Total Phenolic Contents and Antioxidant Activity of *Musa* AAA Berangan after UV-C Radiation

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What is ultraviolet (UV) radiation?

- **Definition:**
  The portion of the electromagnetic spectrum between X rays and visible light

(Health Physics Society, 2009)
Ultraviolet (UV) Light

- Five ranges of wave lengths
  1. UV-A (320 – 400 nm)
  2. UV-B (290 – 320 nm)
  3. UV-C (220 – 290 nm)
  4. Far UV (190 – 220 nm)
  5. Vacuum UV (40 – 190 nm)
UV-C in Daily Life

• 1900 – Water disinfection
• 1930s – As food preservation techniques
• 1980s – Widely accepted to treat drinking water
• 2005 – 30% total market drinking water treatment
• Food related industries:
  – Food contact surfaces
  – Air in food preparation area
  – Packaging materials
• Hospitals, laboratories and drug facilities
Photobiological Effects

EXPOSURE TO RADIATION

DIRECT ACTION

MOLECULAR CHANGES

INDIRECT ACTION

REVERSIBLE

PHYSIOLOGICAL & BIOCHEMICAL EFFECTS

IRREVERSIBLE

AMELIORATION (good/desire effect)

DEATH
<table>
<thead>
<tr>
<th>Crop</th>
<th>Findings</th>
<th>References</th>
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</table>
| Strawberries | • ‘Camarosa’ - Phenolic and vitamin C content reduced
• Antioxidant activity and enzyme activities (glutathione peroxidase, glutathione reductase, superoxide dismutase, ascorbate peroxidase, guaiacol peroxidase, monodehydroascorbate reductase and dehydroascorbate reductase) increased
• Phenolic content increased
• Softening delayed
• Gene that encode proteins and enzymes involved in cell wall degradation being modified and gene expression being reduced
• Gene expression and enzymatic activity related to plant defense against pathogens were modified | Allende et al. (2007) Erkan et al. (2008) Pombo et al. (2009, 2011) |
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| Watermelon (fresh-cut)| • More effective than chlorine and ozone  
• Microbial populations decreased  
• Colour slightly affected  
• Lycopene content preserved at 2.8 kJ/m² or slightly decreased at 1.6 kJ/m²  
• Vitamin C not affected  
• Catalase activity and total polyphenols decreased                                                                 | Artes-Hernandez (2010)          |
| Papaya (‘Golden’)     | • Not able to control *Colletotrichum gloesporioides*  
• Causing scald                                                                                                                                     | Cia et al. (2007)               |
| Mango (‘Haden’)       | • Overall appearance maintained  
• Decay reduced  
• Total phenols and flavonoids increased  
• Lipoxygenase and phenylalanine ammonia-lyase increased                                                                                         | Gonzalez-Aguilar (2007)         |
# Physiological and Biochemical Changes after UV-C Radiation

<table>
<thead>
<tr>
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</table>
| Blueberries               | • Decay decreased  
• Total anthocyanin, total phenolics and antioxidant activity increased  
• Total flavonoids increased  
• 0.43 kJ/m² could increase phenolics and anthocyanins                                                                                       | Perkins-Veazie et al. (2008)  
Wang et al. (2009)                                                          |
| Apples (fresh-cut)        | • 1.2 – 24.0 kJ/m² reduced total viable counts  
• Antioxidant activity, total phenols, anthocyanins, quercetin glycosides, chlorogenic acid and ascorbic acid increased  
• Skin colour improved  
• Soluble solids concentration, titratable acidity and weight loss not affected                                                          | Manzocco et al. (2011)  
Hagena et al. (2007)                                                          |
Physiological and Biochemical Changes after UV-C Radiation

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<tbody>
<tr>
<td>Grapes for winemaking</td>
<td>• Produced stilbene (protect lipoproteins from oxidative damage and to have cancer chemopreventive) enriched red wine</td>
<td>Guerrero et al. (2010)</td>
</tr>
</tbody>
</table>
Advantages of UV-C Radiation

- Inexpensive
- Simple technique (although subject to certain safety precautions)
- Lack of residual compounds
- Avoidance of chemicals that can cause ecological problems and/or potentially harmful to humans
- Penetrates only 5 – 30 μm of tissue
Berangan Banana

• One of the six fruit crops for development under Entry Point Project of NKEA
• Most favorite among local
• Comprises 50% of banana growing land
• Characters of bunch:
  ✔ Weight: 12 – 20 kg
  ✔ Hand: 6 – 10
• Characters of hand:
  ✔ 12 – 20 fingers/hand
  ✔ 12 – 18 cm in length
  ✔ 3 – 4 cm in diameter
Objective

To determine the antioxidant content and activity of Berangan banana after exposure to UV-C radiation
Methodology

UV-C radiation
(0, 0.01, 0.02, 0.03 and 0.04 kJ/m²)

Ripening initiation
(1 ml/l C₂H₄/24 h)

Total phenolic contents
(Using Folin-Ciocalteu assay and result was expressed as mg gallic acid equivalents (GAE)/ g dry weight)

Antioxidant activity
(FRAP, DPPH and ABTS assays and results were expressed in μmol trolox/g dry weight)

Extraction
(Pulp freeze-dried → extract using 50 ml 80% methanol)

Analyse at day 0, 1, 3 and 5 after ripening initiation

FRAP = Ferric-reducing antioxidant power
DPPH = 1,1-Diphenyl-2-picrylhydrazl
ABTS = 2,2’,-Azino(bis-3-ethyl-benzothiazoline-6-sulfonic acid)
Irradiation Treatment

Low pressure mercury lamp – 254 nm
Statistical Analysis

- Factorial arrangements:
  - 5 UV-C radiation dose x 4 ripening stages
- Randomized complete block design
- 3 replications
- Data analyzed using ANOVA
- Means separation using least significant difference
- Correlation analysis was performed to correlate antioxidant content and antioxidant activities
# Results and Discussion

Table 1: Effect of UV-C dose and day after ripening total phenolic contents and antioxidant activity (FRAP, DPPH and ABTS) of Berangan banana

<table>
<thead>
<tr>
<th>Factors</th>
<th>Total phenolic contents (mg GAE/g)</th>
<th>FRAP (µmol trolox/g)</th>
<th>DPPH (µmol trolox/g)</th>
<th>ABTS (µmol trolox/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV-C dose</td>
<td>5.54**</td>
<td>4.28*</td>
<td>2.92*</td>
<td>2.99*</td>
</tr>
<tr>
<td>Day after ripening</td>
<td>157.69**</td>
<td>112.02**</td>
<td>53.86**</td>
<td>149.11**</td>
</tr>
<tr>
<td>Interaction</td>
<td>2.00*</td>
<td>1.28&lt;sup&gt;NS&lt;/sup&gt;</td>
<td>0.93&lt;sup&gt;NS&lt;/sup&gt;</td>
<td>1.62&lt;sup&gt;NS&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*<sup>,</sup> **<sup> or</sup> NS Significant, highly significant or non significant at P≤ 0.05, respectively.
Interaction Effect of TPC

Fig. 1. Effects of UV-C radiation x ripening day on total phenolic contents of Berangan banana. Means separations pertaining to each ripening day followed by the same letters are not significantly different by LSD at (P< 0.05).
Main Effects of UV-C Dose on TPC and Antioxidant Activity

Antioxidant activity (μmol trolox/g fruit DW)

UV-C dose, kJ/m²

Total phenolic contents (mg GAE/g fruit DW)
Main Effects of Day after Ripening on TPC and Antioxidant Activity

- **TPC** (Total Phenolic Contents): measured in mg GAE/g fruit DW
- **FRAP** (Ferric reducing antioxidant power)
- **DPPH**
- **ABTS**

**Antioxidant Activity (μmol trolox/g fruit DW)**

**Day after ripening**

- **0**
- **1**
- **3**
- **5**

**Total phenolic contents (mg GAE/g fruit DW)**
## Correlation Coefficient of TPC and Antioxidant Activity

<table>
<thead>
<tr>
<th></th>
<th>TPC</th>
<th>DPPH</th>
<th>FRAP</th>
<th>ABTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPC</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPPH</td>
<td>0.613**</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRAP</td>
<td>0.909**</td>
<td>0.674**</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>ABTS</td>
<td>0.921**</td>
<td>0.717**</td>
<td>0.930**</td>
<td>-</td>
</tr>
</tbody>
</table>

** Highly significant at $P \leq 0.05$. 
Conclusions

• UV-C radiation has preserved total phenolic contents of fruit during ripening

• 0.01 kJ/m² UV-C is able to increase total phenolic contents and antioxidant activity

• Total phenolic contents is major contributor to antioxidant activity
Thank you