INFLUENCE OF THE ELECTRON BEAM IRRADIATION ON THE COLORIMETRIC ATTRIBUTES OF STARCHES*

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The work deals with the effects of the electron beams on the color characteristics of corn and wheat starches. The colorimetric attributes were characterized by CIELCH and CIELAB colorimetric systems. The color parameters of starches were influenced as the increase of the absorbed dose having different behavior in accordance with the botanic origin.

Key words: Corn starch, wheat starch, color values, CIELCH, CIELAB.

1. INTRODUCTION

Color is a visual attribute of things that results from the light they emit or transmit or reflect. It characterizes the global aspect of things and any change or variation appeared in structure or composition is reflected through it. Color perception is three dimensional, meaning that three terms describe a color [1]: hue, lightness, and chroma (Fig. 1).

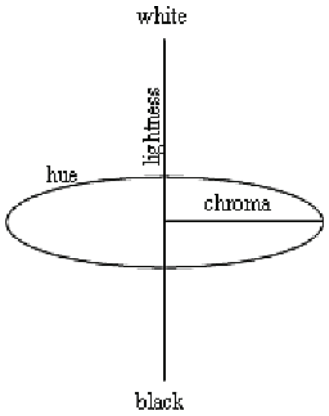

Fig. 1 –The three terms describing a color.

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The Commission Internationale de l'Eclairage (CIE) [2], the organization responsible for international recommendations for photometry and colorimetry, standardized color systems by specifying the illuminants, the observer and the methodology used to derive values for describing color. The CIE Color Systems utilize three coordinates to locate a color in a color space. Nowadays, the most used color spaces are CIE 1976 or CIELAB (L*a*b*) and CIELCH (L*C*h°).

When a color is expressed in CIELAB (Fig. 2), L* defines lightness, a* denotes the red/green value and b* the yellow/blue value. Thus, L* has values from 0 (black) to 100 (white); $a^* > 0 \rightarrow$ red color and $a^* < 0 \rightarrow$ green color; $b^* > 0 \rightarrow$ yellow color and $b^* < 0 \rightarrow$ blue color.

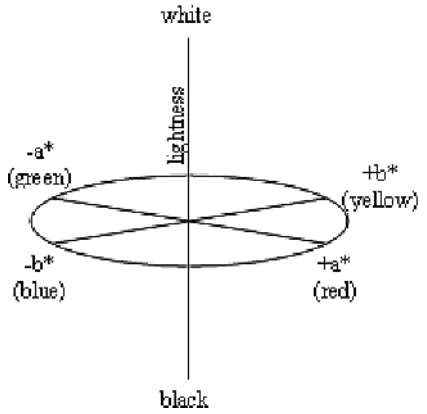

Fig. 2 – CIELAB color system.

CIELCH (D65/CIE 1964 10^0) is a polar representation of the CIELAB rectangular coordinate system and describes color in terms of lightness, chroma (saturation) and hue.

The CMC color difference (ΔE_{CMC}) is based on the colorimetric principles of the CIE 1976 system. It is typically employed as a color system in industrial applications, proving to be a useful measure of the commercial acceptability of colored products [3].

Starch as a raw material can be subjected to the ionizing radiation action in order either to be decontaminated from microbiological point of view or to be modified with purpose to improve the physicochemical and functional properties.

Taking into account that polymers may generally suffer changes of their structure under irradiation conditions and the color can offer global information about possible changes being a kind of quality parameter, we pursued to discuss the effects of the electron beams (ionizing radiation) on the color characteristics of the corn and wheat starches.

2. EXPERIMENTAL

Corn and wheat starches from Romanian market were used for experiments.

Starch samples were treated using a linear electron accelerator facility (INFLPR, Bucharest-Magurele, Romania) with doses up to 10 kGy (checked by ferrous cupric sulphate dosimetry procedure), at room temperature and ambient pressure.

The colorimetric characteristics of the samples were measured by a portable spectrocolorimeter MiniScan XE Plus (HunterLab, USA) and expressed in CIELCH and CIELAB colorimetric systems. The data were processed using the Microcal Origin v5.0 and TableCurve 2D v2.03 softwares.

3. RESULTS AND DISCUSSION

Fig. 3 illustrates the CIELCH variables for corn starch before and after electron beam (e-beam) treatment. Native corn starch had very slight yellowish color with high lightness degree (L* = 93.48%). The e-beam treatment caused some changes of the color attributes (hue, chromaticity and lightness) of the corn starch as the increase of the absorbed dose, probably due to the some modifications of its chemical structure. Thus, the hue and lightness were lower than the control sample value, but a leap of chromaticity was notable even after

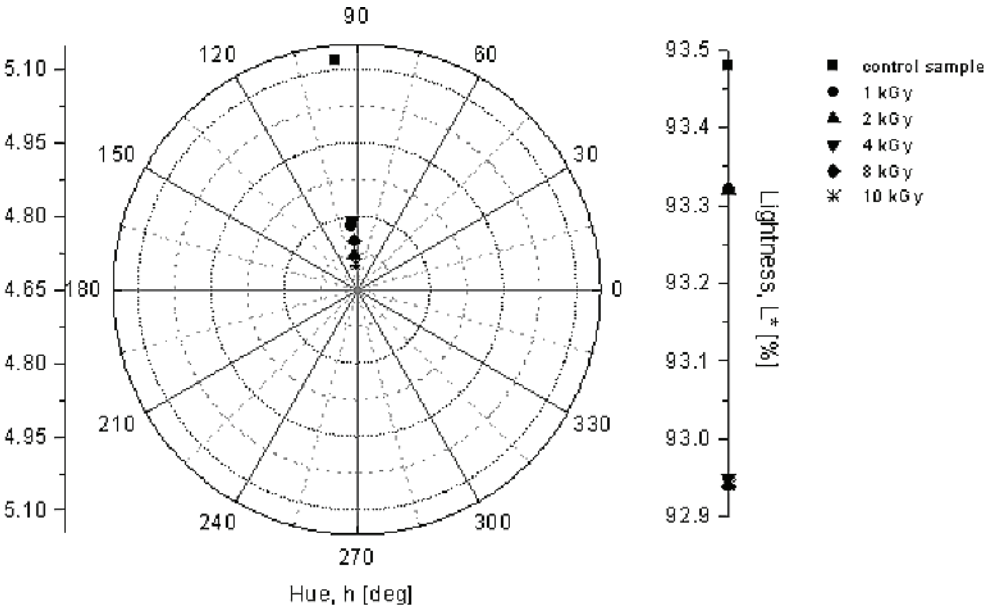

Fig. 3 – CIEL*C*h parameters of the corn starch.

first absorbed dose (1 kGy). The chroma value decreased as the absorbed dose increased indicating therefore the decrease of the color saturation (to gray) for treated samples in comparison to the control one.

Native wheat starch had very low value of chromaticity which indicates gray tone and high lightness degree (L* = 97.92%). The color characteristics (Fig. 4) varied in reverse direction than the corn starch ones after e-beam treatment. It was observed here that the evolution of the color parameters was in the growth direction with the increase of the absorbed dose. Therefore, the color of the wheat starch moved to yellow due to C* (chroma) and h (hue) parameters, but at the same time with its bleaching reflected by L* increase. This behavior suggested that the wheat starch structure suffers opposite changes that the corn starch ones.

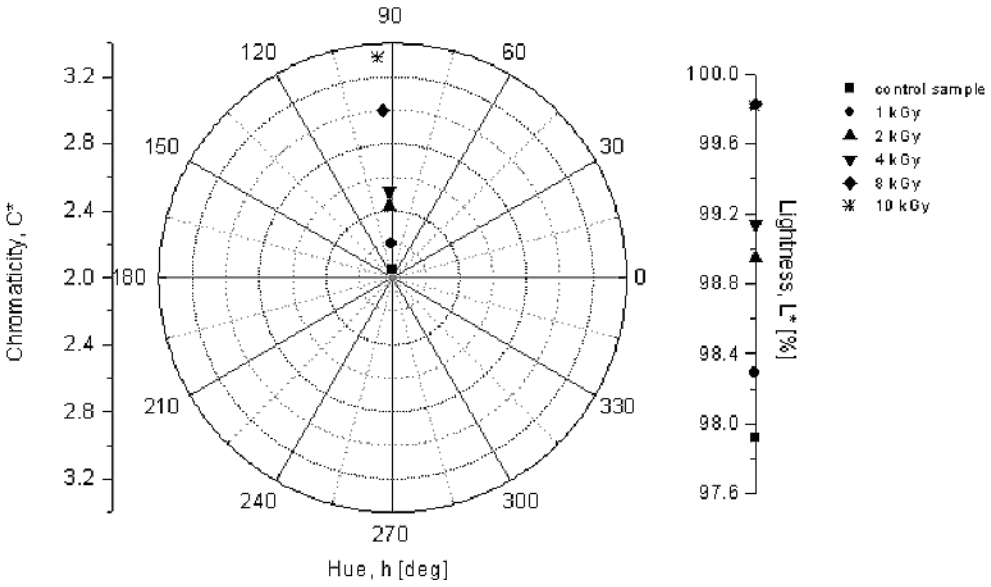

Fig. 4 – CIEL*C*h parameters of the wheat starch.

Also, it was noticed that the yellow-blue and red-green coordinates modified for both starches (Figs. 5 and 6) from the perspective of the color coordinates.

In the case of the corn starch, the color movement of the irradiated samples in the +a* direction depicted a shift toward red as the increase of the absorbed dose, while –b* movement indicated the shift toward blue (Fig. 5). Once again, one could noticed the significant shift in the chromatic space that appeared after 1 kGy irradiation showing that the corn starch can be modified easily at low doses.

The color evolution with the increase of the absorbed dose for the irradiated wheat starch was in the –a* direction toward green and +b* direction

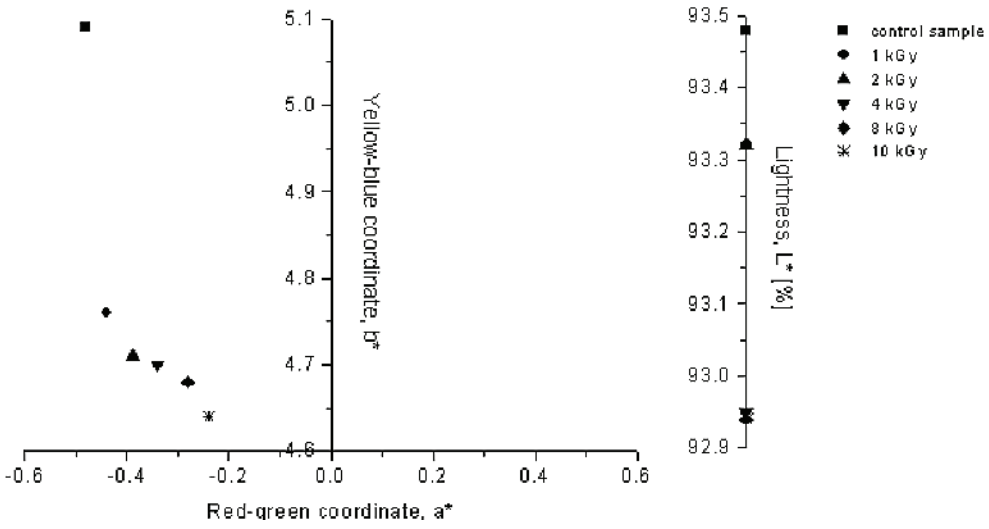

Fig. 5 – CIEL*a*b* parameters of the corn starch.

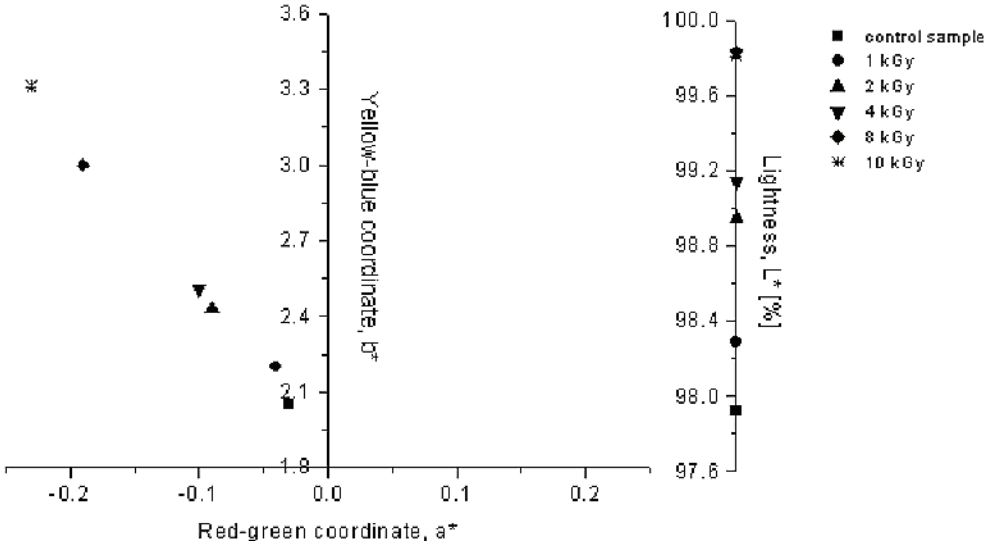

Fig. 6 – CIEL*a*b* parameters of the wheat starch.

toward yellow (Fig. 6). This shifts of the irradiated wheat starch in the chromatic space confirmed the opposite effects that e-beams had on the wheat starch structure comparing to the corn starch.

The total color difference, ΔE_{CMC}, is a value useful as an indicator of the difference between a sample and a control one [4]. This value allows generally the evaluation of the acceptability of a product color. Analyzing the total color

difference between the irradiated sample and control one expressed as chromatic units, it was observed that it increased with the absorbed dose increase following a polynomial model ($r^2 = 0.995–0.998$) both for corn starch and wheat starch (Figs. 7 and 8). The levels considered for the ΔE_{CMC} perception were the following:

- < 0.2 – no measurable difference
- 0.2–0.5 – no visible difference
- 0.5–2 – visible but acceptable
- 2–5 – visible and not acceptable
- 5 – not acceptable

Taking into account the above limits, it was noticed that the $\Delta E_{CMC} \leq 0.5$ showing differences in color but not visible ones for corn starch irradiated with doses up to 8 kGy. For samples treated with 10 kGy, ΔE_{CMC} had value of 0.62 indicating that visible but acceptable modification in the color characteristics occurred.

The irradiated wheat starch showed some higher total color differences than those of the corn starch: $\Delta E_{CMC} \leq 0.5$ for doses up to 2 kGy and $\Delta E_{CMC} = 0.51–1.68$ for doses higher than 2 kGy up to 10 kGy. However, there were also no more than visible but acceptable changes in the colorimetric space. Wheat starch may be treated with e-beam up to 2 kGy without visible modification of the color and with doses in the range of 2–10 kGy with acceptable modification of the color, even it is visible.

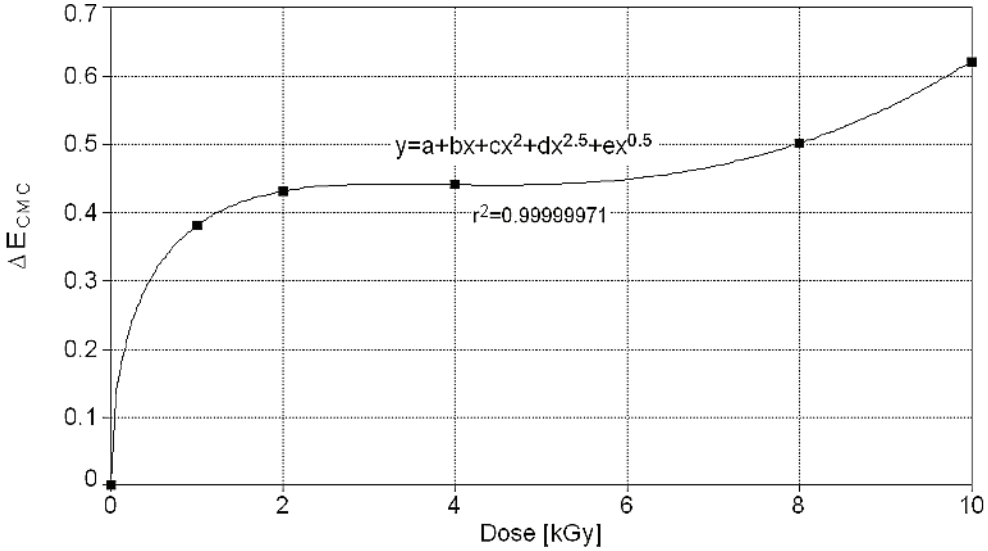

Fig. 7 – Total difference of color for corn starch.

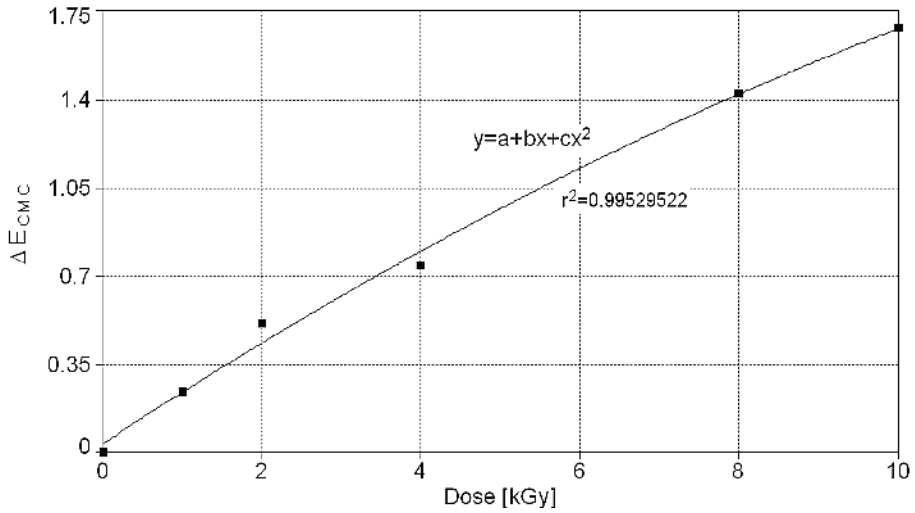

Fig. 8 – Total difference of color for wheat starch.

4. CONCLUSIONS

Irradiated corn and wheat starches have been subjected to spectrophotocolorimetric study. The spectrophotocolorimetric analysis of these starches showed us that global modification occurred in their structure when they are exposed to e-beam treatment. The color changes, as a consequence of the e-beam irradiation with doses up to 10 kGy, were either no visible or visible but acceptable depending on the dose range. Also, the evolution of the colorimetric parameters depended on the vegetal source of starch.

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