

Vitamin E content and sensory qualities of γ -irradiated sunflower whole grain cookies

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Abstract. The sources of vitamin E in the diet are oils, margarines, seeds, nuts and cereal grains. Industrialized sunflower whole grain cookies were treated with gamma irradiation and evaluated for changes in vitamin E content and sensory properties. Radiation doses were 0.0, 1.0 and 3.0 kGy, the dose rate was 3.5 kGy/h. Irradiation at 1 and 3 kGy resulted in no changes in vitamin E content measured as α -tocopherol equivalents by a colorimetric measurement based method. A sensory panel composed of 22 trained members found that irradiation even at 1 kGy induced certain small, but statistically significant differences in sensory characteristics for appearance, aroma, texture and flavor attributes. From the obtained results, it is possible to conclude that there was a notorious stability of the vitamin content of the product submitted to γ -irradiation at the assayed doses. Meanwhile, irradiation at room temperature of this ready to eat food item caused small but statistically significant effects on sensory (marketing) attributes.

Key words: ionization radiation • cookies • vitamin E • sensory evaluation

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Introduction

Bakery and intermediate moisture food products like breads, dried fruit, cereals, cookies and crackers can benefit from irradiation processing. However, irradiated lipid rich products must be assayed carefully in terms of safety, nutrition and acceptability. Bread types enriched with combinations of whole oil seeds are being readily accepted by consumers the importance of combinations being related to their high content of polyunsaturated fatty acids, vegetal protein, phosphorus, iron, magnesium, vitamin E, niacin, folate and phytoestrogens [24].

The possibility of using gamma irradiation to improve the microbiological and fungal quality of different foods has been studied and is at present applied commercially in the USA and France among other countries. The need to eliminate undesired pathogens from food products must always be balanced with the maintenance of product quality. In many cases, food irradiation is limited due to fatty acid decomposition and subsequent off-flavor formation in the foodstuff [4]. Then, in addition to determining the effective ionizing radiation doses required for a proposed objective, the effects of irradiation on product chemistry, nutritional value and sensory quality must also be determined.

Vitamin E (a family of eight natural structurally related tocopherols and tocotrienols, compounds expressed as α -tocopherol) represents an essential component in human nutrition required for the preservation

of lipids in stable form in biological systems and also in foods. In commonly consumed foods vitamin E appears among the main antioxidants together with vitamins A and C and minerals like copper, zinc and selenium [28]. Antioxidants neutralize free radicals formed in the normal process of oxidation in the human body. 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. In general, lipid peroxidation markers are elevated during vitamin E depletion [9]. A diet rich in foods containing vitamin E may help to protect against Alzheimer's disease, cancer and coronary heart disease [18].

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) [8, 20, 26].

Most individuals are believed to obtain sufficient vitamin E from dietary sources, although individuals with very low-fat diets or intestinal malabsorption disorders may require supplementation. The Brazilian Agency for Sanitary Surveillance [2] (ANVISA, 2005) consider 10 mg as the Recommended Daily Allowance (RDI) for adults for vitamin E provided in Alpha-Tocopherol Equivalents (ATE) to account for the different biological activities of the various forms of vitamin E. On the other hand, the USA RDI for men or women older than 14 years is 15 mg (or 22.5 IU, where 1 mg ATE = 1.5 IU); for pregnant women of any age is 15 mg (or 22.5 IU); and for breastfeeding women of any age is 19 mg (or 28.5 IU) [9].

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 like vitamin E are considered able to behave as radioprotectors [11, 15, 16, 27]. A 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 α -hydroxyl-containing radicals yielding the respective carbonyl or reduce them to the initial molecules [21].

Sensory analysis must be used in order to assess sensory attributes in foods that were subjected to irradiation processes. The Multiple Comparison or Control Difference test is often used for checking significant differences among samples, which were subjected to different treatments when compared to a pattern or control [17]. Each panelist is required to taste test-samples and to compare them against a control that is codified too, by using an appropriate scale to evaluate the degree of difference. Obtained results can be assessed via Variance Analysis (ANOVA) and the Dunnett mean test.

Whole grain cereals are related to gut health [14]. Sunflower seed oil ranks among the best vegetable oils, typically up to 90% of their fatty acids are unsaturated and more than 90% of their vitamin E family of com-

pounds is α -tocopherol [23]. In this work data on the effects of ionizing radiation on the vitamin E content of sunflower whole grain cookies commercially found at the Brazilian market are reported as well as the sensory evaluation of the irradiated samples about appearance, odor, texture and flavor.

Material and methods

Material

Industrialized sunflower whole grain ring cookies found at the market in 200 g pouches were employed. Three different lots of biscuits were used, kept at a refrigerator (4–7°C) before and after irradiation.

Irradiation

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

Vitamin E measurement

For vitamin E (as α -tocopherol) determination, a method based on colorimetric measurements [10] was chosen as recommended in the literature [1, 5]. The method consists of a saponification step applied to 2 g samples with ethanol potassium hydroxide in the presence of pyrogallol acid, followed by a petroleum ether extraction. The extracts were thoroughly washed with water. Absorbance measurements were made at 520 nm and a previously prepared calibration curve was used.

Sensory evaluation

Analytical sensory testing was performed by 22 qualified panelists using Multiple Comparison test or Control Difference [3], which evaluated irradiated samples, comparing them to the non-irradiated control, by dimensioning the difference degree in global terms as per sensory attributes of appearance, aroma, texture and flavor, within a 9 score category (from 1 = none difference, to 9 = extreme difference from "C" control). Cookies appearance was assessed in white china plates, glass-covered, under white artificial illumination. Other attributes were evaluated in a climate-controlled individual cabinet illuminated with red artificial light. Samples were shown simultaneously and codified with random three-digit numerical figures, including the own codified control. The panelists were trained and orientated in the correct use of scale and instructed to rinse the mouth with water, in order to remove residues among samples. The experimental outlining employed was the balanced complete blocks, with data obtained after subjection to variance analysis, ANOVA, and mean comparisons by the Dunnett test, at error 5%.

Table 1. Effects of irradiation on the vitamin E content of sunflower whole grain cookies. Means \pm standard deviations and % of activity retention

Sample	Vitamin E (mg/100 g)				
	0 kGy	1 kGy	% Retention	3 kGy	% Retention
1st lot	10.89 \pm 0.61	11.84 \pm 0.48	108.72	10.93 \pm 0.45	100.31
2nd lot	9.00 \pm 0.37	9.11 \pm 0.47	101.20	9.01 \pm 0.38	100.09
3rd lot	8.16 \pm 0.90	8.15 \pm 0.88	99.90	8.22 \pm 0.89	100.72

Table 2. Effects of irradiation on sensory attributes of sunflower cookies. Means \pm error deviations and the least significant difference (LSD)

Sensory attribute	Irradiation dose			
	0 kGy	1 kGy	3 kGy	LSD
Appearance	1.17 ^b \pm 0.06	1.67 ^a \pm 0.10	1.68 ^a \pm 0.11	0.20
Texture	1.23 ^b \pm 0.06	1.67 ^a \pm 0.11	1.89 ^a \pm 0.12	0.24
Odor	1.27 ^b \pm 0.08	2.53 ^a \pm 0.18	3.65 ^a \pm 0.19	0.40
Flavor	1.38 ^b \pm 0.09	2.45 ^a \pm 0.19	3.82 ^a \pm 0.23	0.45

n = 66 assessments (triplicate).

Means within a row with common superscript no differ ($p < 0.05$).

Results and discussion

Table 1 shows the results of vitamin E content determination in irradiated industrialized sunflower whole grain cookies for the 3 different lots of samples, non-irradiated and irradiated with 1 and 3 kGy. The total amount of tocopherol expressed as α -tocopherol was found to be above 10 mg/100 g for all samples. As can be seen, there was no loss of vitamin content as result of gamma irradiation with neither 1 nor 3 kGy.

Some authors reported also that no significant differences were observed in α -tocopherol loss from the irradiation with different dose rate of pure sunflower oil at a total dose of 1 kGy [22]. Studies on the E vitamin content in foods emphasize the vast differences of bioactivities of individual E vitamin confirming the need for analyses of food consumed in specific study populations [7]. Also, there are substantial differences in calculated/measured vitamin E content of foods, explained by intrinsic variability (breeding, season, country of origin, ripeness, freshness), and should be taken into account when interpreting data of dietary intervention studies [25].

In Table 2 are displayed the results for the multiple comparison test or control difference of whole grain cookies treated with two different radiation doses, in global terms for sensory attributes of appearance, texture, odor and flavor, in comparison to a non-irradiated control sample.

In the present study vitamin E known as the most radiation-sensitive of the fat-soluble vitamins [13] retained their activity when submitted to 1 and 3 kGy doses of ^{60}Co gamma irradiation. Nevertheless, doses of 1 and 3 kGy of ^{60}Co gamma irradiation caused dose dependant differences for sensory characteristics related to the appearance, texture, odor and flavor, whose values were considered significantly different ($p < 0.05$). Each one of the attributes had different appreciation. Appearance and texture, for instance, ranked as "none difference" (up to 2) for the 1 kGy sample, within a 9 score scale. In the meantime, the attribute odor and flavor fostered a "slight difference" as ranked 3–4 in that scale.

Other authors had also studied radiation effects on vitamin E containing foods. They found different results according to the system assayed, water activity and radiation conditions [13, 19]. Recent evidences from the literature indicate that oxidative stability of oils depends mainly on their degree of unsaturation [12]. The food material used in the present work, i.e., sunflower whole grain cookies containing sunflower seed, known as very rich in unsaturated fatty acids that could be responsible for the radiation stability of this antioxidant vitamin. Nevertheless, it was not enough to prevent sensory changes.

The American Food and Drugs Administration (1997) considered a dose between 0.2 and 0.5 kGy as effective in eliminating spoilage fungus from, for instance, wheat flour and wheat. Maintaining the irradiation doses below 1 kGy could be the best way to treat this kind of food without detrimental radiation effects [6].

Conclusions

Irradiated industrialized sunflower whole grain cookies with doses of 1 and 3 kGy maintained their original vitamin E content, showing a good radioresistance. However, doses of 1 and 3 kGy of ^{60}Co gamma irradiation caused statistically significant differences in the sensory characteristics related to the appearance, texture, odor and flavor, whose values were considered significantly different. A sensory analysis will be always required in order to recommend the application of the radiation technique for microbiological or fungal assurance to any kind of vitamin E containing product.

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