2007 International Nuclear Atlantic Conference - INAC 2007
Santos, SP, Brazil, September 29 to October 5, 2007
***Associação Brasileira De Energia Nuclear** – ABEN*
ISBN: 978-85-99141-02-1

SENSORIAL EFFECTS OF GAMMA RADIATION PROCESSING IN CINAMOM *(Laurus cinnamomum*) AND NUT MEG (*Myristica fragans*)

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ABSTRACT

Food irradiation is the processing of food products by ionizing radiation in order, among other things, to control food borne pathogens, reduce microbial load and insect infestation, inhibit the germination of root crops, and extend the durable life of perishable products. Irradiation of dried food ingredients, particularly herbs and spices, has a great application potential, and has already been implemented in many countries. Spice irradiation is performed to increase the hygienic quality and used as decontamination processes instead of fumigation methods. European Community approves irradiation processing as an effective residue-free alternative. The present paper evaluates the effect of ionizing radiation on sensorial properties of cinnamon (*Laurus cinnamomum*) and nut meg (*Myristica fragans*). The samples have been irradiated in multipurpose irradiator of ^{60}Co in the doses: 0, 5, 10, 15, 20 e 25kGy.

1. INTRODUCTION

Cinnamon is the dried inner bark of various evergreen trees belonging to the genus *Cinnamomum*. Cinnamon in the ground form is used in baked dishes, with fruits, in confections, in moles, garam masala and berbere. *Cinnamomum Cassia* is predominant in the spice blends of the East and Southeast Asia. *Cinnamomum burmannii* is primarily imported from Indonesia and is the most common form of Cinnamon in the United States.

Vietnam has become the source for *Cinnamomun loureirii*, referred to as Saigon Cinnamon, and considered the finest Cinnamon available. *Cinnamomum zeylanicum* is native in South-West Asia, e.g. Sri Lanka, and the bark is sold in powder, scraping and branches (Pratt, 1992), is actually named "true Cinnamon", widely used due to its unique flavor.

Nut meg is the seed of the fruit which grows on the tree *Myristica fragans*, the same fruit from which Mace is derived. The oval shaped seeds have a sweet, spicy flavor. Commonly used in sweet foods and enhances savory foods. Nut meg originating from the East Indies has relatively high volatile oil content and a distinctively rich flavor and aroma. As opposed to the highly aromatic East Indian Nut meg, the lighter colored West Indian type has a milder flavor and higher fatty oil content.

Spices such as cinnamon and nut meg are frequently exposed to insects and microorganisms during cultivation and storage, what may be potential contaminations sources in foods, even when added in small amounts. For sanitation, fumigation with ethylene oxide has been widely used. Despite its strong effect, many countries restrict its use in foods because of possible toxic residues and occupational health hazards for workers (Fowels and others 2001). Gamma-irradiation is more effective than ethylene oxide fumigation in controlling microbial contamination without adverse effect (Cho and others 1986; Farkas and Andrassy 1988; Byun and others 1996).

Since irradiation has achieved limited regulatory approval, qualitative and quantitative tests should be available to enforce restrictions and labeling regulations (Diehl, 2002).

Numerous studies have been conducted on the chemical, microbiological, and toxicological aspects of irradiation in spices (Lianzhong and others 1998). Nevertheless, more studies concerning nutrient losses, formation of radiolytic products, suitability of packaging materials, and sensory quality of irradiated food are still needed (Diehl 2002). The purpose of the study was to investigate the effects of gamma-irradiation on quality factors in C*innamomum* and *Myristica Fragans*. Specifically, the aim of the study was to evaluate the effects of gamma-irradiation on the color, pungency, odor and development of volatiles of *Cinnamomum* and *Myristica Fragans*.

2. MATERIAL AND METHODS

2.1. Materials

Cinnamon (*Laurus Cinnamomum*) and Nut Meg (*Myristica Fragans*) powder samples were obtained from the local market in São Paulo.

2.2. Irradiation of the samples

The samples were irradiated in polyethylene packaging in a ^{60}Co, Gammacell 220 (A.E.C.L.), installed at Instituto de Pesquisas Energéticas e Nucleares - IPEN (São Paulo, Brazil). The applied radiation doses were 0, 5, 10, 15, 20, 25 kGy.

2.3. Separation of the volatile compositions for Gas Chromatography/ Mass Spectrometry (GC/MS) System

A Chromatographer Hewlett Packard, model 5890, series II, equipped with split injector, splitless, column DB-5 (25m of length and 0,35mm of internal diameter), liquid phase IF-54 and film thickness of 0,52mm was used. The carrier gas was helium, and the quantification was done by normalization.

2.4. Isolation of the volatiles for Solid Phase Microextraction- SPME

SPME was used for isolation of the volatiles, silica device and polidimetilsiloxan film (PDMS), with 100 micrometers of thickness.

2.5. Analysis of the results of the sensorial evaluation (Dutcosky, 1996)

After the processing for radiation of ^{60}Co, the bottle of glass contend cinnamom and nut meg in powder, destined to sensorial analysis had been separate and numbered aleatorily. Each bottle corresponded to determined dose of irradiation:

Bottle	**Dose of Irradiation (kGy)**
1	15
2	5
3	25
4	0
5	20
6	10

For the analysis of the results, the number of members of the Sensory Panel who have chosen sample A as having the most intense odor, the number of members who have chosen sample B and the number of members who have not found any difference between the samples were summed up. A significance table (P=½) was used.

3. RESULTS AND DISCUSSION

3.1. Chemical analysis

For the analysis, which was carried out by isolating the volatiles through static headspace and separating the volatiles through gas chromatography with flame ionization detector, the chromatograms were obtained.

For better understanding of the results obtained through the chromatograms, the table below presents the retention times and the respective areas for nut meg and cinnamon.

Nut meg

Doses → (kGy) / **Time** (min)↓	**0**	**5**	**10**	**15**	**20**	**25**
2,7	$5,1598.10^{5}$	$5,7461.10^{5}$	$5,2307.10^{5}$	$5,3300.10^{5}$	***$1,0799.10^{6}$***	$6,7099.10^{5}$
3,9	$2,4922.10^{5}$	$2,7673.10^{5}$	$2,8407.10^{5}$	$2,4625.10^{5}$	***$4,8420.10^{5}$***	$3,9036.10^{5}$
6,1	------------	3271,2	3881,4	3177,5	251,6	------------
7,1	------------	2230,0	5100,0	6650,0	8800,0	8600,0
8,8	3315,3	5802,1	6821,5	$1,0250.10^{4}$	***$1,1685.10^{4}$***	$1,0591.10^{4}$
12,0	------------	------------	------------	------------	2675,3	2828,6
12,9	------------	2100,0	3600,0	4100,0	6300,0	6500,0
15,5	$5,5173.10^{5}$	$5,5142.10^{5}$	$5,0433.10^{5}$	$4,4489.10^{5}$	***$9,5170.10^{5}$***	$7,7945.10^{5}$
16,3	$7,3974.10^{5}$	$7,7980.10^{5}$	$6,7371.10^{5}$	$7,9407.10^{5}$	$8,4336.10^{5}$	$6,3758.10^{5}$
17,9	$2,7953.10^{4}$	$2,8276.10^{4}$	$2,6436.10^{4}$	$3,0418.10^{4}$	$4,0157.10^{4}$	$2,8622.10^{4}$
21,4	$1,9310.10^{6}$	$2,0285.10^{6}$	$1,9085.10^{6}$	$2,1965.10^{6}$	$1,6604.10^{6}$	$1,5496.10^{6}$
24,2	$2,4794.10^{5}$	$2,5390.10^{5}$	$2,3914.10^{5}$	$2,5982.10^{5}$	$2,6104.10^{5}$	$2,3376.10^{5}$
26,3	$1,3759.10^{5}$	$1,3545.10^{5}$	$1,3261.10^{5}$	$1,2058.10^{5}$	***$2,1025.10^{5}$***	$1,8845.10^{5}$
27,4	$1,1446.10^{5}$	$1,1495.10^{5}$	$1,0972.10^{5}$	$1,1669.10^{5}$	$1,2089.10^{5}$	$1,0856.10^{5}$
28,7	-----------	$4,8341.10^{5}$	$4,7715.10^{5}$	$4,1004.10^{5}$	$6,8975.10^{5}$	$6,1889.10^{5}$
30,3	$1,2802.10^{5}$	$2,2947.10^{5}$	$2,2594.10^{5}$	$2,4168.10^{5}$	$2,6124.10^{5}$	$2,4660.10^{5}$
31,3	$7,1601.10^{5}$	$7,9328.10^{5}$	$7,7772.10^{5}$	$7,9670.10^{5}$	$9,2297.10^{5}$	$8,7761.10^{5}$
34,1	5678,3	-----------	------------	------------	------------	------------
36,8	4033,5	3725,4	3856,0	5390,6	6221,2	7084,1
39,2	$6,3325.10^{5}$	$6,1423.10^{5}$	$6,3194.10^{5}$	$5,4625.10^{5}$	$8,0117.10^{5}$	$7,5784.10^{5}$
41,0	$3,7610.10^{4}$	$4,2716.10^{4}$	$4,8636.10^{4}$	$6,4601.10^{4}$	$2,9637.10^{4}$	$3,1266.10^{4}$
48,3	$1,6482.10^{5}$	$1,5909.10^{5}$	$1,6793.10^{5}$	$1,4964.10^{5}$	$1,8942.10^{5}$	$1,8798.10^{5}$
51,2	12400	13100	20500	23500	3900,0	5500,0
53,7	$1,4114.10^{4}$	$1,2863.10^{4}$	$1,8230.10^{4}$	$1,4234.10^{4}$	$1,3211.10^{4}$	$1,5164.10^{4}$
55,1	------------	------------	------------	------------	------------	2614,66
56,1	------------	$8,7968.10^{4}$	------------	------------	------------	------------
56,9	$8,7637.10^{4}$	------------	------------	------------	------------	------------

In the table, shaded retention times indicate those at which significant variations of area were found. Nevertheless, concerning peak intensities, it's possible to say that the variation was not so accentuated.

At the bolded retention times 2.7; 3.9; 8.8 and 26.3 min., it's possible to realize that, from the sample not irradiated to the dose of 15kGy, the variation oscillated for more or for less, whereas at the dose of 20kGy, the areas of the peaks were found to be twice as much as the area in the not irradiated sample. Among the shaded retention times, 11 show up in the not irradiated sample, and 4 when doses are higher than 5kGy. From these 4, 3 show up in the other doses, and only the retention time 56.1 min., with longer retention time and therefore higher area, disappear again. Other peak of large are, due to its long retention time, is the one at 56.9 min., which shows up only in the chromatogram of the not irradiated sample. Among the shaded peaks, already existing in the not irradiated sample, the majority reaches the maximum area at the dose 20kGy, whereas only the retention time 51.2 min. reaches at 25 kGy and 21.4 min. and 41.0 min. at 15 kGy. From the 15 shaded peaks, 9 reach maximum values of area at 20 kGy.

Cinamon

Doses → (kGy) / **Time** (min)↓	**0**	**5**	**10**	**15**	**20**	**25**
2,7	$1,3842.10^{5}$	$1,9011.10^{5}$	Área não	$2,1552.10^{5}$	Área não	Área não
3,4	$6,4786.10^{5}$	$6,0626.10^{4}$	dividida	$7,7488.10^{4}$	dividida	dividida
4,1	$5,9060.10^{4}$	$6,1526.10^{4}$	$5,1714.10^{4}$	$7,0220.10^{4}$	$6,7896.10^{4}$	$7,2828.10^{4}$
6,2	6817,9	7559,2	8004,1	6990,5	8090,2	8957,8
7,1	1199,3	6232,0	7499,7	7818,8	8019,7	9178,9
12,3	6187,3	8202,6	7217,9	$1,1198.10^{4}$	$1,0756.10^{4}$	$1,2042.10^{4}$
16,3	$3,9235.10^{4}$	$3,9667.10^{4}$	$3,6758.10^{4}$	$4,3855.10^{4}$	$4,0640.10^{4}$	$4,2909.10^{4}$
18,0	$2,1223.10^{4}$	$2,3918.10^{4}$	$2,1002.10^{4}$	$2,7315.10^{4}$	$2,4507.10^{4}$	$2,6972.10^{4}$
19,0	$1,6672.10^{4}$	$2,7153.10^{4}$	$2,9752.10^{4}$	$4,0288.10^{4}$	$3,8865.10^{4}$	$5,0242.10^{4}$
21,7	9647,4	$1,5589.10^{4}$	9086,7	$2,3592.10^{4}$	$2,2910.10^{4}$	$2,3804.10^{4}$
24,4	-----------	3584,6	----------	5410,3	4530,9	6163,6
26,9	5317,0	5698,5	5802,2	5694,6	$1,1607.10^{4}$	$2,5221.10^{4}$
28,8	3192,5	4191,2	-----------	3170,4	4550,9	$1,0105.10^{4}$
30,4	$1,1425.10^{4}$	$1,3275.10^{4}$	9066,8	$1,7882.10^{4}$	$1,8116.10^{4}$	$2,2248.10^{4}$
31,6	$1,4803.10^{5}$	$1,3345.10^{5}$	$1,3345.10^{5}$	$1,5226.10^{5}$	$1,3327.10^{5}$	$1,5847.10^{5}$
33,9	-----------	-----------	-----------	5107,1	-----------	4047,5
41,0	-----------	-----------	-----------	5599,1	6160,3	6673,8
53,8	9228,1	$1,1761.10^{4}$	$1,4212.10^{4}$	$1,3776.10^{4}$	$1,1327.10^{4}$	$1,2082.10^{4}$
56,3	-----------	-----------	-----------	$7,3503.10^{4}$	$7,5106.10^{4}$	$6,6738.10^{4}$
58,2	-----------	$2,4968.10^{4}$	-----------	-----------	-----------	-----------

In the chromatograms obtained for cinammon, the variations in terms of area were found to be less significant, and a smaller number of retention times was shaded in the table above.

At the doses 10, 20 and 25 kGy, the values of area at 2.7 and 3.4 min. were obtained by summing the areas. Nevertheless, it´s possible to visualize from the chromatograms that there was a significant increase in the peak intensities when comparing the samples: not irradiated and 25 kGy. At the other shaded retention times, the areas oscillated, reaching its maximum at the dose 25 kGy. It's important to observe that, at the retention time 56.3 min., its peak only show up at doses higher than 15kGy, reaching maximum area at the dose 20 kGy. This area is relatively larger due to its longer retention time shown on the chromatogram. The last peak, at the retention time 58.2 min., is another peak of importance. It only shows up at the dose 5 kGy, and its area is large due to its long retention time.

3.2. SENSORIAL ANALYSIS

From the answers obtained with sensorial evaluations, the following table was elaborated for better understanding and visualization of the results.

Nut meg

Comparisons	**Answers**		
	No	yes	
1 e 2	**7**	1 + intense than 2:**11**	2 + intense than 1: **2**
1 e 3	**8**	1 + intense than 3:**10**	3 + intense than 1: **2**
2 e 3	**10**	2 + intense than 3: **6**	3 + intense than 2: **4**
1 e 4	**6**	1 + intense than 4:**11**	4 + intense than 1: **3**
2 e 4	**7**	1 + intense than 4: **9**	4 + intense than 2: **4**
3 e 4	**8**	3 + intense than 4:**12**	3 + intense than 4: **1**
3 e 5	**8**	3 + intense than 5:**11**	5 + intense than 3: **2**
3 e 6	**10**	3 + intense than 6: **7**	6 + intense than 3: **4**
4 e 5	**6**	4 + intense than 5:**10**	5 + intense than 4: **5**
4 e 6	**11**	4 + intense than 6: **7**	6 + intense than 4: **3**
1 e 5	**6**	1 + intense than 5: **9**	5 + intense than 1: **5**
1 e 6	**5**	1 + intense than 6:**12**	6 + intense than 1: **3**
5 e 6	**5**	5 + intense than 6: **3**	6 + intense than 5: **2**
2 e 5	**7**	2 + intense than 5: **6**	5 + intense than 6: **7**
2 e 6	**8**	2 + intense than 6: **8**	6 + intense than 2: **4**

Cinamon

Comparisons	Answers		
	No	Yes	
1 e 2	**9**	1 + intense than 2: **9**	2 + intense than 1: **2**
1 e 3	**10**	1 + intense than 3: **7**	3 + intense than 1: **3**
2 e 3	**10**	2 + intense than 3: **5**	3 + intense than 2: **5**
1 e 4	**9**	1 + intense than 4:1**0**	4 + intense than 1: **1**

2 e 4	**12**	1 + intense than 4: **7**	4 + intense than 2: **1**
3 e 4	**7**	3 + intense than 4:**10**	3 + intense than 4: **3**
3 e 5	**10**	3 + intense than 5: **7**	5 + intense than 3: **3**
3 e 6	**9**	3 + intense than 6: **9**	6 + intense than: **2**
4 e 5	**6**	4 + intense than 5: **7**	5 + intense than: **7**
4 e 6	**6**	4 + intense than 6: **8**	6 + intense than 4: **6**
1 e 5	**6**	1 + intense than 5: **8**	5 + intense than 1: **6**
1 e 6	**9**	1 + intense than 6: **9**	6 + intense than 1: **2**
5 e 6	**13**	5 + intense than 6: **5**	6 + intense than 5: **2**
2 e 5	**8**	2 + intense than 5: **6**	5 + intense than 6: **6**
2 e 6	**9**	2 + intense than 6:**10**	6 + intense than 2: **1**

According to the significance table (P=1/2), it was possible to find a few conclusive results, with probability level of 5% for nut meg: the odor of sample 3 (25kGy) is more intense than the odor of sample 4 (0 kGy); the odor of the sample 1 (15 kGy) is more intense than the odor of sample 6 (10 kGy); the odor of sample 5 (20 kGy) is more intense than the odor of sample 6 (10 kGy). Concerning results on the difference between odors from cinnamon samples, it was not possible to find any conclusive result, once the highest summed value to the answer “no” was 13 (sample 5 (20 kGy) has the same odor as sample 6 (10 kGy)), and the highest value for the response “yes” was 10.

For nut meg, among few conclusive differences: the sample irradiated with 25 kGy has more intense odor than the not irradiated sample; the sample irradiated with 15 kGy has more intense odor than the one irradiated with 10 kGy; the sample irradiated with 20 kGy has more intense odor than the one irradiated with 10 kGy. It´s possible to say that, among the mentioned samples, those who underwent processing through irradiation at more intense doses have more intense odors.

4. CONCLUSION AND DISCUSSION

In the sensorial analysis, although it was not theoretically possible to obtain conclusive results on most of the variations of odors among the samples, it is possible to say that there were difficulties among the participants to define the differences. Most participants were in serious doubts concerning the differences between the odors, what indicates that, often, these differences would not be recognized by consumers without training for odors recognition.

In the analysis of the volatiles with static headspace and gas chromatography, it was possible to realize from the chromatographic results of nut meg that at the considered retention times with relatively high variations, the maximum areas were obtained at the irradiation dose of 20kGy. One can assume that from this dose on, the compounds represented by the peaks partly are not maintained any longer, being transformed into others compounds. These new compounds supposed to be formed would have to appear at new peaks or already existing peaks, however, significant increase of the areas of the peaks in the sample radiated with dose of 25kGy was not observed.

From the results of the cinnamon chromatograms, there was not very large variation between the areas of the peaks of the shaded retention times, and most compounds which increase in quantity already were not existent in the chromatogram of the not irradiated sample.

After the obtaining of these initial information, the peaks of the chromatograms of nut meg and cinnamon, considered as having significant changes will be analyzed again, however with a technique able to identify the compounds.

The technique of isolation of volatiles (SPME) will be used with a gas chromatographer coupled to a mass spectrometer. It will be possible to find conclusive results, identifying the compounds that increase in quantity with the irradiation doses and the formation of new compounds, whose nature can be analyzed and made available to the science, but mainly to consumers, who will use these herbs irradiated in research with higher safety.

This research will go on in agreement with the procedure mentioned above and new species of herbs will be considered.

ACKNOWLEDGMENTS

The authors wish to thank the technical support of Faculdade de Ciências Farmacêuticas, FCF/USP

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