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Effect of gamma irradiation on the physicochemical properties and nutrient contents of peanut

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ABSTRACT

This study aims to assess the effect of gamma irradiation on the physicochemical properties and nutrient contents of two different peanut cultivars. The peanuts were treated with 0, 1, 3, 5, and 10 kGy gamma irradiation doses. The examined physicochemical properties were water activity, fatty acid value (FAV), peroxide value (PV), carbonyl value (CV), malondialdehyde (MDA) content, and lipase activity. The examined nutrient contents were moisture and ash contents, total sugar, protein and fat contents, fatty acid and amino acid composition. Results showed that high irradiation dose (10 kGy) significantly decreased the fat and protein contents and increased the water activity of peanut. However, the moisture and ash contents and total sugar were not affected by irradiation. The FAV, PV, CV, and MDA contents increased depending on the radiation dose. Fatty acid and amino acid composition changed when the irradiation dose increased. Sodium dodecyl sulfate polyacrylamide gel electrophoresis analysis revealed that irradiation did not modify the protein subunits but disrupted the disulfide bonds. Furthermore, lipase activity decreased with the increased irradiation dose. This phenomenon may positively affect peanut quality during storage.

1. Introduction

Peanut is an important source of oil and is consumed by many consumers worldwide because of its rich nutrient substance (fat, protein, unsaturated fatty acid, and amino acid). Peanuts easily oxidize and decompose due to its high fat content (50%) during storage and transportation; this phenomenon affects its nutritional value and agricultural importance (Ren et al., 2017). To maintain good peanut quality during storage, scholars have applied various preservation methods, such as controlling the storage environment, fumigating, irradiating, and surface coating. Irradiation is a non-thermal, environment-friendly and rapid technology that has become a popular pretreatment method in industrial production (El-Rawas et al., 2012).

Irradiation can be effective in postharvest pest control because of the gamma rays' ability to kill insects and inhibit mycotoxin biosynthesis. Exposure of peanut seeds to gamma irradiation significantly reduces surface microorganisms and microbial population to below the detection limits of 6 and 9 kGy, respectively (Albachir, 2016). Camargo, Gallo, and Shahidi (2015) reported that gamma irradiation decreased the yeast, mold, total coliform, and *Staphylococcus* contents of peanut skin. However, the free radical produced by irradiation may produce some molecular substances and influence the food quality. For example, Jittrepotch, Kongbangkerd, and Rojsuntornkitti (2010) reported that the peroxide value (PV), p-anisidine, and free fatty acid (FFA) of extracted peanut oil significantly increased after irradiation. Similar research on other types of nut reported that gamma irradiation did not significantly alter nut oil content but proportionally increased the fatty acid content and PV with the dose (Gecgel, Gumus, Tasan, Daglioglu, & Arici, 2011). Al-Bachir (2015) proved that gamma irradiation decreased the oleic acid content and increased the linoleic acid content of pistachio. On the contrary, some studies reported that irradiation did not influence food quality and nutrient content. Gölge and Ova (2008) reported that irradiation did not influence the nut's physical qualities, such as texture color and fatty acid content. According to Güler, Bostan, and Çon (2017), the FFA value in the untreated hazelnuts were comparable with that of the treated samples. The PV increased proportionally with the dose, but the difference was insignificant. The applied doses did not significantly modify the crude protein content, water activity, crude cellulose content, and moisture content of the hazelnuts.

Although substantial studies have reported the effect of irradiation on food, the results are unclear and contradictory. Information about the effect of irradiation on the amino acids, subunits, and disulfide bonds are scarce. These aspects are important to food's nutritional

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quality. Furthermore, irradiation undoubtedly kills most microorganisms in food; however, the enzyme passivation caused by irradiation is rarely mentioned and might play an important role in food preservation. This study aims to explore the effect of increasing gamma irradiation dose on the physicochemical properties and nutrient content of peanuts.

2. Materials and methods

2.1. Preparation of samples

Newly harvested peanuts YuHua-9326 (YH-9326) and YuHua-22 (YH-22) were purchased from Henan Academy of Agricultural Sciences, China. The samples were shelled and stored in −20 °C for further treatment.

2.2. Irradiation of samples

Irradiation was conducted at the Isotope Institute Co., Ltd., Henan Academy of Sciences. The peanut seeds were treated with Co-60 gamma-ray. The samples were exposed to irradiation with the total amount of radiation absorbed restricted to 1, 3, 5, and 10 kGy at room temperature. The samples were stored at −20 °C until analysis.

2.3. Determination of the proximate composition and water activity

Proximate analysis of the peanut moisture, ash, fat and protein contents were conducted using the method described by AOAC (1995). Total sugar was determined by measuring the absorbance at 620 nm with a spectrophotometer. Water activity was estimated by the Labmaster-aw water activity meter.

2.4. Lipid oxidation

2.4.1. Fatty acid value (FAV)

FAV of peanut was determined using titrimetric procedure described in AACC method (2000). The FAV was quantified in accordance with mg of NaOH required to neutralize the acid in 100 g of dried peanut sample.

2.4.2. Peroxide value (PV)

PV of peanut oil was measured using the method reported by Shantha and Decker (1994). In brief, 5 mL of a mixed solution of chloroform and methanol was used to dissolve the oil extract from peanut. This mixture was adequately blended with ferrous chloride solution and potassium thiocyanate solution and then incubated for 5 min at room temperature. Absorbance of the solution was measured at 500 nm.

2.4.3. Carbonyl value (CV)

CV was determined according to the method described in AOAC (1995).

2.4.4. Malondialdehyde (MDA) content

MDA content was determined by spectrophotometry (Fan & Thayer, 2002). The samples were mixed with 10% chloroacetic acid and centrifuged for 15 min (4000 r/min), and the supernatant obtained by centrifugation is the MDA extract of the peanut. The extract was mixed with 0.2% thiobarbital acid and reacted in a boiling bath. Absorbance was measured at 450, 500, and 600 nm.

2.5. Fatty acid composition

Fatty acid composition was determined by gas chromatography (GC) (Mexis & Kontominas, 2009b). Accurately weighted 0.1 g of peanut oil which was blended with sodium hydroxide and methanol, and then esterified drastically. The samples were placed in a 1.5 mL bottle and injected in the GC unit. During injection, the injector was operated in the split mode (1:2 split ratio) at a temperature of 330 °C.

2.6. Amino acid composition and content analysis

Amino acid composition and contents were analyzed according to the method reported by El-Rawas et al. (2012). Samples (50 mg) were subjected to acid hydrolysis with 6 mol/L HCL at 110 °C for 24 h. The hydrolysate was vacuum dried until waterless and then mixed with sodium citrate buffer.

2.7. Sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE)

The peanut protein was diluted with sample treatment buffer and heated in boiling water for 5 min (Maity et al., 2009). Two different experiments, namely, reductive and non-reductive SDS-PAGE, were conducted in this study. The only difference is whether or not reductant was added in the sample treatment buffer.

2.8. Lipase activity

Lipase activity was determined by spectrophotometry, and the experimental process was conducted in four steps, namely, substrate preparation, extraction of crude enzymes, reaction and identification (Cato, Halmos, & Small, 2010). The substrate was the mixture of olive oil and Tween-20 (w: w = 1:1). In extracting the crude lipase, the samples (5 g) were mixed with 3 mL of Tris-HCL (pH 7.5) and grinded with an ice bath until the mixture formed a homogenate. This homogenate was dissolved again (Tris-HCL, pH 7.5), vibrated (4 h), and centrifuged (9000 g, 20 min). Finally, the crude lipase solution was added to the substrate and reacted at 37 °C for 3 h. The reaction mixture was colored by developer, and the absorbance was measured at 715 nm.

2.9. Statistical analysis

Values were expressed as means ± standard deviations, and measurements were obtained in triplicate. Data were analyzed by ANOVA, and significant difference was determined at the $P < 0.05$ level for Duncan's multiple range test by using SPSS software (version 16.0).

3. Results and discussion

3.1. Moisture, ash content and total sugar

Peanut seeds of YH-9326 and YH-22 had moisture contents (%) of 3.65 ± 0.05 and 4.05 ± 0.09, ash contents (%) of 2.38 ± 0.01 and 2.54 ± 0.20, and total sugar (%) of 13.27 ± 0.51 and 14.04 ± 0.49, respectively. No significant differences ($P > 0.05$) were found after irradiation with 0–10 kGy doses.

3.2. Fat and protein contents

The fat and protein contents in peanut seeds are shown in Fig. 1. No significant differences ($P > 0.05$) in fat contents were observed during irradiation with 1, 3, and 5 kGy. However, the fat content was significantly reduced when the peanut seeds were irradiated at a high dose (10 kGy). A similar pattern for peanut protein content was noted. Irradiation with doses of 1, 3, and 5 kGy did not significantly ($P > 0.05$) influence the protein contents, whereas only the highest dose (10 kGy) caused a significant reduction.

3.3. Water activity

The water activity of the samples was increased significantly when