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# Effects of gamma irradiation on chemical and sensory characteristics of natural hazelnut kernels

Saadet Koç Güler[a,*], Saim Zeki Bostan[a], Ahmet Hilmi Çon[b]

[a] Ordu University, Faculty of Agriculture Department of Horticulture, Ordu Turkey
[b] Ondokuz Mayıs University, Faculty of Engineering, Department of Food Engineering, Samsun Turkey

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ABSTRACT

In present study, natural hazelnut kernels were treated with, 0.5, 1 and 1.5 kGy of gamma irradiation. The irradiated and untreated hazelnuts were stored at 20 ± 0.5 °C and 55–60% relative humidity for 18 m. After irradiation, 0.5, 1 and 1.5 kGy doses of gamma irradiation significantly increased the total fat values ($p < 0.05$) and this value decreased during the storage. After treatment, free fatty acid values were similar in untreated and treated hazelnuts. After 6 m of storage, irradiated and untreated hazelnuts had less than 1% free fatty acid values. However, control and 1.5 kGy yielded higher than 1% free fatty acid after 9 m of storage. After irradiation, peroxide values increased proportionally to the dose but the increase was not significant. Peroxide values increased during the storage period ($p < 0.05$). Control and 0.5 kGy-treated hazelnuts had maximum peroxide values after 9 m of storage, while 1 kGy and 1.5 kGy-treated hazelnuts had maximum levels after 12 m of storage. Applied doses did not cause any significant changes in crude protein, water activity ($a_w$), crude cellulose and moisture content of hazelnut**s** ($p > 0.05$). Storage period significantly affected the water activity and crude cellulose ($p < 0.05$). Irradiation doses didn't affect the L*, a* and b* values ($p > 0.05$), but storage period significantly affected the color values ($p < 0.05$). At the end of storage period, L* and vitamin E values decreased proportionally to the dose.

The 0.5 kGy-treated hazelnuts had the lowest free fatty acid and peroxide values and such a case also reflected in sensory analyses. Furthermore, these hazelnuts had the highest vitamin E value after the control group. Application of 0.5 kGy gamma irradiation seems to be acceptable for natural hazelnut kernels, but food safety issues have to be evaluated in order to recommend its application as a useful conservation alternative.



## 1. Introduction

Turkey is the leading largest hazelnut producer of the world. Turkey alone produces more than three-quarters of the world total supply and around 70% of production is exported.

Hazelnut has significant contributions to human health, thus plays an important role in human nutrition. It is a good source of vitamin E (247 mg $kg^{-1}$) (a-Tocopherol 24.7 mg/100 g), protein (17–20%) (11.7–20.8%) and fats (55–65%) (56.07–68.52%). Of the fat, 74.2–82.8% is oleic acid (C18:1) (Köksal et al., 2006).

Many of the post-harvest fumigants currently in use such as ethylene dibromide, methyl bromide and ethylene oxide are either banned or to be phased out because of their adverse impact**s** on human health and environment (Al-Bachir, 2004).

The application of gamma irradiation seems to be a promising technology since it may achieve various effects (depending on the absorbed radiation dose) like reduced storage losses, extended shelf life and/or improved microbiological and parasitological safety of foods (Fernandes et al., 2011a). Food irradiation researches started at the beginning of 1900s (Farkas and Mohacsi-Farkas, 2011). Because of the unsuitable irradiation capacities for practical application**s** (Farkas and Mohacsi-Farkas, 2011), first half of the last century was called the age of inventors (Diehl, 2002). From the middle of the XXth century, systematic research efforts, national research programmes and international cooperations were developed (Farkas and Mohacsi-Farkas, 2011). The first international meeting, exclusively devoted to a discussion of wholesomeness data and legislative aspects of irradiated foods, was held in Brussels in October 1961. Based on scientific judgement provided by the Joint Expert Committee in 1980, as well as additional supportive evidence, the FAO/WHO Codex Alimentarius Commission was adopted in 1983. The Codex General Standard for

* Corresponding author.
*E-mail address:* saadet.koc@gmail.com (S. Koç Güler).

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Irradiated Foods limits the overall average dose to 10 kGy (Anonymous, 1999a). Irradiation has been approved in 40 countries for some 50 food products. Irradiated foods usually have a label or a sign indicating that they have been irradiated. This includes the internationally recognized symbol called the "radura" (Anonymous, 1999b).

There are many studies carried out on irradiation of foodstuffs (Pinela et al., 2016; Zhang et al., 2014; Galan et al., 2013), including nuts (Ma et al., 2013; Ozyardimci et al., 2006; Gecgel et al., 2011; Mexis and Kontominas, 2009a,b). The particular effect of irradiation on physicochemical and sensory characteristics of nuts depends on several factors including fruit species, irradiation dose and type of irradiation (gamma vs. e-beam) (Mexis and Kontominas, 2009a). Some studies showed that irradiation did not cause any significant changes in proximate composition of nuts (Al-Bachir, 2004; Fernandes et al., 2011b; Gölge and Ova, 2008; Lanza et al., 2013). In contrast, some others showed that irradiation caused significant changes in some properties of nuts (Bingol et al., 2011; Barreira et al., 2012, 2013; Mexis and Kontominas, 2009b).

Hazelnut irradiation was studied by Dogan et al. (2007), Ozyardimci et al. (2006) and Mexis and Kontominas (2009a). They investigated the effects of irradiation on tissues at the molecular level, on quality parameters and inhibition of some pests which are important for hazelnut storage. No research had been done on the effect of gamma irradiation on chemical and sensory parameters of natural hazelnut kernels during long-term storage. The objective of this study was to investigate the effects of different gamma radiation doses (0.5, 1 and 1.5 kGy) recommended in Food Irradiation Regulation on chemical and sensory properties of hazelnut kernels during 18 m of storage.

## 2. Material and methods

### 2.1. Preparation of natural hazelnut kernel samples

The natural hazelnut kernel samples (grown in Ordu province) were purchased from Gürsoy Tarımsal Ürünler Gıda Sanayi ve Ticaret A.Ş. Samples were packed (each package is 200 g) in vacuum polyethylene pouches (150 ±8 μm thick, oxygen permeability 0.029 $g/m^2$/day, water vapor permeability 5 $g/m^2$/day).

### 2.2. Irradiation of the natural hazelnut kernel samples

The packages were divided into four groups, one of which was chosen as a control. The others were irradiated at the GAMMAPAK Company, Çerkezköy, Tekirdağ, Turkey. The irradiation process of the samples was carried out in $^{60}$Co gamma irradiator (MS Nordion, Canada) at the average absorbed doses of 0.5, 1 and 1.5 kGy doses. The absorbed dose was monitored by a Horwell Amber Perpex dosimeter. Each treatment had three replicates. After treatment, untreated and irradiated samples were stored at 20 ± 0.5 °C and 55–60% relative humidity (RH) for 18 m. Samples were analyzed before irradiation and after irradiation and in months 3, 6, 9, 12, 15 and 18. All analyses were conducted in triplicate.

### 2.3. Chemical analyses

Total free fatty acids, total fat and protein values (Nx6.25) were determined using the AOAC Standard Method (Anonymous, 1990a), peroxide values were determined according to Official Methods and Recommended Practices of the American Oil Chemist's Society method (Anonymous, 1990b), TS 3075 method for moisture (Anonymous, 2001), water activity was determined according to Novasina aw Sprint TH 500 water activity analyzers' method (Anonymous, 2004). To determine free fatty acid, 2.5–5 g (m) oil was weighted in a glass vial and dissolved in 25–50 mL mixture of ethanol and diethyl ether (1/1, v/v) and 2–3 drops of phenolphthalein were titrated with NaOH (0.1 N) (V) until the pink color persisting for at least 10s. The free fatty acid was calculated by the formula: FFA (%) = (V/m)*28.2. Total fat was determined by extracting a known weight of sample (5 g) with *n*-hexane, using soxhlet apparatus. The protein content (Nx6.25) of the samples was estimated by the macro Kjeldahl method. To determine peroxide value, 2–2.5 g of oil was weighted in a glass vial and dissolved in 100 mL acetic acid/isooctane (3/2, v/v) and supplemented with 0.2 mL potassium iodide. Lingered in a dark place for 5 min and then 50 mL distillate water was added. After titration, the value acquired was expressed as% acid.

Vitamin E and crude cellulose analyses were carried out at TUBITAK MAM (The Scientific and Technological Research Council of Turkey-Marmara Research Center) according to HPLC-FLD all foods and Fibertech Device hand book methods (Anonymous, 2012), respectively.

### 2.4. Color

The color of the natural hazelnut kernels was measured using a Konika Minolta CR-400 Chroma Meter and expressed as color L* (lightness), a* (redness) and b* (yellowness) values (Dermirci Ercoşkun, 2009). The results reported (L*, a*, b*) were the average of ten measurements.

### 2.5. Sensory analysis

Hazelnut kernels were prepared for sensory assessments and placed in numerically coded plastic dishes. A sensory test, using a consumer panel composed of 8 members (mean age: 25), was employed to detect sensory differences between irradiated and untreated samples. Male to female ratio was 1:1. They were untrained panelists. Panelists were chosen using the following criteria: nonsmokers and consuming hazelnut regularly. Each member independently evaluated one piece for flavor, crispness and color on a 5-point scale (1—very bad, 2—bad, 3—acceptable, 4—good, 5—very good), for rancidity and off-odor on a 5 point scale (1—very good, 2—good, 3—acceptable, 4—bad, 5—very bad) according to Dermirci Ercoşkun (2009).

### 2.6. Statistical analysis

Measurements were obtained in triplicate. Anderson Darling test was applied to examine normality. Levene's test was used to investigate the homogeneity of variances. All data were analyzed on a significance level of 0.05 with Two-way ANOVA with the Tukey's honestly significant difference test. The sensory analysis scores were statistically analyzed according to Kruskal-Wallis with a Dunn's all pairwise test. These calculations were performed with the Minitab 17 statistical software for Windows.

## 3. Results and discussion

### 3.1. Total fat

Total fat values decreased at the end of storage ($p < 0.05$). However, total fat didn't decrease regularly during the storage period.

Differences between total fat values of treated samples were affected by irradiation doses and storage period. The dose*storage period interaction was found to be significant ($p < 0.05$). The highest total fat values were observed after irradiation (1 and 1.5 kGy), 3 m of storage (0.5 kGy) and 6 m of storage (control) (Table 1).