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# Effects of Gamma Irradiation on Curcumin

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ABSTRACT

In this study, remnants concentrations of curcumin in Curcuma longa (organic turmeric powder) were determined after it was exposed to irradiation doses of 1, 2 and 3 kGy. Curcumin analysis was performed using the analyte-sensitive impulse differential polarography technique (LOD: 0.621 ppm and LOQ: 2.130 ppm). The results obtained showed a decreasing concentration of curcumin as a function of the irradiation dose. This reduction is low in terms of affecting the product's quality with respect to its concentration.

## 1. Introduction

### *1.1 Ionizing Radiation in Food*

The application of ionizing irradiation in food has been developed over the past 60 years [1]. It has been applied to a variety of food products, such as meat, poultry, dry ingredients, stored grains and spices. The main potential value of ionizing (gamma) irradiation for the consumer is in food security by reducing pathogens [2].

### *1.2 Curcuma Longa and Curcumin*

*Curcuma longa* is a plant of Asian origin that has been used in different forms (for coloring and food seasoning) since ancient times. Currently, this plant's ground rhizome is used to aromatize and color food products [3].

In *Curcuma longa*, the most important chemical components are a group of compounds called curcuminoids (natural antioxidants), which includes curcumin, the majority compound within the rhizome (3-8%) [4].

Several analytical techniques with high sensitivity can be used to analyze curcumin. Among them are electrochemical techniques (voltamperometry and polarography) [5], which are very sensitive and easy to reproduce without large variations in its matrix.

## 2. Experiment

### *2.1 Electrochemical System for the Determination of Curcumin*

The electrochemical system (differential pulse polarography) used to determine the standard compound curcumin was a 797 VA Computrace potentiostat coupled with Metrohm software V. 1.02, which had a dropping electrode arrangement of mercury (working electrode), an Ag/AgCl electrode in KCl 3 mol/L (reference electrode) and a platinum electrode (auxiliary electrode). This was performed with the following conditions suitable for the system:

Start potential (V): -0.800
End potential (V): -1.700
Voltage step (V): 0.005
Voltage step time(s): 1.000
Sweep rate (V/s): 0.005
Pulse amplitude (V): -0.050
Pulse time(s): 0.040

Polarographic curves were performed with 10.000 mL of electrolyte-support $LiClO_4$ at 0.25 mol/L (70% ethanol and 30% deionized water) in the work cell.



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### *2.2 Gamma Radiation of Curcuma Longa*

Three grams of the dry natural sample (organic turmeric powder) in glass containers were irradiated at doses of 1, 2 and 3 kGy by means of the Gamma-Beam 651 PT equipment, at Instituto de Ciencias Nucleares, UNAM.

### *2.3 Electrochemical System for the Determination of Curcumin in the Irradiated Ground Rhizome*

The curcumin concentration in the rhizome of *Curcuma longa* (organic turmeric powder) was determined with the electrochemical system (differential impulse polarography), with the same parameters as with the curcumin standard. For irradiated samples, this parameter is between 0.0200–0.0400 g at a 10.000 mL capacity (70% ethanol and 30% deionized water), with an addition of 1500 μL in the cell. The concentration was determined using the standard addition method for each sample.

## 3. Results and Discussion

### *3.1 Limits to the Quantification and Detection of Standard Curcumin*

The electrochemical study (differential pulse polarography) showed a reduction signal with $E_{peak}$ (peak of the current intensity) of –1.100 V (with established conditions) proportional to the additions of standard curcumin ($2.620\times10^{-3}$ mol/L) in 70% ethanol and 30% deionized water (Figure 1).

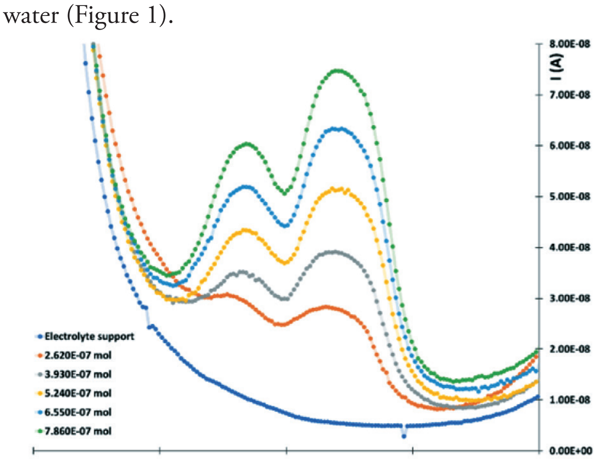


**Figure 1:** Polarograms (differential pulse polarography) (potential [V] vs. current intensity [A]) of the curcumin standard. Work conditions: start potential (V): –0.800; end potential (V): –1.700; voltage step (V): 0.005; step voltage time(s): 1.000; sweep rate (V/s): 0.005; pulse amplitude (V): -0.050; and pulse time(s): 0.040, with 10.000 mL of electrolyte-support $LiClO_4$ at 0.25 mol/L (70% ethanol and 30% deionized water).

With the $I_{peak}$ data of polarograms (Figure 1) a standard curve is constructed (Figure 2) (standard curcumin concentration [mol] vs $I_{peak}$(A) at -1.100 V) (Figure 2), where LOD and LOQ are obtained.

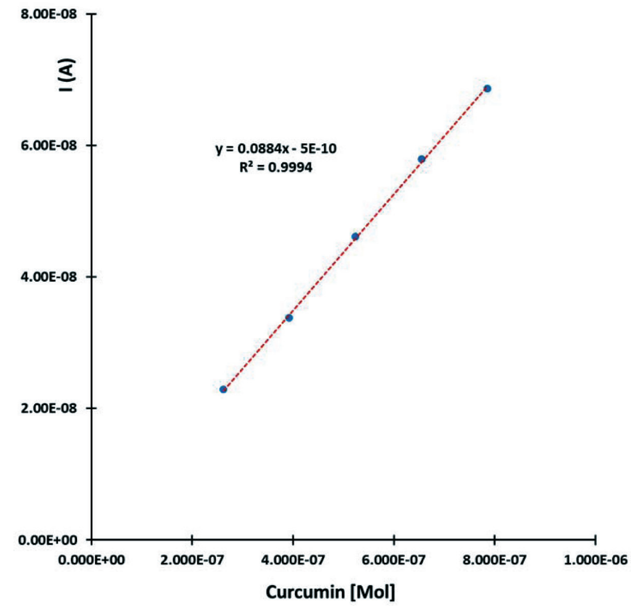


**Figure 2:** Standard curve of curcumin [mol] vs $E_{peak}$ for LOD and LOQ determination.

The results obtained are as follows:

Limit of detection (LOD): 0.621 ppm ($1.735\times10^{-8}$ mol curcumin)

Limit of quantification (LOQ): 2.130 ppm ($5.783\times10^{-8}$ mol curcumin)

The proposed system for curcumin determination denotes its sensitivity and precision to determine changes in curcumin concentration.

### *3.2 Determination of Curcumin in Irradiated Rhizome Samples*

Electrochemical determination (polarography impulse difference). Figure 3 shows an example for determination of curcumin: 1500 μL for the organic turmeric powder irradiated at 1 kGy (0.0282 g in 10.000 mL of 70% ethanol and 30% deionized water). Other samples were irradiated at 0, 1, 2 and 3 kGy and the same procedure was made.

### *2.3 Effect of Irradiation on Curcumin*

Determining the effect of irradiation doses on curcumin concentration in organic turmeric powder using polarogram analysis; this analysis is by creating a standard addition curve (Figure 4), where curcumin concentration [mol] vs $I_{peak}$ (A)(at –1,100 V) is graphed, being the first point of the graph (X=0) corresponding to the sample and the substitutions corresponding to the curcumin standard, obtaining a linearity with respect to the concentrations.

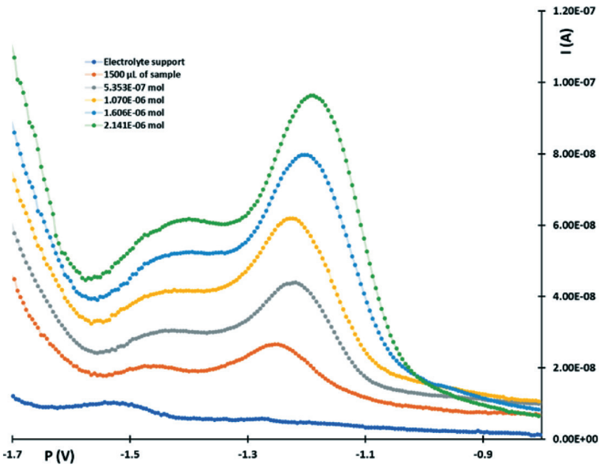


**Figure 3:** Polarograms (polarography impulse difference) (potential [V] vs. current intensity [A]) of organic turmeric powder irradiated at 1 kGy (0.0282 g in 10.00 mL of 70% ethanol and 30% deionized water) and standard additions of curcumin. Work conditions: start potential (V): -0.800; end potential (V): −1.700; voltage step (V): 0.005; step voltage time (s): 1.000; sweep rate (V/s): 0.005; pulse amplitude (V): -0.050 and pulse time(s): 0.040, with 10.000 mL of electrolyte-support $LiClO_4$ at 0.25 mol/L (70% ethanol and 30% deionized water).

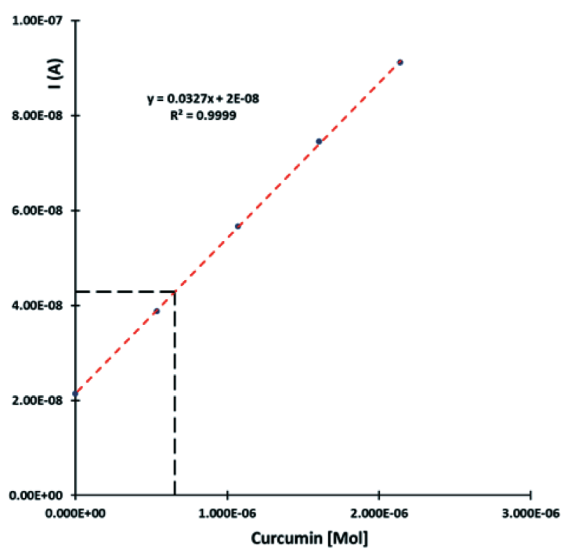


**Figure 4:** Standard addition curve of organic turmeric powder with 1 kGy irradiation (1500 µL of 0.0282 g in 10.000 mL of 70% ethanol and 30% deionized water), concentrations of curcumin vs. $I_{peak.}$

The concentration of curcumin in the irradiated samples was calculatedas percentage ratio by mass (Table 1); this data can be denoted (Figure 5) as a change in curcumin loss with increasing ionizing radiation.

**Table 1:** Results of the electrochemical analysis (differential impulse polarography) of curcumin concentration with respect to ionizing dose ratio.

| Ionizing Irradiation Dosage (kGy) | Percentage of Curcumin (remaining) |
|---|---|
| 0 | 5.722 |
| 1 | 5.695 |
| 2 | 5.667 |
| 3 | 5.621 |

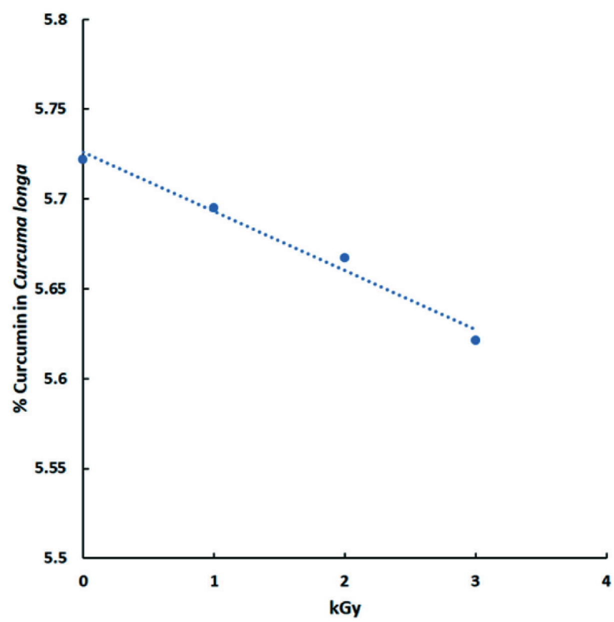


**Figure 5:** Effect of irradiation dose in the concentration of curcumin in organic turmeric powder.

## Conclusions

The effects of ionizing radiation (gamma) on the concentration of curcumin in the ground rhizome of *Curcuma longa* was studied by means of an electrochemical system. The results showed that the curcumin concentration had minimal variation, and that radiation does not affect the quality of the product.

These results can provide information on the effects of ionizing radiation within a natural system with high sensitivity.

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