EXPLORING THE COLOR MODIFICATIONS IN BIOPOLYMERS INDUCED BY DUAL PROCESSING WITH IONIZING RADIATION AND COLD PLASMA

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INTRODUCTION

- Ionizing radiation and cold plasma treatments → promising non-thermal, environmentally friendly practices that may change the functionality of natural polymers
- Recent research in the field of in the field of biopolymer modification → dual modification by combining different modification methods to enhance the biopolymer physicochemical and functional features while optimizing performance
- Starch → modified to enhance its functionality and to extend its utilization
- Assessing color parameters ⇨ understanding of changes in biopolymer properties, optimizing processing conditions, and meeting consumer preferences

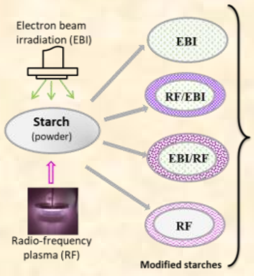
AIM

to explore the impact of dual processing with an electron beam and cold plasma, varying the processing sequences, on the color attributes of starch as a biopolymer.

METHODOLOGY

- *Material*: Native regular corn starch (white powder; moisture content: ≤15%)

- *Processing*:
  1. RF plasma (RF): 40 W, 150 mTorr, 10 min, in air
  2. Electron Beam Irradiation (EBI): 5.5 MeV; 5-20 kGy; 2.9±0.2 kGy/min
  3. RF/EBI
  4. EBI/RF



- *Spectrophotocolorimetric measurements*:
  - Absorbance in the visible region (360–830 nm), standard illuminant D65 (daylight source), observer angle of 10° (perception angle of a human observer) ⇨ two color spaces: CIE $L^*a^*b^*$ and CIE $L^*C^*h^o$
  - Cary 100 Bio spectrophotometer (Varian, Inc., USA)
  - Gelatinized starch 1% (w/v)
  - Total color difference ΔE_{ab} → reference for calculated values: native starch

- *Statistics*: Hierarchical cluster analysis (HCA) (OriginPro 2017): Ward's method, Euclidean distance, sum of distance, normalized variables to [0,1]

RESULTS

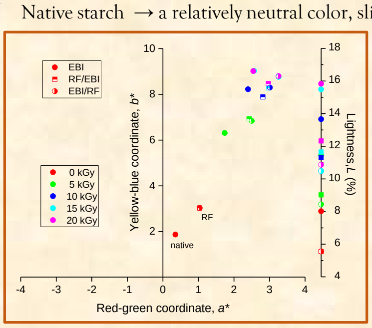
❖ **CIE $L^*a^*b^*$ ⇨ system**

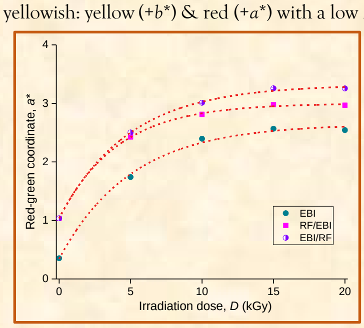
Lightness, L^* : 0 (black) → 100 (white);
Red-green coordinate, a^*: $+a^*$ → red, $-a^*$ → green
Yellow-blue coordinate, b^*: $+b^*$ → yellow, $-b^*$ → blue
Total color difference, $\Delta E_{ab} = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$

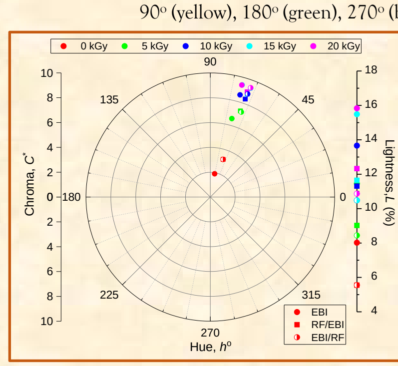
❖ **CIE $L^*C^*h^o$ ⇨ system**

Lightness, L^*: 0 (black) → 100 (white)
Chroma (saturation), C^* - quantitative component
Hue, h^o - qualitative component: 0° (red), 90° (yellow), 180° (green), 270° (blue)

✓ Native starch → a relatively neutral color, slightly yellowish: yellow ($+b^*$) & red ($+a^*$) with a low L^* (~8%)

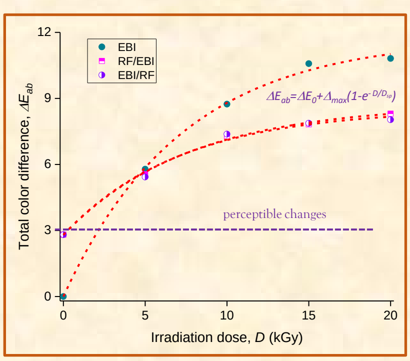






✓ Dual-modified samples → L^*, $+a^*$, $+b^*$ ↗ with irradiation dose
→ $+a^*$: the largest change in values among $L^*a^*b^*$ coordinates

✓ Dual-modified samples → C^* ↗ with irradiation dose
→ h^o: shifted toward red
→ C^*: the largest change in values among $L^*C^*h^o$ coordinates

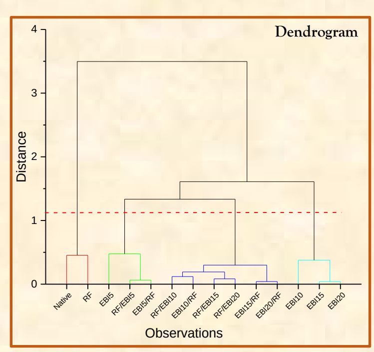


✓ ΔE_{ab} → comparable between dual treatments
→ visible to the human eye as the irradiation dose increased
→ significantly lower values than a single EBI

Sample classification (dendrogram)

✓ **4 clusters** at a cut-off = 1.125, according to the type/level of processing:

Cluster 1: Non-irradiated samples (native & RF-modified starches)
Cluster 2: EBI- & dual-modified samples, irradiated with the lowest irradiation dose
Cluster 3: Single-irradiated samples at irradiation doses ≥ 10 kGy
Cluster 4: Dual-modified samples at irradiation doses ≥ 10 kGy



CONCLUSIONS

- ❑ **Dual processing ⇝ significantly altered starch color parameters, primarily based on irradiation dose**
- ❑ **Dual-processed samples ⇝ perceptible color changes, though less than EBI alone at the same irradiation dose**
- ❑ **Clustering ⇝ samples categorized by the type/level of processing**

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