

## STABILITY OF VITAMIN E CONTENT OF $\gamma$ -IRRADIATED BISCUITS

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### ABSTRACT

The technology of food irradiation is seen by the industry as a means of ensuring food safety, since it exposes foods to ionizing radiation that kills insects, moulds and bacteria. The need to eliminate bacterial pathogens from read-to-eat food products must always be balanced with the maintenance of product quality. In addition to determining the effective ionizing radiation doses required for pathogen elimination the effects of irradiation on product chemistry, nutritional value and quality must also been determined. Vitamin E ( $\alpha$ -tocopherol) is one of the most potent natural lipophilic antioxidants commonly present in the human diet. As it is considered a free radical scavenger there is a growing concern that irradiation might reduce the vitamin E content of food products prepared with ingredients rich in any of the dietary source of the vitamin. This work describes the effects of ionizing radiation on the vitamin E content of some biscuits commercially found in the market. Three lots of biscuits were used. Irradiation was performed in a <sup>60</sup>Co Gammacell 220 source, dose rate of about 3.5kGy/h at doses of 1kGy and 3kGy. For vitamin E determination samples were saponified with ethanolic potassium hydroxide in the presence of pyrogallol, and the tocopherols were extracted with petroleum ether. The absorbance was measured at 520 nm. From the obtained results it is possible to conclude that there was a notorious stability of the vitamin content of the biscuits submitted to  $\gamma$ -irradiation at the assayed doses.

### 1. INTRODUCTION

Vitamin E (a family of eight natural structurally related tocopherols and tocotrienols compounds expressed as  $\alpha$ -tocopherol) represents an essential component in human nutrition required for the preservation of lipids in stable form in biological systems and also in foods [1]. In commonly consumed foods vitamin E appears among the main antioxidants together with vitamins A and C and minerals like copper, zinc and selenium [2]. Antioxidants neutralize free radicals formed in the normal process of oxidation in the human body [3]. Although the body can cope with some free radicals and needs them to function properly, an overload of them has been linked to the variety of chronic degenerative diseases. Then, a diet rich in antioxidants has an important role in the prevention of diseases related to oxidative stress.

Increased dietary vitamin E had been shown to reduce serum lipid peroxides [4]. A diet rich in foods containing vitamin E may help to protect against Alzheimer's disease, cancer and coronary heart disease [5][6][7].

The sources of vitamin E in the diet are oils (soybean, corn, linseed, cotton, rapeseed, palm, sesame, wheat-germ, peanut, sunflower, olive), margarines (corn, soybean, sunflower), seeds (sesame, sunflower), nuts (almonds pecan, peanuts, Brazil) and cereal grains (corn, rice) [1].

The possibility of using gamma irradiation to improve the microbiological quality of different foods has been studied and is presently applied commercially in USA and France among other countries. The need to eliminate bacterial pathogens from read-to-eat food products must always be balanced with the maintenance of product quality. In addition to determining the effective ionizing radiation doses required for pathogen elimination the effects of irradiation on product chemistry, nutritional value and organoleptic quality must also be determined [8].

The role of reactive oxygen species in ionizing radiation injury and the potential of antioxidants to reduce these deleterious effects have been studied for several decades. Naturally occurring antioxidants are considered able to behave as radioprotectors [9]. Radiation protecting properties of vitamin E has been described [10] [11]. The study of the effects of vitamin E on the formation of final products of radiation-induced free-radicals transformation has shown that the vitamins were able to either oxidize  $\alpha$ -hydroxyl-containing radicals yielding the respective carbonyl or reduce them to the initial molecules [12]. On the other hand, irradiation of turkey meat where the birds were fed diets enriched with vitamin E shown that the antimicrobial effectiveness of ionizing radiation was not affected [13].

In this work data on the effects of ionizing radiation on the vitamin E content of some biscuits commercially found in the market are reported.

## 2. MATERIAL AND METHODS

### 2.1 Material

Biscuits -weighing 40g each- commercially found in the market in 200g pouches, containing the following ingredients (as described by the producer) were employed: whole grain wheat flour, raw sugar, sunflower, maize oil, wheat flour enriched with iron and folic acid, maize starch, honey, barley malt, cinnamon, carnation powder, salt, chemical baking substances (sodium bicarbonate, ammonium bicarbonate and sodium acid pyrophosphate), soy lecithin, flavoring and citric acid. Three different lots of biscuits were used, kept at a refrigerator (4-7°C) before and after irradiation.

### 2.2 Irradiation

Irradiation was performed in a  $^{60}\text{Co}$  Gammacell 220 (AECL) source, dose rate about 3.5kGy/h at doses of 1kGy and 3kGy, dose uniformity factor, 1.13. Dosimetric mapping was previously performed by Fricke dosimetry.

### 2.3 Vitamin E measurement

For vitamin E (as  $\alpha$ -tocopherol) determination a method based on colorimetric measurements [14] was chosen as recommended in the literature [15][16]. The method employed consists of

a saponification step applied to 2-g samples with ethanolic potassium in the presence of pyrogalic acid, followed by a petroleum ether extraction. The extracts were thoroughly washed with water. Absorbance measurements were made at 520nm and a previously prepared calibration curve was used.

### 3. RESULTS AND DISCUSSION

The Table 1 shows the results of vitamin E content determination of the non irradiated biscuits (0kGy) and irradiated with 1 and 3 kGy for the three different lots employed.

**Table 1. Vitamin E content of irradiated biscuits with 0, 1 and 3kGy, means (X) and standard deviations (sd), and % of activity retention for the 3 lots employed.**

| Sample              | Vitamin E content (mg/100g) |       |            |       |            |
|---------------------|-----------------------------|-------|------------|-------|------------|
|                     | 0kGy                        | 1kGy  | %Retention | 3kGy  | %Retention |
| 1 <sup>st</sup> lot |                             |       |            |       |            |
| 1                   | 10.25                       | 11.38 |            | 10.45 |            |
| 2                   | 11.48                       | 12.33 |            | 10.98 |            |
| 3                   | 10.95                       | 11.83 |            | 11.35 |            |
| X                   | 10.89                       | 11.84 | 108.72     | 10.93 | 100.31     |
| s.d.                | 0.61                        | 0.48  |            | 0.45  |            |
| 2 <sup>nd</sup> lot |                             |       |            |       |            |
| 4                   | 8.80                        | 8.88  |            | 8.80  |            |
| 5                   | 8.78                        | 8.80  |            | 8.78  |            |
| 6                   | 9.43                        | 9.65  |            | 9.45  |            |
| X                   | 9.00                        | 9.11  | 101.20     | 9.01  | 100.09     |
| s.d.                | 0.37                        | 0.47  |            | 0.38  |            |
| 3 <sup>th</sup> lot |                             |       |            |       |            |
| 7                   | 7.40                        | 7.40  |            | 7.38  |            |
| 8                   | 7.93                        | 7.93  |            | 8.13  |            |
| 9                   | 9.15                        | 9.13  |            | 9.15  |            |
| X                   | 8.16                        | 8.15  | 99.90      | 8.22  | 100.72     |
| s.d.                | 0.90                        | 0.88  |            | 0.89  |            |

From the analysis of the present results there was no loss of  $\alpha$ -tocopherol content in the biscuits as a result of gamma irradiation.

Vitamin E is known as the most radiation-sensitive of the fat-soluble vitamins. Even though and since the main sources of this vitamin are oils and dairy products, none of which suitable for irradiation on account of their sensitivity to off-flavor development, some effects on that kind of food would be of no nutritional relevance [17].

Diverse authors had studied radiation effects on vitamin E containing foods. They found different results according to the system assayed, the water activity and the radiation conditions. Fresh skinless turkey breasts packaged in air or nitrogen gas were either irradiated (2.4 to 2.9 kGy) or not and stored at 2° C. Samples of raw and cooked turkey were evaluated by a descriptive panel. Irradiation affected color, odor, flavor, and levels of  $\alpha$ -tocopherol by 33% [18].

Treatment of minced pork with a dose of 50kGy in the presence of air at ambient temperature destroyed  $\alpha$ -tocopherol completely. When irradiation was carried out at 0°C the loss was 75%, and at 30°C it was 55% [19]. In another work, after irradiation of sunflower oil no significant difference was found on vitamin E degradation in air and in nitrogen at different dose rates [20]. Irradiating  $\alpha$ -tocopherol in the presence of air at 10, 50, or 100kGy produced a 51%, 78%, or 95% loss of tocopherol activity, respectively. The loss of tocopherol in oatmeal steadily increased as the irradiation temperature increased from 7% at 18°C to 46% at 50°C [21].

Other authors found that the vitamin E content of wheat decreased by irradiation at ambient temperature in the presence of air. Oats that were packaged, irradiated at 1kGy, and stored for 8 months under nitrogen lost only 5% of their tocopherol content compared with a 56% loss in oats irradiated and stored in air. The irradiation of hazel nuts at 1kGy produced an 18% loss of  $\alpha$ -tocopherol, while baking produced a 13% loss [21].

#### 4. CONCLUSIONS

From the obtained results it is possible to conclude that there was a notorious stability of the vitamin content of the biscuits submitted to gamma-irradiation at the assayed doses. A sensory analysis will be required in order to recommend the application of the radiation technique for microbiological assurance to this kind of vitamin E containing product.

#### REFERENCES

1. Wagner, K.H.; Eldin, A.K.; Ibrahim, E. Gamma-tocopherol – An Underestimated Vitamin?. *Nutrition & Metabolism*, v. **48**, p. 169-188, 2004.
2. Wu, X.; Beecher, G.R.; Holden, J.M.; Haytowitz, D.; Gebhardt, S.E; Prior, R.L. Lipophilic and hydrophilic antioxidant capacities of common foods in the United States. *J. Agric. Food Chem.*, v. **52**, p. 4026-4037, 2004.
3. IOM-Institute of Medicine. *Dri. Dietary references intakes for vitamin C, vitamin E, Selenium and carotenoids*. Washington, D.C: Academy Press, 2000, p. 186-283.
4. Avula, C.P.R.; Fernandes, G. Effect of dietary vitamin E on apoptosis and proliferation of murine splenocytes. *Nutrition Research*, v. **20**, n. 2, p. 225-236, 2000.
5. National Institutes of Health. Diet rich in foods with vitamin E may reduce Alzheimer's Disease Risk. NIH News Release, n. 301, p. 496-1752, 2002. <http://www.nia.nih.gov>.
6. Ferreira, PR.; Fleck, J.F.; Diehl, A.; Barletta, A.; Ilha, L. Protective effect of alpha-tocopherol in head and neck cancer radiation-induced mucositis: A double-blind randomized trial. *Head and Neck J. Sc. Special Head and Neck*. v. **26**, n. 4, p. 313-321, 2004.

7. Maguire, L.S.; O`sullivan, M.; Galvin, K.; O`connor, T.P.; O`brien, N. M. Fatty acid profile, tocopherol, squalene and phytosterol content of walnuts ,almonds, hazelnuts and the macadamia nut. *Int. J. Food Sci. Nutrit.*, v. **55**, n. 3, p. 171-178, 2004
8. Sommers, C.; Fan, X.T.; Niemira, B; Rajkowski, K. Irradiation of ready-to-eat foods at USDA Eastern Regional Research Center-2003 update. *Radiation Physics and Chemistry*, v. **71**, n. 1-2, p. 511-514, 2004.
9. Weiss, J.F.; Landauer, M.R. Radioprotection by antioxidants. *React Oxyg. Species: Radiat. Mol Biol.* v. **899**, p. 44-60, 2000.
10. Kammerer, C.; Czernak, I.; Getoff, N. Radiation protecting properties of vitamin E- acetate and beta-carotene. *Radiation Physics and Chemistry*, v. **60**, n. 1-2, p. 71-72, 2001.
11. Manzi, F.R.; Boscolo, F.N.; Almeida, S.M.D. *et al.* Morphological study of the radioprotective effect of vitamin E (dl-alpha-tocopherol) in tissue reparation in rats. *Radiol. Bras.*, v. **36**, n. 6, p. 367-371, 2003.
12. Shadyro, O.I.; Sosnovskaya, A.A.; Edimecheva, I.P. *et al.* Effects of various vitamins and coenzymes Q on reactions involving  $\alpha$ -hydroxil-containing radicals. *Free Radical Research*, v. **39**, n. 7, p. 713-718, 2005.
13. Romero, M.G.; Mendonça, A.F. Influence of dietary vitamin E on behavior of *Listeria monocytogenes* and color in ground turkey meat following electron beam irradiation. *J. Food Protection*, v. **68**, n. 6, p. 1159-1164, 2005.
14. Instituto Adolfo Lutz. *Normas analíticas do Instituto Adolfo Lutz. Métodos químicos e físicos para análise de alimentos*. IV ed. São Paulo: IAL,2005, p.645-682.
15. Deustsh, M.J. *Vitamins and Other Nutrients*. In: Cuniff, P., ed. Official Methods of Analysis of International AOAC. 16. Ed. Arlington, VA: AOAC International, 1995. cap.45.
16. Amin, A.S. Colorimetric determination of tocopheryl acetate (vitamin E) in pure form and . in multivitamin capsules. *Eur. J. Pharm. Biopharm.*,v. **51**, n. 3, p. 267-222, 2001.
17. Kilcast, D. Effect of Irradiation on vitamins. *Food Chem.*, v. **49**, p.157-164, 1994.
18. Bagorogoza, K.;Bowers, J.;Okot-Kotber, M. The effect of irradiation and modified atmosphere packaging on the quality of intact chill-stored turkey breast. *J.Food Sci.* v. **66**, n. 2, p. 367-372, 2001.
19. Diehl, J.F. *Safety of irradiated foods*. New York, N.Y: Marcel Dekker,1990, p. 95-199.
20. Singh.H. *Dose rate effect in food irradiation: A review. L' Effect debit de dose en irradiation des aliments: Un examen*. Pinawa, Manitona: Whistshell Laboratories, Aug. 1991. (AECL-10343).
21. Thayer, D.W.; Fox, J.B.;Lakritz. L. *Effect of Ionizing Radiation on vitamins*. In: THORNE, S. Food irradiation. London: 1991, p. 286-314.