. A. 1972. Textural properties of irradiated tomatoes. J. Tex. Stud., 3: 115-121.
2. Alba, R., Cordonnier-Pratt, M. M. and Pratt, L. H. 2000. Fruit-Localized phytochromes regulate lycopene accumulation independently of ethylene production in tomato. Plant Physiol., 123: 363-370.
3. Barkai-Golan, R., Padova, R., Ross, I., Lapidot M., Davidson, H. and Copel, A.1993. Combined hot water and radiation treatments to control decay of tomato fruits. Ientia Hort., 56(2):101-105. doi:10.1016/0304-4238(93)90011-E
4. Bard, Z. J. and Kaiser, C.1996. Post-harvest vapor heat shock treatments of fuerte avocado fruit. South African Growers' Assoc. Yearbook 19: 116-118.
5. Bedi, S. S. and Singh, M. 1992. Microwaves for control of stored grain insects. Nat. Acad. Sci. Lett. 15 (6):195-197.
6. Boylston, T. D., C. A. Reitmeier, J. H. Moy, G. A. Mosher, and L. Taladriz, 2002. Sensory quality and nutrient composition of three Hawaiian fruits treated by X-irradiation. J. Food Qual., 25(5): 419-433.
7. Bramlage, W. J. and Lipton, W. J. 1965. Gamma radiation of vegetables to extend market life. Mktg. Research Report. 703, USDA,Washington, D.C.
8. Cheour, F. and Mahjoub, A. 2003. Delayed ripening and senescence of strawberry (Fragaria ananassa Duch.) by irradiation with gamma rays. Sci. des Alim., 23(3):355-366.
9. Commission Regulation (EEC), 1988. Laying down quality standards for cucumbers number 1677/88. Official Journal L 150, 16/06/1988:21-25.http://europa.eu.int./eur-lex/lex/LexUriServe.do?uri=CELEX:31988R1677:EN:HTML
10. Drake, S. R., Moffitt, H. R. and Kupferman, E. M. 1991. Quality characteristics of 'Bing' and 'Rainer' sweet cherries treated with gibberellic acid, following fumigation with methyl bromide. J. Food Qual. 14:119-125.
11. Food and Agriculture Organization of the United Nations. 2005. Production quantity (1000 tonnes)/ cucumbers and gherkins. Retrieved from http://faostat.fao.org/site/336/DesktopDefault.aspx?PageID=336
12. Gautier, H., Diakou-Verdin, V., Benard, C., Reich, M.and Buret, M. *et al.* 2008. How does tomato quality (sugar, acid and nutritional quality) vary with ripening stage, temperature and irradiance? J. Agric. Food Chem., 56: 1241-1250.
13. Giese, J. 1992. Advances in microwave food processing. Food Technol. 46: 118-123.
14. Glegg. R.E., Boyle, F.P., Tuttle, L.W., Wilson D. E. and Kertesz, Z. I. 1956. Effect of ionizing radiations on plant tissues. I. Quantitative measurements of the softening of apples, beets and carrots. Radiation Res., 5: 127-133.
15. Gnanasekharan, V., Shewfelt, R.L., Chinnan, M.S., 1992. detection of color in green vegetables. J. Food Sci. 57, 149-154.
16. Gonzalez-Aguilar, G., Wang, C.Y. and Buta, G.J. 2004. UV-C irradiation reduces breakdown and chilling injury of peaches during cold storage. J. Sci. Food Agric, 84(5): 415-422.
17. Halverson, S. L., Burkholder, W. E., bigelow, T. S., Nordheim, E. V., Misenheimer, M. E. 1996. High-power microwave radiation as an alternative insect control method for stored products. J. Econ. Entomol. 89: 1638-1648.
18. Hardenburg, R. E., A. E. Watada and C. Y. Wang, 1986. The commercial storage of Fruits, Vegetables and Florist and Nursery stocks. United States Department of Agriculture, Agricultural Research Service. Agricultural Handbook. Pp:66.
19. Ikediala, J. N., Tang J., Neven, L. G. and Drake, S. R. 1999. Quarentine treatment of cherries using 915 MHz microwaves: temperature mapping, colding moth mortality and fruit quality. Post. Biol. and Technol. 16: 127-137.
20. Kader, A. A 1983. Post harvest quality maintenance of fruits and vegetables in developing countries. In: Lieberman M, eds. Post harvest physiology and crop preservation. Plenum Press, London, England, 455-470. http://dx.doi.org/10.1007/978-1-4757-0094-7_21.
21. Kader, A. A., 1986. Potential application of ionizing radiation in postharvest handling of fresh fruits and vegetables. Food Technol.,40(6): 117-121.
22. Kader, A. A., 2002. Postharvest Biology and Technology: An Overview In: Postharvest Technology of Horticultural Crops, Kader, A. A.(Ed.), University of California Agriculture and Natural Resources Publication, California, USA., pp:39-47.
23. Khattak, A. B., Bibi, N., Chaudry, M. A. Khan, M., Khan, M. and Qureshi, M. J. 2005. Shelf life extension of minimally processed cabbage and cucumber through gamma irradiation. J. Food Protec. 68:105-110.
24. Khattak, M. K. Bibi, N., Khattak, A. B. and Chaudry, M. A. 2005. . Effect of irradiation on microbial safety and nutritional quality of minimally processed bitter gourd (Momordica charantia). J. Food Science. 70:M255-M259.
25. Konopacka, D. and Plocharski, W. J. 2003. Effect of storage conditions on the relationship between apple firmness and texture acceptability. Postharv. Biol. Technol. 32: 205-211.
26. Le, T. N., Shiesh, C. C. and Lin, H. L. 2010. Effect of vapor heat and hot water treatments on disease incidence and quality of Taiwan native strain mango fruits. Int. J. agric. Biol., 12:673-678.

27. Mansour, F. E., Abd-El-Aziz , S. A. and Helal, C. A. 2006. Effect of fruit heat treatment in three mango varieties on incidence of post harvest fungal disease. J. Plant Pathol., 88: 141-148.
28. Mitcham, B., 1999**.** Irradiation as a Quarantine Treatment. Perishables Handling Quarterly (99): 19-21.
29. Naqvi, M. H., 2005. Management and quality assurance of fruits and vegetables for export-needs for product to market approach, In *Use of irradiation for quarantine treatmentr of fresh fruits and vegetables*. Proceedings of the first national seminar held at atomic energy centre, Dhaka, Bangladesh, 19 Sep., 2005.
30. Paull, R. E. and Armstrong, J. W. 1994. Introduction. In: Insect pests and fresh horticultural products: treatments and responses, Paul, R.E. and J. W. Armstrong, (eds.).CAB International, Wallingford, UK, pp: 1-33.
31. Prakash, A., Inthajak, P., Huibregtse, H., Caporaso, F. & Foley, D. M., 2000. Effects of low-dose gamma irradiation and conventional treatments on shelf life quality characteristics of diced celery. Journal Food Science. 65:1070-1075.
32. Prakash, A., Manley, J., Decosta, S., Caporaso, F. and Foley, D. 2002. The effects of gamma irradiation on the microbiological, physical and sensory qualities of diced tomatoes. Radiation Phys. Chem., 63(3-6): 387-390.
33. Schouten, R. E., Otma, E. C., van Kooten, O., Tijskens, L. M. M., 1997. Keeping quality of cucumber fruits predicted by biological age. Postharvest Biol. Technol. 12:175-181.
34. Schouten, R. E., Tijskens, L. M. M., van Kooten, O., 2002. Predicting keeping quality of batches of cucumber fruit based on a physiological mechanism. Postharvest Biol. Technol. 26:209-220.
35. Snowdon, A. L.1990. A colour atlas of post harvest diseases and disorders of fruits and vegetables. Volume 2: Vegetables. Wolfe Scientific Ltd. Barcelona, Spain, 12-15.
36. Steven, L. Halverson, Wendell, E. Burkholder, Timothy, S. Bigelow, Erik, V., nordheim and Misenheimer, M. E. 1996. High power microwave radiation as an alternative insect control method for stored products. 89(6): 1638-1648.
37. Van Dijk, C., C. Boeriu, Stolle-Smits, T. and Tijskens, L. M. M. 2006. The firmness of stored tomatoes (cv. Tradiro). 2. Kinetic and Near Infrared models to describe pectin degrading enzymes and firmness loss. J. Food Eng., 77: 585–593. doi:10.1016/j.jfoodeng.2005.07.017.