ELSEVIER

Food Chemistry 80 (2003) 159–163

Food Chemistry

www.elsevier.com/locate/foodchem

Compositional profiles of γ-irradiated cashew nuts

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Received 5 February 2002; received in revised form 22 May 2002; accepted 22 May 2002

Abstract

Cashew nuts, an important export item from India, contribute to about 7% of the national exchequer. Insect infestation of the cashew nut, leading to economic losses is a frequently encountered problem. The present work aims to combat this problem by using low dose γ-irradiation and evaluating the effect of such treatment on the physico-chemical properties of cashew nuts. Cashew nuts, irradiated at 0.25, 0.50, 0.75 and 1.00 kGy and stored under ambient conditions were analyzed periodically every 2 months for 6 months with respect to the changes in 10-kernel weights, colour characteristics and proximate composition. Visual inspection showed no insect infestation for six months, even at 0.25 kGy, while the control sample was totally infested. This was evident from the 10-kernel weights, which decreased gradually with time of storage. While an increase in yellowness of the cashew nuts was observed as a function of storage time and irradiation dose, no substantial changes in proximate composition between the samples or with storage time were observed. This study underlines the use of 0.25 kGy of irradiation for preservation of cashew nuts.
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Keywords: Cashew nut; Irradiation; Insect infestation; Proximate composition; Colour characteristics

1. Introduction

The cashew tree, *Anacardium occidentale* Linn, is susceptible to contamination by a wide variety of insects, fungi, bacteria and parasites. Over 100 insects and mites attack cashew. There are about 30 species of insects infesting cashew, such as *Ephestia* spp., *Tribolium* spp., *Carpophilus* spp., *Plodia interpunctella, Corcyra cephalonic, Oryzaephilus* spp., tea mosquito, flower thrips, stem and root borer, fruit and nut borer and Kolanut weevil and which are reported to cause around 30% loss to the yield (Anon, 1995; Narvaiz, Lescapo & Kairiyama, 1992; Tyman, 1980; Woodroof, 1967). These insects feed and multiply in the product from the time of primary storage until the product is consumed. To prevent insect infestation, chemical disinfestation methods such as insecticide spraying and fumigation with methyl bromide, are widely used (Brower & Tilton, 1972; Elvers, Hawkins, Ravenscroft, & Schulz, 1989a; ICGFI, 1995). Besides being toxic, these chemicals also accumulate in the food, and may be carcinogenic and deleterious to human life (Elvers, Hawkins, Ravenscroft, & Schulz, 1989b). An aeration period is required before the dried fruits can be brought to the market; in the process, the sensory quality may be impaired or insects may develop resistance. These drawbacks can be overcome by use of low dose irradiation (Switzer, 1985; Thomas, 1988).

Low dose irradiation has been shown to be useful in controlling insect infestation in many agricultural products, such as for fruits as apples, apricots, coconuts, figs, dates, pears, berries, mango, raisins, prunes, etc. (IAEA, 1990; Irradiation of food, Part XVII, 2001; Potter, 1978; Tilton & Burditt, 1983) for tree nuts such as peanuts, almonds (Gonzalez, 1975; IAEA, 1990; Narvaizet al., 1992) and walnuts (IAEA, 1990; Switzer, 1985), for onions, potatoes, rice, ginger and garlic (Irrariation of food Part XVII, 2001) and also for fish and pork meat for pasteurization (Potter, 1978). Low dose irradiation up to 1 kGy is being routinely used for control of insect infestation in stored cereals (Irradiation of food, Part XVII, 2001; Karel, 1975; Potter, 1978; Tilton & Burditt, 1983) inhibition of sprouting of potatoes, onions and carrots (Irradiation of food, Part XVII, 2001; Karel, 1975; Potter, 1978; Manay & Shadaksharaswamy,

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0308-8146/02/$ - see front matter © 2002 Elsevier Science Ltd. All rights reserved.
PII: S0308-8146(02)00248-0

2001), for delay of ripening and senescence and for retardation of development of pickled mushrooms (Manay & Shadaksharaswamy, 2001) and pasteurization of fresh fruits and vegetables (Karel, 1975). The "Code of Good Irradiation Practice for Insect Disinfestation of Dried Fruits and Tree Nuts" is applicable for cashew nuts, almonds and the like. In accordance to this Codex Standard, the ionizing radiation to be employed for such products is limited to gamma rays from the radionuclides ^{60}Co and ^{137}Cs, X-rays generated from machine sources operating $\leqslant 5$ MeV, and electrons generated from machine sources operating $\leqslant 10$ MeV (ICGF, 1995).

Irradiation of high lipid-containing materials could lead to lipid peroxidation and consequently to development of off-flavour and off-odour (Manay & Shadaksharaswamy, 2001; Narvaiz et al., 1992; Urbain, 1986) and in loss of natural antioxidants. Doses above 1.5 kGy have been found to increase fatty acids liberation in peanuts (Gonzalez, 1975). Hence, high dose irradiation is generally not carried out with lipid rich materials. The present work aims to study the effect of low dose (0.25–1.00 kGy) irradiation on the proximate constituents and colour changes in cashew nuts over a 6-month storage period. The nuts were also checked visually for insect infestation.

2. Materials and methods

2.1. Materials

Whole cashew nuts (commercial grade White Wholes W 320; specification laid down by Government of India under the Export Quality Control and Inspection Act, 1963, implemented by the Cashew Export Promotion Council of India, Cochin) (Woodroof, 1967) were procured from a local market of Mumbai city, India. Batches of 100 g each were packed into 60-gauge thick self-sealable low-density polyethylene (LDPE) bags. All samples were stored under ambient conditions (room temperature, 31–32 °C) during the study. All chemicals used for this work were of AR grade, and obtained from reliable sources in Mumbai.

2.2. Methods

2.2.1. Irradiation process

The cashew nuts, packed as above, were irradiated at 0.25, 0.50, 0.75 and 1.00 kGy using a ^{60}Co gamma source at the Food Technology Division of Bhabha Atomic Research Center, Mumbai. Fricke's Dosimeter was used for the measurement of the applied irradiation dose. The temperature and the dose rate for all samples were 30C and 55Gy/min, respectively.

2.2.2. 10-kernel weight and visual inspection of cashew nuts

From each 100 pack of cashews, 10 whole cashew kernels were randomly chosen and their weights taken. The weight of 10 such kernels together gave the 10-kernel weight. Five such sets were weighed and the mean was recorded. This was determined during the entire storage period to serve as an indicator of insect infestation, which would be apparent from the loss in weight. The packets were unsealed after varying storage periods and visually inspected for insect eggs.

2.2.3. Colour characterization of cashew nuts

Cashew nuts were ground using a mortar and pestle and used for the purpose. The Hunter Lab colorimeter (Hunter Lab, D25, A optical sensor, Model DP-9000, Virginia, USA) was first standardized in the range of black to white using standard black and white tiles. About 30 g of ground sample were placed in the sample cup and readings of '*L*', '*a*' and '*b*' were taken at four different positions of the sample cup by rotating through 90°. The average values of the four readings were taken. Chroma, total colour difference and hue angle of the irradiated samples were calculated with respect to the fresh, control sample of cashew nuts from the average '*L*', '*a*', '*b*' values. In the Hunter Lab scale, '*L*' is visual lightness in perceptibility units; positive '*a*' value indicates redness, and negative '*a*' value greenness. Positive '*b*' values indicate yellowness and negative '*b*' value blueness. Hue is given by the angle $\theta = \tan^{-1}(a/b)$, while the chroma or saturation is defined as $\sqrt{(\Delta a^2 + \Delta b^2)}$; where $\Delta a = a_{\text{standard}} - a_{\text{sample}}$ and $\Delta b = b_{\text{standard}} - \text{b}_{\text{sample}}$. The total colour difference (ΔE) between a sample and a standard in visual perceptibility units (NBS units) is given by $\sqrt{(\Delta L^2 + \Delta a^2 + \Delta b^2)}$. The following equations were used for calculation of chroma, intensity and hue angles (Ranganna, 1986):

$$\text{Hue} = \theta = \tan^{-1}(a/b) \quad (1)$$

$$\text{Chroma or saturation} = \sqrt{\left(\Delta a^2 + \Delta b^2\right)} \quad (2)$$

$$\text{Total colour difference} = \Delta E = \sqrt{\left(\Delta L^2 + \Delta a^2 + \Delta b^2\right)} \quad (3)$$

2.2.4. Proximate composition of cashew nuts

The proximate compositions of cashew nuts, with respect to the moisture, ash, protein, fat and carbohydrate were determined for both the non-irradiated and irradiated samples at intervals of 2-months, for 6 months, using standard procedures (AOAC, 1995; Pearson, 1976).

3. Results and discussion

3.1. 10-kernel weight of cashew nuts

The 10-kernel weights of the cashew nuts under study are recorded in Table 1. It can be seen that there is a

Table 1
10-grain weights (g) of whole cashew kernels as a function of time[a]

Irradiation dose (kGy)	Storage time (days)			
	0	60	120	180
0	14.40±0.87	14.19±0.57	13.45±0.67	12.75±0.40
0.25	15.22±0.79	14.61±0.98	14.48±0.78	13.93±0.54
0.50	15.30±0.39	14.56±0.51	14.32±0.65	13.92±0.46
0.75	15.08±0.64	14.60±0.6077	14.40±0.22	14.99±1.57
1.00	15.32±0.26	14.68±0.6234	14.65±0.32	14.43±0.39

[a] The results are expressed as mean±SD of five individual determinations ($n=5$).

progressive decrease in the weight of the cashew kernels as a result of insect infestation. This was also apparent from visual inspection. While control, unirradiated cashew kernels were heavily infested within 2 months, cashew kernels irradiated, even at 0.25 kGy, were free of insect infestation after 6 months of storage.

3.2. Colour characterization of cashew nuts

The values of chroma, total colour difference and hue angle for the control and for each irradiation dose of cashew nuts are shown in Fig. 1a–e as a function of storage time. It is seen that ΔE, with respect to the fresh, control sample, increased with storage time, whereas chroma and hue angle did not show any particular trend. The increase in ΔE can be considered as an indicator of storage time; i.e., there existed a perceptible difference in the yellow colour of the cashew nuts on storage with respect to the control sample (0 days, 0

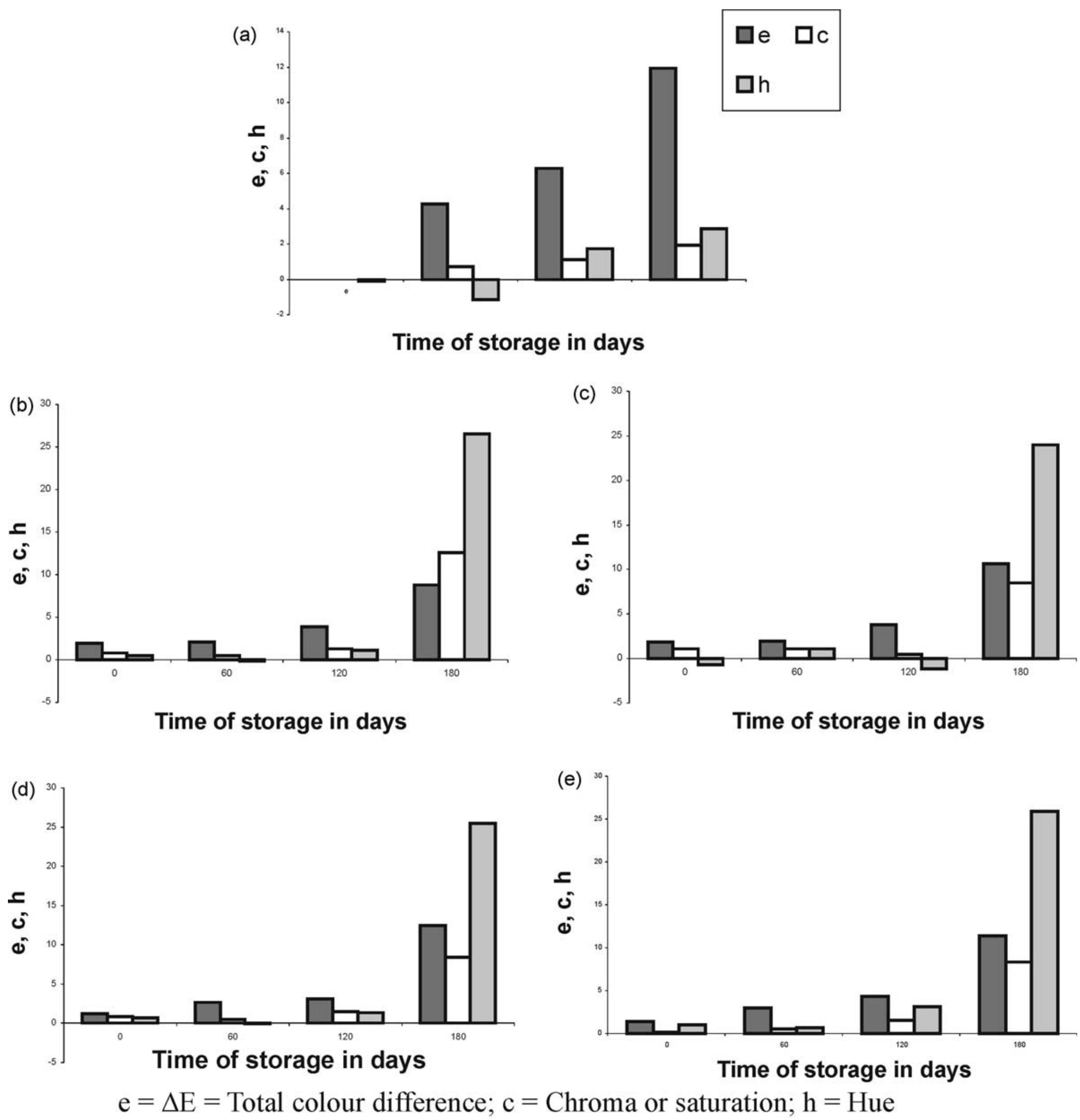

Fig. 1. Colour characterisation of cashew nuts (a) control, (b) irradiated to 0.25 kGy, (c) 0.50 kGy, (d) 0.75 kGy, (e) 1.00 kGy.

kGy). Glycosylamines and Amadori products are produced in heated, dehydrated and stored foods as a result of non-enzymatic browning reaction. These are degraded to deoxyosones which, as reactive α-dicarbonyl compounds, yield many secondary products that are very rapidly converted to coloured compounds of unknown structure (Belitz & Grosch, 1999b). Light induced fat oxidation and changes in protein cause sunlight flavour in milk, principally due to conversion of methionine to methional (Belitz & Grosch, 1999a). Cashew nuts contain around 1.3% methionine; hence the possibility of such a reaction cannot be ruled out. In cashew nuts with high lipid content, fats may undergo hydrolytic rancidity in the presence of natural lipolytic enzymes, which are not deactivated on low-dose irradiation, to produce free fatty acids. These fats and fatty acids can undergo autoxidation and may contribute carbonyl group for Maillard type reaction (Anglemier & Montgomery, 1975). Non-enzymatic lipid-protein interactions may cause browning too. It is also reported that some properties of proteins are changed through cross-linking when they react with hydroperoxides and their degradation products, which is manifested as browning (Anglemier & Montgomery, 1975; Belitz & Grosch, 1999c). All these reactions, in isolation or in combination, may have contributed to yellowing of cashew nuts on storage.

3.3. Proximate composition

Table 2 shows proximate composition of cashew nuts, unirradiated (control) and irradiated over a period of 6 months at intervals of 2 months. No substantial change in proximate constituents amongst the samples or during storage was observed. Though considerable changes in the 10-kernel weights and colours of the cashew nuts samples have occurred with storage, chemical analysis reveals practically no change between the samples. The values of proximate constituents present in the samples were almost in agreement with those reported by Tyman (1980). The samples under study recorded a lower moisture content of 4.5% as against 6%, and a slightly lower fat content of 45%, compared to 47% reported. This substantiates the wholesomeness of the samples taken for the study. No data are available on proximate constituents, as affected by irradiation and subsequent storage. For the control non-irradiated sample, there could have been changes in the protein content with insect infestation. However, insect infestation by itself does not cause a significant change in protein content at a level of infestation less than 75%, as has been reported for insect-infested wheat, maize and sorghum grains (Jood & Kapoor, 1993). The level of infestation for the cashew nut samples was too far below 75% to effect a change in the proximate constituents.

Table 2
Proximate composition of cashew nuts

Storage period (months)	Proximate constituents (%)																								
	Moisture at irradiation dose (kGy)					Ash at irradiation dose (kGy)					Protein at irradiation dose (kGy)					Fat at irradiation dose (kGy)					Carbohydrates (by difference) at irradiation dose (kGy)				
	0	0.25	0.50	0.75	1.00	0	0.25	0.50	0.75	1.00	0	0.25	0.50	0.75	1.00	0	0.25	0.50	0.75	1.00	0	0.25	0.50	0.75	1.00
0	4.58	4.52	4.53	4.61	4.59	2.33	2.36	2.40	2.37	2.34	19.96	20.0	19.8	19.8	19.7	45.72	45.71	45.84	45.39	45.73	22.6	22.7	22.6	23.10	22.9
2	4.99	4.58	4.57	4.59	4.56	2.38	2.37	2.43	2.35	2.32	20.84	20.7	20.8	20.7	20.6	45.85	45.72	45.76	45.48	45.71	21.2	21.83	21.7	22.1	22.1
4	4.52	4.62	4.54	4.53	4.51	2.36	2.35	2.40	2.29	2.35	21.68	21.1	21.6	21.8	21.4	45.81	45.80	45.72	45.41	45.58	20.8	21.3	21.0	21.2	21.43
6	4.57	4.58	4.51	4.50	4.56	2.33	2.32	2.38	2.35	2.34	22.36	22.4	22.3	22.1	22.2	45.73	45.78	45.70	45.43	45.52	20.2	20.2	20.3	20.8	20.6

4. Conclusion

Low dose irradiation at 0.25 kGy could arrest insect infestation in cashew kernels, an important item of commerce, while maintaining the quality, as judged from proximate constituents and physical tests. Hence it is recommended as a viable alternative to chemical methods for arresting insect infestation.

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