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EFFECT OF IONIZING RADIATION ON THE TEXTURE OF MINIMALLY PROCESSED APPLES FOR A FRUIT SALAD

Adriana D. T. Fabbri[1]*, Juliana M. A.Sagretti[1], Vladimir D. Rogovschi[1], Thaise C. F. Nunes[1], Susy F. Sabato[1]

[1]Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP - Brazil
*adrianafabbri@usp.br

ABSTRACT

Brazil is the third largest producer of fruits (43 million tons), being preceded only by China (175 million tons) and India (57 million tons). Regular consumption of fruit is associated with a better quality of life and is pointedly recommended by their high fiber content, water, vitamins and organic salts, as well as being tasty and quick digestion. Currently, the fresh market has grown significantly, especially the segment washed, peeled, cut or sliced, raw packaged and stored under refrigeration, known as minimally processed and / or ready for consumption. Apples in addition to several important nutritional characteristics are widely consumed fresh and are used as important components of desserts in Brazil, for example, fruit salads. Considering the many benefits demonstrated by the application of food irradiation, the purpose of this study was to evaluate the texture of minimally processed apples submitted to doses of 0.25, 0.5, 0.75, 1.0 and 2.0 kGy in multipurpose irradiator located at IPEN / CNEN-SP during the 10 days after irradiation. The results indicated that radiation was beneficial for all treatments and that the presented statistical differences were more due to the intrinsic factors of the fruit, than the day or dose. These results were evaluated using Statistica 8.0, by tukey's test and two-way ANOVA.

1. INTRODUCTION

Currently, the fresh market has grown significantly, especially if the product segment washed, peeled, cut or sliced, raw packaged and stored under refrigeration, known as minimally processed or ready for consumption [1] [2] [3].

The consumer demand for minimally processed products is increasing due to the nature of product quality, convenience and fresh as feature [4].

In addition to several important nutritional characteristics, fresh apples are widely consumed and used as important components of desserts in Brazil, for example, fruit salads. However, some changes occur in the physiological deterioration especially minimally processed due to injury in tissues, often reducing the retention period. These injuries result from handling and processing, such as mechanical damage, which promote increased contact between enzymes and substrates, inducing undesirable enzymatic reactions, loss of ions and other cellular compounds and moisture loss [5].

Low temperatures minimize the effects of mechanical injuries because they are able to reduce enzymatic activity, metabolic reactions, and microbial growth [6].

Coupled with cooling, irradiation has been shown to be an important part in supporting the increased shelf-life and in maintaining the quality of minimally processed. By correlating studies in a recent review [3], the authors found that irradiation has proved extremely beneficial by increasing the shelf life of fruits and vegetables, three to five times more than conventional ones.

Therefore, the objective of this study was to evaluate the texture of minimally processed apples subjected to different doses of gamma radiation kept under refrigeration during the period of 10 days.

2. MATERIALS AND METHODS

2.1. Materials

Apples belonging to the cultivar 'Gala' were used. The apples were purchased in a market of São Paulo, at the same point of ripeness and sent to the IPEN / CNEN-SP.

2.2. Sampling

Apples selected were manually cut into cubes of approximately 2 x 2 cm with the aid of stainless steel knives and packed in polyethylene bags, one for each day of analysis.

2.3. Irradiation

The minimally processed apples (MPA) were irradiated in a Multipurpose Gamma Source (IPEN, São Paulo – Brazil) and were divided in six groups (treatments): Control; dose 0.25 kGy; dose 0.5 kGy; dose 0.75 kGy; dose 1.0 kGy and dose 2.0 kGy. Gammachrome YR Bath 530 nm dosimeters were used for the measurement of radiation dose.

2.4. Storage and measurements

After the treatment, the MPA were kept in a refrigerator at 4°C ± 1ºC until the end of the analysis [7]. The texture was analyzed in the following days after irradiation: 0, 2, 4, 6, 8 and 10.

2.5. Texture Analyses

Texture measurements were made at Stable Micro Systems texture analyzer, model TA-TX Plus, equipped with a 50 kg load cell with 2 mm cylindrical probe to determine the resistance of the fruit in relation to the force applied by the device. Thus was set in a square base of support equipment, to allow the positioning of the cube of apple. In carrying out penetration tests, the probe was moved toward the support, from top to bottom at a speed of 1.0 mm/s to 10 mm after the break. Analyzes were performed in triplicate and the unit used to measure force was the Newton (N). The results were evaluated using Statistica 8.0, by tukey's test and two-way ANOVA.

3. RESULTS AND DISCUSSION

The MPA had firmer texture at day zero immediately after irradiation to a dose of 0.25 kGy and less firm for the group of 1.0 kGy, as shown in Table 1. On the fourth day, the MPA had higher firmness for samples of the Control group and for the 0.25 kGy group.
The quality of fresh-cut fruits depends directly on the quality of the raw material and other factors related to processing, storage, and distribution [8]. These factors include the condition of the raw materials such as firmness, size, variety, and ripeness at processing. These significantly affect the shelf life and quality of produce [6].

Table 1. Results to maxim force on texture of minimally processed apples.

	Control	0.25 kGy	0.5 kGy	0.75 kGy	1.0 kGy	2.0 kGy
Day 0	2.16 ± 0.21^{a}	3.58 ± 0.65^{b}	2.82 ± 0.66^{a}	1.87 ± 0.17^{a}	1.69 ± 0.16^{c}	2.05 ± 0.25^{a}
Day 2	2.40 ± 0.10^{a}	2.30 ± 0.87^{a}	2.52 ± 1.03^{a}	2.30 ± 0.37^{a}	2.76 ± 0.66^{a}	1.65 ± 0.25^{a}
Day 4	3.72 ± 0.20^{b}	3.43 ± 1.00^{ab}	1.93 ± 0.24^{a}	1.78 ± 0.29^{a}	1.70 ± 0.16^{a}	1.80 ± 0.36^{a}
Day 6	2.96 ± 0.31^{a}	2.13 ± 0.93^{a}	2.45 ± 0.68^{a}	3.05 ± 0.09^{ab}	1.82 ± 0.26^{a}	2.06 ± 0.31^{a}
Day 8	2.39 ± 0.35^{a}	2.05 ± 0.25^{a}	2.77 ± 0.46^{a}	2.21 ± 0.50^{a}	2.34 ± 0.67^{a}	1.66 ± 0.09^{c}
Day 10	1.96 ± 0.17^{a}	2.44 ± 0.38^{a}	2.36 ± 0.60^{a}	1.94 ± 0.12^{a}	2.54 ± 0.29^{a}	1.66 ± 0.10^{c}

Averages followed by the same letter on the line or column do not differ by Tukey test at 5% level of significance.

Over the days we observed a decrease in the texture of the control samples, and a better texture for groups 0.25 kGy, 0.5 kGy and 1.0 kGy. However the sample of 2.0 kGy, had less rigid texture from the eighth day, as shown in Fig.1.

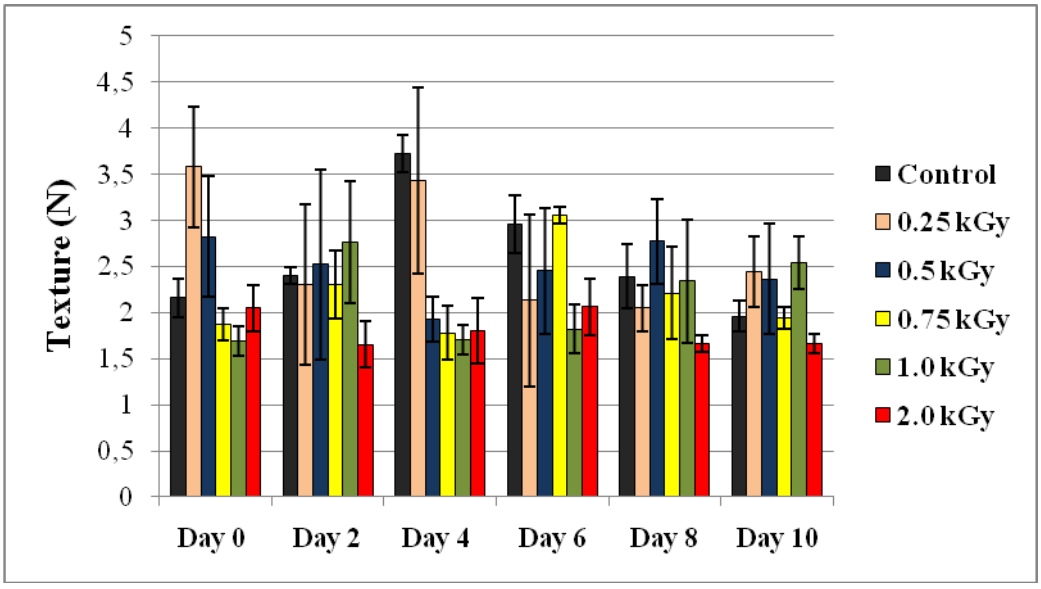

Figure 1. Values of texture for minimally processed apples subjected to different doses of gamma radiation: Control, 0.25kGy, 0.5 kGy, 0.75 kGy, 1.0 kGy and 2.0 kGy.

In a study of mango fruits irradiated at 1.0 kGy had lower firmness [12]. The limiting factors in irradiation of horticultural products are sensorial changes, particularly softening of fruit and vegetable tissue [9]. Therefore, doses higher than 1–2 kGy are not feasible for these practical reasons. Low-dose irradiation may be implemented as a terminal, postpackaging treatment for fruit juices, fruit salads, etc [6]. Irradiation of fresh and minimally processed fruits, vegetables, and juices has been discussed recently in detail by [10] The FAO/IAEA Joint Division runs presently a coordinated research program on the use of irradiation to ensure hygienic quality of fresh, precut fruits and vegetables, and other minimally processed food of plant origin [11].

Some browning was observed after the processing of apples. This darkening occurred in all samples including the control, not being attributed to irradiation, but due to contact with oxygen. This darkening was noted in other studies after the first day of processing [7] and also according to storage time [5].

Several oscillations occurred in the measurements of each treatment. This could be attributed to the intrinsic characteristics of the fruit. Factors controlling the shelf life of minimally processed (MP) fruits are a result of a complex process concerning a number of physico-chemical and biochemical modifications that mainly affect flavour, colour and texture [13].

In a research with sliced apples, higher doses to 0.34 kGy statistically reduced the firmness of the apples. This fact was justified by the authors for a possible association of irradiation with the increase in water soluble pectin and decreased oxalate-soluble pectin content [4].

Irradiation stimulated respiration, but inhibited ethylene production in apple slices from different cultivars [14]. Investigation of the influence of irradiation on the texture of cut processed apples is needed for determining the feasibility of using this technology on minimally processed apples [6].

In this study ‘Gala’ apples were used which had a high respiratory rate, high ethylene production and rapid loss of firmness [15]. Such information enables correlate that irradiation was effective to maintain the quality of the apple during the 10 days, especially the doses of 0.25, 0.5 and 1.0 kGy. The dose of 2.0 kGy caused softening of texture on the termination of analysis.

3. CONCLUSIONS

Minimally processed apples submitted to six different treatments, showed better results than the control. Groups 0.25, 0.5 and 1.0 kGy kept the texture over the 10 days of analysis. Thus, irradiation is indicated for minimally processed apples since properly packaged refrigerated, suggesting its use in fresh ready meals such as the fruit salad.

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REFERENCES

1. S.A.G. Berbari, J.E. Paschoalino, N.F.A. Silveira. "Efeito do cloro na água de lavagem para desinfecção de alface minimamente processada". *Ciência e Tecnologia de Alimentos*, Campinas, maio/ago.,Vol. 21, n.2, pp. 197-201 (2001).

2. N.M. de S. Pinheiro, E.A.T. de Figueiredo, R.W. de Figueiredo, G.A. Maia, P.H.M. de Souza. "Avaliação da qualidade microbiológica de frutos minimamente processados comercializados em supermercados de Fortaleza". *Revista Brasileira de Fruticultura*, Jaboticabal-SP, abr., Vol. 27, n. 1, pp. 153-156 (2005).

3. I.S. Arvanitoyannis, A.C. Strakos, P. Tsarouhas. "Irradiation applications in vegetables and fruits: a review". *Critical Reviews in Food Science and Nutrition*, **Vol. 49**, pp.427-462 (2009).

4. G. Gunes, J.H. Hotchkiss, C.B. Watkins. "Effects of gamma irradiation on the texture of minimally processed apple slices". *J Food Sci.*, **Vol. 66**, No. 1, (2001).

5. L.C.B. Fontes, S.B.S. Sarmento, M.H.F. Spotp, C.T.S Dias. "Conservação de maçã minimamente processada com o uso de películas comestíveis". *Ciência e Tecnologia de Alimentos*, Campinas, out.-dez., Vol.28, pp. 872-880 (2008).

6. Y.H. Hui. *Handbook of Fruits and Fruit Processing*, Blackwell Publishing, 1ed. (2006).

7. E. Cocci, P. Rocculi, S. Romani, M.D. Rosa. "Changes in nutritional properties of minimally processed apples during storage". *Postharvest Biology and Technology* **Vol. 39**, pp. 265-271 (2006).

8. J.R. Gorny, B. Hess-Pierce, A.A. Kader. "Effects of fruit ripeness and storage temperature on the deterioration rate of fresh-cut peach and nectarine slices". *Hortscience*. **Vol. 33**, pp. 110–113 (1998).

9. L. Yu, C.A. Reitmeier, M.H. Lore. "Strawberry texture and pectin content as affected by electron beam irradiation". *J Food Sci*. **Vol. 61**, pp. 844–846 (1996).

10. B.A. Niemira. "Irradiation of fresh and minimally processed fruits, vegetables and juices". *Microbial Safety of Minimally Processed Foods*, Ed. Novak, J.S., Sapers, G.M. and Juneja, V.K. pp. 279–299 (2003).

11. Food and Agriculture Organization and International Atomic Energy Agency (FAO/IAEA). *The Co-ordinated Research Programme on Use of Irradiation to Ensure Hygienic Quality of Fresh, Pre-cut Fruits and Vegetables and Other Minimally Processed*

Food of Plant Origin. Report of First FAO/IAEA Research Co-ordination Meeting, 5–9 November, Rio de Janeiro, Brasil. D6-RC-844; 319-D6-10-22. Vienna, International Atomic Energy Agency, (2001).

12. S.F. Sabato, J.M. Silva, J.N. Cruz, S. Salmieri, P.R. Rela, M. Lacroix. "Study of physical–chemical and sensorial properties of irradiated Tommy Atkins mangoes (Mangifera indica L.) in an international consignment". *Food Control*, Vol. 20, pp. 284–288 (2009).

13. F. Mencarelli, R. Massantini. "Imballaggio funzionale per una migliore qualit_a degli alimenti confezionati". *Quality aspects of minimally processing fruits*. Flair-Flow Europe:CNR Raisa, pp. 225-230 (1994).

14. G. Gunes, C.B. Watkins, J.H. Hotchikiss. "Effects of irradiation on respiration and ethylene production of apple slices". *J Sci. Food Agric* **Vol. 80,** pp.1169-1175 (2000).

15. A. Brackmann, R.F.H. Giehl, S.T. Freitas, A.M. Mello, R.B.O Antes. "O resfriamento rápido e a rápida instalação da atmosfera controlada como substituto do 1-MCP no armazenamento de maçãs Gala". *Rev. Bras. Frutic*., Jaboticabal – SP, Vol. 27, pp.379-382 (2005).