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Gamma Radiation Processing for Disinfection of a 19th Century Photo Album

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ABSTRACT

A 19th century photo album was donated to the Hercule Florence Institute collection. After going through the quarantine, it was discovered that the album was contaminated by anobides. The album was sent for disinfestation treatment by ionizing radiation processing at IPEN. The dose applied was 3 kGy for the immediate eradication of the insects. Colorimetry analysis performed before and after irradiation found that treatment with ionizing radiation did not affect human color perception in the album and the photographs present.

Keywords: **ionizing radiation, photographic album, disinfection.**

1. INTRODUCTION

Over the past years cultural heritage materials have been irradiated for disinfection purposes successfully such as works of art, museum collections artifacts, books, manuscripts, drawings, archive documents, musical instruments, ethnographic objects, archaeological findings, natural history collections among others [1,2].

The Hercule Florence Institute (IHF) safeguards a historical collection with documentation from the 19th century. Part of the collection is related to the life and work of Hercules Florence (1804-1879), producer of a vast iconographic artwork about the region of São Paulo and Brazil, in addition to being recognized as one of the inventors of the photographic process.

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In February 2021, the Institute received a donation of a photo album belonging to Carlos Florence. After 2 months in quarantine, the presence of live insects and accumulation of residues from the biodeterioration of the album was found. The photo album was packed and sent to the gamma radiation disinfection process in the Cobalt-60 Multipurpose Irradiator of the Nuclear and Energy Research Institute, in São Paulo. Gamma irradiation has several advantages when compared with conventional preservation methods mainly related to the safety, efficiency, reliability, capacity, process time and safe for environment [3]. A dose of 3 kGy was applied for the immediate elimination of insect contamination. To ensure the safety of the irradiation process, analytical techniques such as colorimetry can indicate the existence of effects from the interaction of gamma rays with cultural heritage materials [4–8]. Colorimetric analysis using the parameters of the CIELAB system were used to verify possible changes on the color perception of the photo album.

2. MATERIALS AND METHODS

2.1. Irradiation by Gamma Rays from Cobalt-60 Sources

The gamma irradiation of the photo album was carried out in air, at room temperature, at the Multipurpose Gamma Irradiation Facility of the Nuclear and Energy Research Institute – IPEN-CNEN/SP, Brazil, located inside the University of São Paulo campus. The installed current activity is around 13.0 PBq (350 kCi).

The photo album was packed in a polypropylene box and irradiated by gamma rays with absorbed dose of 3 kGy. Dose rate was 5-6 $kGy.h^{-1}$. The PMMA-Harwell dosimetry system (Harwell, United Kingdom) was used to estimate the absorbed dose in the irradiated samples.

2.2. Colorimetric Measurements

Possible changes in the perception of the colors of the album and photographs due to the interaction of gamma rays in the disinfestation dose were investigated by the colorimetry technique. The colorimetry system developed by the Commission internationale de l'éclairage (CIE) provides a standardized procedure for quantifying color perception. The CIELAB system published in 1976 is

based on the theory that colors have three-dimensional characteristics, one being luminosity and the other two chromatic attributes: red-green and yellow-blue [8,9].

Color differences can be computed as the relative distance between two reference points within a color space. This difference is typically expressed as delta E (ΔE) and is calculated, Eq. 1, by comparing non-irradiated points and irradiated points L*a*b* (L* = Lightness, a* = red to green, b* = yellow to blue).

$$\Delta E = \sqrt{(\Delta L*)^2 + (\Delta a*)^2 + (\Delta b*)^2} \qquad (1)$$

Colorimetric parameters were made with a PCE-CSM 8 equipment using the CIELAB 1976 color coordinate system and SQC8 Color Management Control System (0°/45° geometry; 58 mm diameter aperture) connected to a computer.

The PCE-CSM8 colorimeter was used at six selected points in the photo album (Fig. 1) before and after irradiation. The measurements were performed at least 48 hours after album irradiation, when the electron excitation process was already stable.

(a) (b) (c) (d)

Figure 1: Locations of the measurement points in the photo album (a) P1 – album front cover; (b) P2 – endpaper; (c) P3 - rose flower engraving, P4 – photograph detail; (d) P5 – blue color, P6 – photograph detail

3. RESULTS AND DISCUSSION

After processing by radiation with a dose of 3 kGy, no live insects were found in the photo album.

The selected points from the photo album were measured before and after the radiation processing using the PCE spectrophotometer. A rule of thumb for the practical interpretation of the color difference (ΔE) when two colours are shown side by side is presented in Table I.

Table I: Hardeberg Criteria for the practical interpretation of ΔE* measuring the color difference between two color [10]

ΔE*	**Effect**
< 3	Hardly perceptible
3 < 6	Perceptible, but acceptable
> 6	Not acceptable

All L*, a*, b* and ΔE values in the 6 analyzed points are presented in Fig. 2. No ΔE of all analyzed points exceeded the value of 0.659. Thus, according to Hardeberg criteria, the outcomes indicated that irradiation at a dose of 3 kGy for disinfection of the photo album did not cause noticeable changes in the analyzed points.

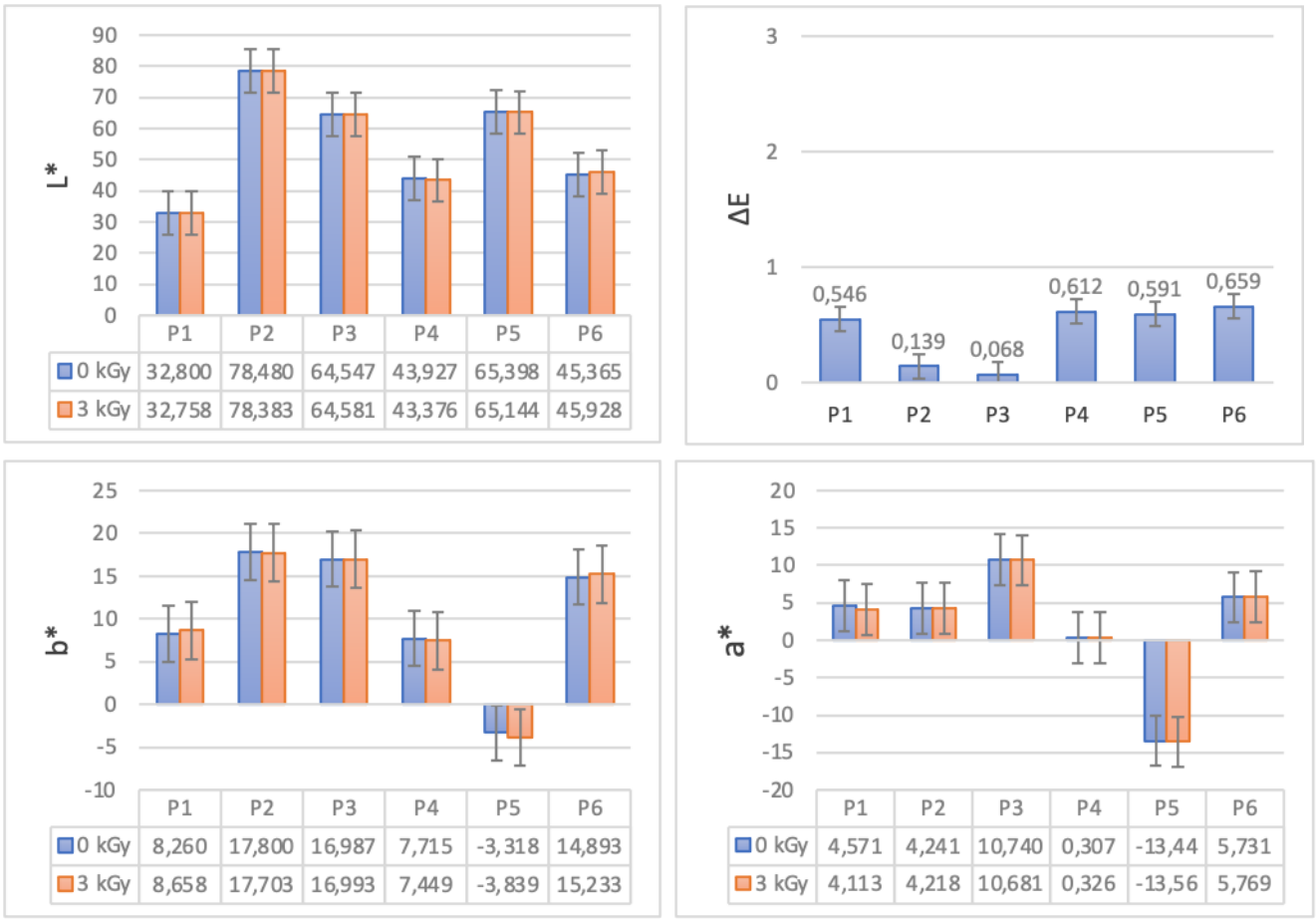

Figure 2: Measurements of L*, a*, b* and total color difference (ΔE) of selected points in the photo album before (0 kGy) and after (3 kGy) irradiation.

4. CONCLUSION

The 19th century photo album was properly disinfected by processing with gamma rays at a dose of 3 kGy. The results of the colorimetry analysis did not reveal significant changes in the perceptions of the color of the photo album as a possible effect of irradiation.

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