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INFLUENCE OF GAMMA RADIATION ON CENTESIMAL COMPOSITION AND FATTY ACIDS PROFILE OF MACADAMIA CAKE

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ABSTRACT

Macadamia (*Macadamia integrifolia*) is an edible nut species with commercial importance also in cosmetic and pharmaceutical industries due to its high concentration in monounsaturated fatty acids and its low cholesterol levels. Macadamia cake or meal is the byproduct obtained after oil removal by cold pressing. The process presents low extraction yields, generating partially defatted meal as a byproduct, being in that way a product with still great potential of nutritious applications. Irradiation is a food processing procedure that allows the extension of shelf life and can guarantee the safety of food products by pathogenic bacteria elimination. The aim of this work was to evaluate the influence of gamma irradiation process on chemical composition and fatty acid profile of Brazilian macadamia cake. The major components of the analyzed macadamia samples were lipids (>50g/100g), especially monounsaturated fatty acids (>39g/100g), carbohydrates and protein. Macadamia nut and cake showed high oleic (>60g/100g) and palmitic acids (>18g/100g). According to present results, gamma radiation had no effect on the centesimal composition and fatty acids profile of the macadamia cake, and did not change its nutritional quality.

1. INTRODUCTION

Many byproducts of food industry are still rich in nutrients, however, they usually need further treatments for human consumption. The macadamia kernel is a rich source of lipids, proteins and important micronutrients such as calcium, potassium, manganese, magnesium and zinc [1, 2]. The partially defatted meal resulting from the oil extraction (macadamia cake) is a considerable important byproduct that deserves consideration for new commercial applications. Macadamia oil cake meal was evaluated as feed ingredients for diverse animals and we propose now it can be used as food ingredient as well. Some examples of the proposed uses to macadamia cake in the food industry are the use in cookies [3] in breads and cakes [4], protein concentrates [5], and supplements [6]. Centesimal composition of macadamia may present variations due to climate, soil, growing season and harvesting method [7, 8].

Irradiation is a process that exposes food to ionizing radiations such as gamma rays emitted from the radioisotopes ^{60}Co and ^{137}Cs, high energy electrons or X-rays produced by machine sources. Depending on the absorbed radiation dose, various effects can be achieved resulting in reduced storage losses, extended shelf life and/or improved microbiological and parasitological safety of foods. Then, the aim of this work was to evaluate the influence of

gamma irradiation process on chemical composition and fatty acid profile of Brazilian macadamia cake.

2. MATERIAL AND METHODS

Macadamia nuts and samples of macadamia cake were obtained from Queen Nut Macadamia Company, main macadamia nut and oil Brazilian producer. Samples are from different cultivars planted in the same orchard of *Macadamia integrifolia*, varieties from Hawai, Australia and Brazil, mainly cultivars Hawaiian HAES 741, HAES 660, HAES 344, and Brazilian IAC 4-12 B. Samples were gamma irradiated in polyethylene bags, at doses of 0 -10 kGy, dose rate ≤ 1 kGy h-1 using a ^{60}Co Gammacell 220, Atomic Energy of Canada Ltd (AECL), dose uniformity factor 1.13 at room temperature. Analyzes of moisture (IAL 12 and 13/IV), ash (IAL 018/IV), and total fat (IAL 032/IV) were undertaken following the Instituto Adolfo Lutz [9] Analytical Standards. Protein (Method 2001.11) and fiber (Method 991.43) were determined following the Official Methods of Analysis of AOAC International. According to the Technical Regulation on Nutritional Labeling of Packaged Food provided in Resolution RDC nº 360 [10], carbohydrates and calorie values were calculated. Analysis of fatty acid profile was undertaken following IAL 053/IV, IAL 056/IV and AOAC Official Method 996.06 by gas chromatography using a GC/MS gas chromatograph/mass spectrometer Shimadzu, model QP 2010, flame ionization detector (FID), capillary chromatographic column (100m x 0.25mm).

3. RESULTS AND DISCUSSION

3.1 Centesimal Composition

Macadamia cake samples were irradiated at doses of 0; 0.5; 2.5 and 5 kGy. Chemical composition was determined, carbohydrates and calories were calculated, and the results are displayed in Tab. 1. The major components of the analyzed samples of *M. integrifolia* were, in order of importance, lipids (>54g/100g), especially monounsaturated fatty acids (>42g/100g), carbohydrates (>20g/100g), protein (>12g/100g), fibers (>7g/100g) and ashes (>2g/100g). Calorie values were calculated (>624kcal/100g).

Table 1: Centesimal composition of irradiated macadamia cake

Component (g/100g)	Dose			
	0 kGy	0.5 kGy	2.5 kGy	5 kGy
Protein	12.93 ± 0.20 [a]	13.25 ± 0.07 [a]	12.64 ± 0.01 [a]	12.90 ± 0.02 [a]
Total fat	55.10 ± 0.49 [a]	54.50 ± 0.35 [a]	54.62 ± 0.65 [a]	54.10 ± 0.60 [a]
Saturated fatty acids	8.07 ± 1.10 [a]	8.08 ± 1.22 [a]	7.69 ± 0.65 [a]	7.56 ± 0.57 [a]
Trans fatty acids	ND	ND	ND	ND
Monounsaturated fatty acids	42.76 ± 0.23 [a]	42.18 ± 0.06 [a]	42.70 ± 0.67 [a]	42.34 ± 0.71 [a]
Polyunsaturated fatty acids	1.85 ± 1.32 [a]	1.85 ± 1.28 [a]	1.82 ± 1.32 [a]	2.22 ± 0.73 [a]
Humidity	2.20 ± 0.02 [a]	2.34 ± 0.08 [a]	2.23 ± 0.06 [a]	2.50 ± 0.27 [a]

Ash	2.06 ± 0.03[a]	2.05 ± 0.07 [a]	2.06 ± 0.06 [a]	2.05 ± 0.06 [a]
Fibers	7.10 ± 0.16 [a]	7.10 ± 0.15 [a]	7.17 ± 0.02 [a]	7.03 ± 0.00 [a]
Carbohydrates	20.76± 0.49 [a]	20.47 ± 0.55 [a]	21.65 ± 0.05 [a]	21.78 ± 0.86 [a]
Calories (kcal/100g)	630.93 ± 2.57[a]	627.30 ± 1.36[a]	625.51 ± 0.18[a]	624.17 ± 4.24[a]
Omega 3 (ω-3)	0.80 ± 1.03 [a]	0.79 ± 1.02 [a]	0.79 ± 1.02 [a]	0.75 ± 1.06 [a]
Omega 6 (ω-6)	1.05 ± 0.29 [a]	1.06 ± 0.26 [a]	1.03 ± 0.30 [a]	1.47 ± 0.33 [a]

ND = not detectable. Analyzes were performed in triplicate (n=3). Carbohydrates and calories were calculated. Values are presented as mean ± standard deviation. The same letter ([a]) in the same line indicates that they do not differ significantly (Tukey test, p <0.05).

The significance level of 95% was used for all statistical tests and according to that, gamma radiation has no significant effect on the centesimal composition of macadamia cake.

Macadamia can reach up to 78% oil [11], being considered the nut richer in oil, which helps to balance cholesterol levels. In present results, the partially defatted residue still present high amount of total fat (> 54g / 100g), besides carbohydrates (> 20g / 100g), protein (> 12g / 100g), and fibers (> 7g / 100g).

In macadamia, the ω-6/ω-3 is balanced, contributing to the reduction of cardiovascular risks. Among the nuts, macadamia has the lowest proportion of ω-6/ω-3 (0.70).

3.2 Fatty acid profile

Analysis of fatty acid profile of macadamia nut (Fig. 1) found mainly oleic (> 60g/100g), palmitoleic (>18g /100g) and palmitic (> 8g / 100g) acids. In a new lot, analysis of fatty acid profile in irradiated macadamia cake (Fig. 2), oleic acid was present (about 60%), palmitoleic acid (about 18%) and palmitic acid (about 8%) as well. Fatty acids profiles of macadamia nut and cake are displayed in Tab. 2.

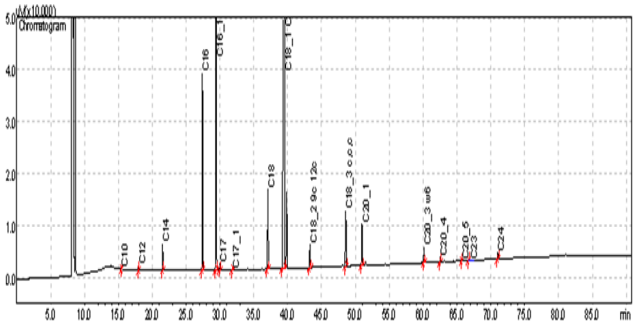
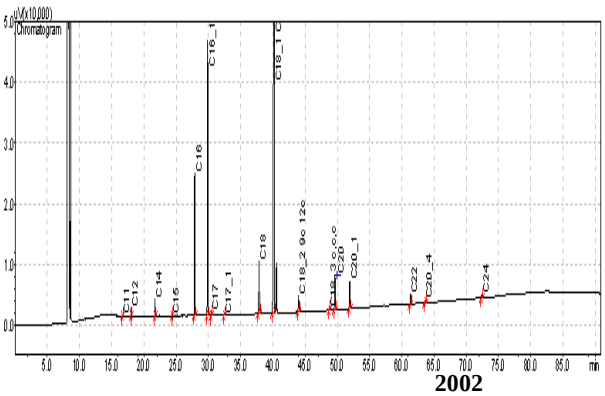


Figure 1: GC/MS Chromatogram of fatty acid profile of macadamia nut.



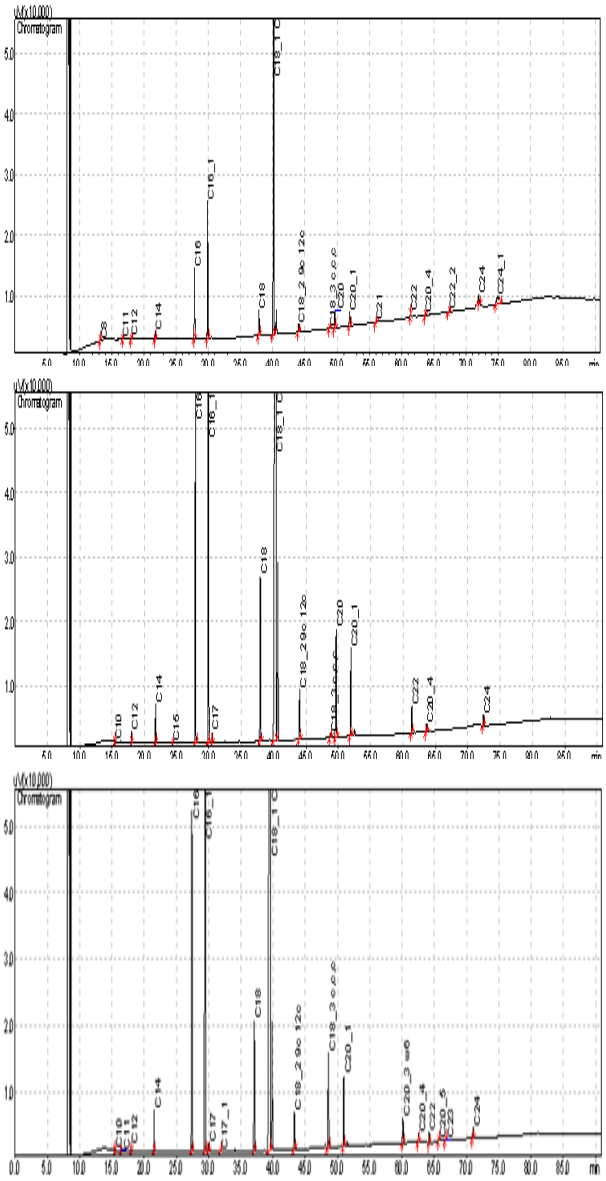


Figure 2: Chromatograms of fatty acid profile of irradiated macadamia cake at 0 kGy; 0.5kGy; 2.5kGy and 5kGy.

Table 2: Fatty acid content (%) of macadamia nut and irradiated macadamia cake

	Macadamia nut	Macadamia cake			
Fatty acid		0 kGy	0.5 kGy	2.5 kGy	5 kGy
C4:0	0	0	0	0	0

C6:0	0	0	0	0	0
C8:0	0	0	0.01689	0	0
C10:0	0.00876	0	0	0.00425	0.00577
C11:0	0.9122	0.01313	0.01767	0	0.00656
C12:0	0	0.24615	0.1115	0.11479	0.26619
C13:0	0.73011	0	0	0	0
C14:0	0	0.6647	0.62905	0.50455	0.70325
C14:1	0	0	0	0	0
C15:0	0	0.01074	0	0.0095	0.00537
C15:1	0	0	0	0	0
C16:0	8.06638	8.4566	8.20221	7.62135	8.28379
C16:1	18.9541	18.17304	17.39215	16.37855	18.45755
C17:0	0.26045	0.2515	0	0	0.25403
C17:1	0.03539	0.03081	0	0	0.02968
C18:0	3.89851	3.98565	3.77371	4.14737	3.97092
C18:1T	0	0	0	0	0
C18:1C	60.0275	60.0676	55.6328	63.0985	60.00589
C18:2T	0	0	0	0	0
C18:2C	1.23512	1.35431	1.25352	1.35483	1.21435
C20:0	0	2.92657	2.75691	2.89569	0.90775
C18:3n6	0	0	0	0	0
C18:3n3C	2.98037	0.13125	0.12367	0.13168	0.4159
C18:3T	0	0	0	0	0
C20:1n9	2.26542	2.31305	2.20699	2.29452	3.3002
C21:0	0	0	0.16871	0	0
C20:2n6	0	0	0	0	0
C22:0	0	0.78811	0.3543	0.72015	0.39405
C20:3n6	0.83822	0	0	0	0.1826
C22:1n9	0	0	0	0	0
C20:3n3	0	0	0	0	0
C20:4n6	0	0.2558	0.22874	0.21683	0.49126
C22:2n6	0	0	0.2088	0	0
C20:5n3	0.01048	0	0	0	0.01566
C23:0	0.02275	0	0	0	0.01233
C24:0	0.34068	0.33096	1.97625	0.28136	0.3306
C24:1	0	0	4.94616	0	0
C22:6n3	0	0	0	0	0

Carrilo et al. [12] found 63.36% oleic acid, 12.48% palmitoleic acid and 9.11% palmitic acid in macadamia oil, the richest nut source of palmitoleic acid. Present results corroborate data from the literature on fatty acid profile, both in the macadamia nut and cake.

With several countries around the world adopting irradiation to treat and preserve food products of various natures [13], studies of application of this technology are positively useful and welcome as the present work, that highlights the preservation of the nutritional value of irradiated macadamia cake.

4. CONCLUSIONS

Present results on composition of macadamia oil corroborated data from the literature. Gamma radiation at the applied doses did not induce significant changes in centesimal composition and fatty acid profile of macadamia cake. The main contribution of this work was the characterization of irradiated macadamia cake, which has important elements from a nutritional point of view: it is still rich in monounsaturated fatty acids, as well as protein and fibers; even after irradiation, showed the same fatty acid profile of macadamia nut with 60% oleic acid, 18% palmitoleic acid and 8% palmitic acid. Gamma radiation can be considered a good alternative to extend the shelf life of macadamia cake without changing its nutritional quality, allowing it to be used safely by the food industry.

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