Extraction methods and plant species influences the anthocyanin and carotenoid content in the flowers of nine common landscape plants

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ABSTRACT

Anthocyanin and carotenoids are the two major groups of plant pigments having beneficial effects on human body. Anthocyanin, a water-soluble coloured flavonoid that imparts red, blue and purple colour in fruit, vegetables and flowers possesses anti-carcinogenic and anti-inflammatory properties, preventive in cardiovascular diseases, obesity and diabetes, and improves visual and brain functions. Carotenoids, C40 isoprenoid compounds, impart yellow to orange red colours to flowers are antioxidants, anti carcinogenic, protect cornea against UV light, and reduces cholesterol levels. Flowers are prominent sources of these two bio-compounds. The present study aimed at extraction of anthocyanin and carotenoid from flowers of nine common landscape plants (Erythrina indica, Delonix regia, Spathodia campanulata, Casis fistula, Peltophorum pterocarpum, Cassia alata, Lagerstroemia sp., Clitoria sp. and Eicchornia crassipes) blooming in red, yellow and blue, through four aqueous extraction methods with varying temperature and microwave assistance. The results indicated that the anthocyanin and carotenoid content varied significantly among the flower species, methods of extraction and their interaction. Maximum anthocyanin content was obtained from blue-coloured flowers of Clitoria sp. (64.44 mg l⁻¹) in microwave assisted extraction and maximum carotenoid content from red-coloured flowers of Delonix regia (99.60 µg g⁻¹) in cold water maceration.

Key words: Anthocyanin, Carotenoid, Extraction, Pigment and Temperature

Introduction

Anthocyanin and carotenoids are the two major groups of plant pigments having beneficial effects on human body. Anthocyanin, a water-soluble coloured flavonoid or phenolic glycosides or acyl-glycosides of anthocyanidins (Alappat and Alappat, 2020) that imparts red, blue and purple colour in fruit, vegetables and flowers possesses anti-carcinogenic and anti-inflammatory properties, preventive in cardiovascular diseases, obesity and diabetes, and improves visual and brain functions (Cisowska et al., 2011; Hui et al., 2010; Belwal et al., 2017; Proteggente et al., 2002; Pereira et al., 2017). Anthocyanins are the secondary plant metabolites which protect plants from biotic as well as abiotic stresses and most prevalent delphinidin, pelargonidin and cyanidin derivatives (Sousa, 2022). Carotenoids, C40 isoprenoid compounds, impart yellow to orange red colours to flowers are antioxidants, anticarcinogenic,
protect cornea against UV light, and reduces cholesterol levels (Fassett and Coombes, 2011). Carotenoids are a type of pigment that may be found in a variety of plants, flowers, fruits and vegetables. They are in charge of giving many naturally occurring foods their red, orange, and yellow hues. Due to their antioxidant qualities and possible health advantages, carotenoids are important for both plant physiology and human health. Carotenoids are also important in industry, where they are employed as food colourants, cosmetics, and nutraceuticals (Stachowiak and Szulc, 2021).

Flowers are prominent sources of these two bio-compounds. Generally flowers like marigold, calendula, saffron, rose etc. are used commercially for their rich carotenoid content. Marigold is the most common natural source of commercial lutein (Sarkar et al., 2023a). Flowers of hibiscus, *Centaura cyanus*, *Clitoria ternata* are used as colouring of food as well as textile as they are rich in anthocyanins. According to Vastrad and Goudar (2016) total flavonoid content of *Spathodia campanulata* flowers with aqueous extract was 17.65 mg g⁻¹, ethanolic extract 10.25 mg g⁻¹ and ethyl alcohol 2.90 mg g⁻¹ whereas flowers of *Peltophorum pterocarpum* contained 0.89 μg g⁻¹ of total carotenoid (Senoretta and Sumanthy, 2016). According to Ratananikom et al., (2022) the total carotenoid content in flowers of *Cassia fistula* and *Clitoria ternata* were 363.88±12.74 μg g⁻¹ and 62.51±3.96 μg g⁻¹ respectively. Cyanidin-3-glucoside and cyanidin-3-gentiobioside are the two major anthocyanins present in the flowers of Delonix regia was reported by Saleh and Ishak (1976). The presence of carotenoids in different floral parts was first reported by Jungalwala and Cama (1962). The flowers of Delonix regia is a rich source of antioxidants and its petal contained 5.8 μg g⁻¹ of anthocyanin and 694 μg g⁻¹ of total carotenoids of which 367 μg g⁻¹ was ß-carotene (Veigas et al., 2007). *Erythrina indica*, *Delonix regia*, *Spathodia campanulata*, *Cassia fistula*, *Peltophorum pterocarpum*, *Cassia alata*, *Lagerstroemia sp.*, *Clitoria sp.* and *Eichhornia crassipes* blooming profusely in red, yellow and blue, through six aqueous extraction methods with varying temperature and microwave assistance. The study was carried out to estimate the bio-pigment content in flowers of commonly occurring ornamental plants and to evaluate the effects of temperature influenced extraction methods on anthocyanin and carotenoid content of bio-pigments extracted from different flowers.

**Materials and Methods**

**Experimental site:** The experiment was conducted in the Department of Floriculture, Medicinal and Aromatic Plants, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, during the period 2018-2020. The University is located at Terai Region of West Bengal, 26.40pN latitude and 89.38pE longitude and 44m above mean sea level.

**Experimental materials:** The experiment was laid in two factors Completely Randomized Design with 12 treatment combinations replicated thrice. Nine common landscape ornamentals of three major colour groups were selected for this experiment. *Erythrina indica*, *Delonix regia* and *Spathodia campanulata* were selected as red flowers, *Cassia fistula*, *Peltophorum pterocarpum* and *Cassia alata* as yellow flowers and *Lagerstroemia sp.*, *Clitoria sp.* and *Eichhornia crassipes* were selected as blue flowers. The flowers were collected from the plants present in and around the university campus.

**Methods of extraction:** Six different aqueous extraction methods were employed for extraction of bio-pigment from the flowers and they were soaking in cold water (18°C-20°C) and maceration (M₂), soaking in hot water (80°C) and maceration (M₃), boiling in water at 100°C (M₄) and microwave assisted extraction (M₅). First the flower petals were separated and sun dried, 2g of dried petals were crushed in each method of extraction.

**Estimation of Anthocyanin:** For determination of anthocyanin content, absorbance light by the solution was measured at 520 nm wavelength in spectrophotometer and total anthocyanin content was calculated using following formula.

\[
\text{Total Anthocyanin content (mg L}^{-1}) = \frac{A_{\text{520nm}} \times DF \times 10^5}{e \times 1}
\]
Where, $A= \text{absorbance on 520nm wavelength}$, $\text{MW (Molecular weight)} = 449.2 \ \text{g/mol for cyanidine-3-glucoside}$, $DF= \text{dilution factor}$, $\varepsilon= \text{molar extinction coefficient}$ which is 26900 $\text{L}^{-1}\ \text{mol}^{-1}\ \text{cm}^{-1}$ for cyanidine-3-glucoside, $10^3= \text{factor for conversion from g to mg}$ (Lee, 2005; Sarkar et al., 2023b).

**Estimation of Carotenoid:** For determination of carotenoid content, absorbance light by the solution was measured at 450nm wavelength in spectrophotometer and Total carotenoid content was calculated using the following formula:

$$\text{Total carotenoid content (\text{ig g}^{-1})} = \frac{A \times V \times 10^{	ext{V}}}{1% \varepsilon \times P}$$

Where, $A= \text{Absorbance at 450nm}$; $V= \text{Total extracted volume in ml}$; $P= \text{Sample weight in gram}$; $A_{1\%} = 2592$ which is $\beta$-carotene extinction coefficient in petroleum ether (Carvelho et al., 2012).

**Statistical analysis:** The experiment was laid in two factorial Completely Randomized Design (FCRD) where first factor was flower species consists of three levels and second factor was methods of extraction comprised of four levels, hence total number of treatment was twelve which were replicated thrice. Statistical analysis was done in OP STAT software.

**Results and Discussion**

Anthocyanin and carotenoid content in the pigments was distinctly influenced by species, extraction methods and their interaction.

**Anthocyanin content in red flowers:** Anthocyanin content in the pigments was distinctly influenced by species, extraction methods and their interaction (Table 1). *Spathodia campanulata* (S3) recorded the maximum anthocyanin concentration (42.19 mg L$^{-1}$) but pigment of *Delonix regia* (S2) flowers was strikingly low in this bio-chemical component (4.82 mg L$^{-1}$). Glucosides of pelargonidin and cyanidin were reported to be the major anthocyanins in *Erythrina cristagali* which make up to 85.86% of the pigment (Susetyarini et al., 2020; Scogin, 1991). Methanolic extract of fresh flowers of *Delonix regia* yielded 101.13mg kg$^{-1}$ anthocyanin which belongs to three different groups, cyaniding-3-o-glucoside, cyaniding-3-o-rutiniside and pelargonidin-3-o-rutiniside (Vankar and Srivastava, 2010; Adje et al., 2008). Presence of anthocyanin was also reported in the flowers of *Spathodia* (Naglaa et al., 2014).

It was interesting to note that higher anthocyanin recovery was obtained by microwave assisted extraction (M4) (35.44 mg L$^{-1}$) whereas the minimum anthocyanin recovery (21.91 mg L$^{-1}$) was observed in cold water soaking and maceration (M1). The results are affirmed by the work of Patil et al., (2016) reported that the process of extraction of pigments significantly influences their mass transfer rate and resultant dye yield in *Spathodia campanulata*. The species responded differently to the pigment extraction methods for anthocyanin recovery. Microwave assisted extraction on the other hand, proved to be efficient for anthocyanin extraction from *Erythrina indica* and *Spathodia campanulata* (S3) flowers, however, the process was not so effective for *Delonix regia* (S2). Strikingly, hot water soaking and maceration (M2) proved to be the most efficient method for anthocyanin recovery for *Spathodia campanulata* (55.12 mg L$^{-1}$) but failed to show such effect on the other two species (Scogin, 1991).

**Anthocyanin content in yellow flowers:** Among the three species, pigment extracted from *Cassia alata*

<table>
<thead>
<tr>
<th>Extraction methods</th>
<th>Red colour flowers</th>
<th>Yellow colour flowers</th>
<th>Blue colour flowers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_1$</td>
<td>$S_2$</td>
<td>$S_3$</td>
</tr>
<tr>
<td>$M_1$</td>
<td>37.44</td>
<td>2.59</td>
<td>25.71</td>
</tr>
<tr>
<td>$M_2$</td>
<td>23.08</td>
<td>3.75</td>
<td>55.12</td>
</tr>
<tr>
<td>$M_3$</td>
<td>33.18</td>
<td>6.00</td>
<td>39.39</td>
</tr>
<tr>
<td>$M_4$</td>
<td>50.85</td>
<td>6.92</td>
<td>48.55</td>
</tr>
<tr>
<td>Mean</td>
<td>36.14</td>
<td>4.82</td>
<td>42.19</td>
</tr>
</tbody>
</table>

**Table 1. Effect of species and method of extraction on anthocyanin content of pigments**

<table>
<thead>
<tr>
<th>Factor</th>
<th>C.D. at 1% SE(m)±</th>
<th>C.D. at 1% SE(m)±</th>
<th>C.D. at 1% SE(m)±</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>0.16</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td>Method</td>
<td>0.19</td>
<td>0.06</td>
<td>0.10</td>
</tr>
<tr>
<td>Species x Method</td>
<td>0.33</td>
<td>0.12</td>
<td>0.20</td>
</tr>
</tbody>
</table>
(Y3) showed the maximum anthocyanin content with a mean value of 43.90 mg l⁻¹ followed by Cassia fistula (Y1) (38.36 mg l⁻¹) and the lowest amount of anthocyanin (20.70 mg l⁻¹) is observed in the pigment extracted from Peltophorum pterocarpum (Y2).

Among the methods of extraction maximum anthocyanin content (52.42 mg l⁻¹) was observed in hot water soaking and maceration (M2) whereas minimum anthocyanin content (26.35 mg k⁻¹) was observed in microwave assisted extraction (M4). The effect of interaction of species and methods of extraction showed statistically significant variation in the total anthocyanin content. The maximum value (58.94 mg l⁻¹) was observed in Cassia alata with hot water soaking and maceration whereas, the minimum value (10.15 mg l⁻¹) was observed in Peltophorum pterocarpum with microwave assisted extraction (M4). Total pro-anthocyanidins content in the flower of Cassia fistula was 14 mg cyaniding chloride equivalent/g of dry weight whereas, in flower bud the amount was 20mg quercetin equivalent g⁻¹ of dry weight (Bahorun et al., 2005). Total flavonoids content in flower buds and flowers were 8mg quercetin equivalent/g of dry weight. In Peltophorum pterocarpum flavonoid content was found to be 1.44 ± 0.01mg quercetin equivalent g⁻¹ of plant tissue (Muthukumaran et al., 2016).

Anthocyanin content in blue flowers: Among the three species, maximum anthocyanin content (48.87 mg l⁻¹) was observed in the pigments extracted from Clitoria sp. followed by Eichhornia crassipes (32.22 mg l⁻¹) and the minimum (29.55 mg l⁻¹) was observed in the pigment extracted from Lagerstroemia sp. Similar findings were noted by (Vankar and Srivastav, 2010) who reported higher anthocyanin content in Clitoria (227.42 mg kg⁻¹) fresh flowers compared to Lagerstroemia fresh flowers (36.22 mg kg⁻¹). Different methods of extraction exerted statistically significant variation in the anthocyanin content. Maximum anthocyanin content (49.18 mg l⁻¹) was observed with hot water soaking and maceration (M2) whereas minimum (22.70 mg l⁻¹) was observed with boiling in water (M3). Interaction between species and methods of extraction varied significantly in the content of anthocyanin. The maximum anthocyanin content (64.44 mg l⁻¹) was observed in Clitoria sp. with microwave assisted extraction and the minimum (17.40 mg l⁻¹) was observed in Eichhornia crassipes with boiling in water. According to a previous study by Vankar and Srivastava (2010) total anthocyanin content in Lagerstroemia sp. and Clitoria sp. are 36.22 mg kg⁻¹ and 227.42mg kg⁻¹, respectively. This data shows similarity with our observations in case of Lagerstroemia sp. but for Clitoria sp. the observations varied.

Carotenoid content in red flowers: Among the pigments extracted from the three species, Delonix regia (S2) showed the maximum content (54.80 ìg g⁻¹) of carotenoid followed by Erythrina indica (S1) (11.72 mg g⁻¹) whereas, the pigments from Spathodia campanulata (S3) recorded the minimum value (4.91 mg g⁻¹). Methods of extraction significantly affected the carotenoid content in pigments which ranged from 6.68 mg g⁻¹ to 36.31 mg g⁻¹ (Table 2).

The maximum value (36.31 ìg g⁻¹) was observed in pigments extracted with cold water soaking and maceration whereas the minimum amount (6.68 ìg g⁻¹) of carotenoid content is observed with microwave assisted extraction (M4). The effect of interaction between species and methods of extraction on carotenoid content of pigments was found statistically significant. The maximum (99.60 ìg g⁻¹) and minimum (2.51 ìg g⁻¹) amount of carotenoid was noted in the pigments from Delonix regia extracted

### Table 2. Effect of species and method of extraction on Carotenoid content (ìg g⁻¹) of pigments

<table>
<thead>
<tr>
<th>Extraction methods</th>
<th>Red colour flowers</th>
<th>Yellow colour flowers</th>
<th>Blue colour flowers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1</td>
<td>S2</td>
<td>S3</td>
</tr>
<tr>
<td>M1</td>
<td>3.08</td>
<td>99.60</td>
<td>6.24</td>
</tr>
<tr>
<td>M2</td>
<td>5.98</td>
<td>91.05</td>
<td>5.98</td>
</tr>
<tr>
<td>M3</td>
<td>23.22</td>
<td>25.59</td>
<td>4.89</td>
</tr>
<tr>
<td>M4</td>
<td>14.59</td>
<td>2.96</td>
<td>2.51</td>
</tr>
<tr>
<td>Mean</td>
<td>11.72</td>
<td>54.80</td>
<td>4.91</td>
</tr>
<tr>
<td>Factor</td>
<td>C.D. at 1% SE(m) ±</td>
<td>C.D. at 1% SE(m) ±</td>
<td>C.D. at 1% SE(m) ±</td>
</tr>
<tr>
<td>Species</td>
<td>0.74</td>
<td>0.25</td>
<td>0.471</td>
</tr>
<tr>
<td>Method</td>
<td>0.86</td>
<td>0.29</td>
<td>0.481</td>
</tr>
<tr>
<td>Species x Method</td>
<td>1.49</td>
<td>0.51</td>
<td>0.834</td>
</tr>
</tbody>
</table>
with cold water soaking and maceration (S,M) and *Spathodia campanulata* with microwave assisted extraction (S,M), respectively. Carotenoid content in Ethanolic extract of *Delonix regia* was recorded as 48.64 μg g⁻¹ (Kamalambigeswari and Rebecca, 2016). According to Vastard and Goudard (2016) concentration of flavonoid in *Spathodia campanulata* flowers imparted a reddish hue to the extract, was 17.65 mg g⁻¹.

**Carotenoid content in yellow flowers:** Among the three species, pigment extracted from *Cassia alata* (Y₁) showed the maximum value for total carotenoid content (15.48 μg g⁻¹) followed by *Cassia fistula* (Y₂) (6.99 μg g⁻¹) and the lowest amount of total carotenoid (5.31 μg g⁻¹) was observed in the pigment extracted from *Peltophorum pterocarpum* (Y₃). Methods of extraction affected significantly in the carotenoid content. Maximum carotenoid content (14.17 μg g⁻¹) was observed with hot water soaking and maceration (M₃) whereas minimum carotenoid content (4.95 μg g⁻¹) was observed with microwave assisted extraction (M₄). Total carotenoid content of the extracted pigments of different species with different methods of extraction varied significantly. Maximum (23.34 μg g⁻¹) and minimum (2.45 μg g⁻¹) were occurred in *Cassia alata* (Y₁, M₃) with hot water soaking and maceration and *Peltophorum pterocarpum* (Y₃, M₄) with microwave assisted extraction, respectively. According to Senoretta and Sumanthy (2016) total carotenoid content in flowers of *Peltophorum pterocarpum* was reported to be 0.89 μg/g. However as per our study the carotenoid content of flowers of this species is 9.53 μg g⁻¹, this variation is due to use of fresh flowers in the previous study. *Cassia alata* flowers are a rich source of α-carotene (Abdulwaliyu et al., 2013).

**Carotenoid content in blue flowers:** Among the three species, pigment extracted from *Clitoria* sp. showed the maximum amount of carotenoid content (5.89 μg g⁻¹) and the minimum (3.60 μg g⁻¹) was observed in the pigment extracted from *Lagerstroemia* sp. (B). Methods of extraction significantly affected the carotenoid content in the pigments. Maximum carotenoid content (6.31 μg g⁻¹) was observed with cold water soaking and maceration (M₃) whereas minimum (2.01 μg g⁻¹) was observed with boiling in water (M₄). The effect of interaction between species and methods of extraction on total carotenoid content of the pigments was found statistically significant. Maximum value of total carotenoid content (11.71 μg g⁻¹) was observed in *Clitoria* sp. with cold water soaking and maceration (B,M₄) whereas, the minimum (1.22 mg g⁻¹) carotenoid content was observed in *Clitoria* sp. with boiling in water (B,M₄) at par with *Clitoria* sp. with microwave assisted extraction, *Lagerstroemia* sp. with boiling in water, *Lagerstroemia* sp. with hot water extraction and *Eichhornia crassipes* with cold water extraction, respectively.

**Effect of temperature on the carotenoids content of flower pigments:** All the pigments extracted from the flowers except *Erythrina indica* showed a similar pattern in the carotenoid content (Fig. 1). Every pigments showed moderate content of carotenoids in soaking and maceration with cold water (18-20 °C) and showed maximum peak at soaking and maceration with hot water (80 °C) but as the temperature rises to 100 °C in boiling in water and more than that in microwave assisted extraction carotenoid content falls drastically and showed the minimum peak.

Only pigments extracted from *Erythrina indica* did not follow the trend and gave a maximum rise of carotenoid content in boiling in water and decreased by increasing temperature in microwave assisted extraction (Fig. 1). As boiling in water needs much more time than the cold and hot water soaking which reduces the carotenoid content and microwave assisted extraction utilized the maximum temperature which also reduces the yield of carotenoid in the pigments. The amount of carotenoid dramatically reduced as the extraction time and temperature increased. Higher temperatures have a number of negative impacts on the extraction of carotenoids, including degradation and isomerisation (Wang and Liu, 2009). Tao et al., (2010) reported that with the use of ethanol and a 50 °C temperature for 40 minutes, carotenoid production was higher from pumpkin skin. According to Aflaki (2012), plant carotenoids are present in cells and have a complex
structure in the cell diaphragm. As temperature rises to a certain point, the cell wall disintegrates and enhances solvent extraction. According to Alidiee et al. (2020) reported that the concentration of carotenoids was dramatically raised by extraction time and temperature, reaching a high of 13.34 mg per 100 g. Thereafter, the concentration of carotenoids was rapidly dropped by extraction time and temperature, reaching a minimum value at 50° for 150 min. In this study, the carotenoid content varies significantly in different temperature incorporated during extraction. The maximum content was recorded at extraction temperature of 60 °C followed by 20 °C and the content is getting lesser as the temperature increased to more than 100 °C (Fig. 2). In a previous study Strati and Oreopoulou (2011) reported that using ethyl lactate for three consecutive extractions of 30 min each at 70 °C, the maximum quantity of total carotenoids, expressed as lycopene, extracted from tomato waste was achieved (243.00 mg kg⁻¹ dry tomato waste). They also reported that in every solvent the maximum carotenoid content was observed at 70 °C temperature. Parjikolaei et al. (2015) reported that astaxanthin content was increased from 8.6 to 14.7 mg kg⁻¹ of wet waste material by increasing the temperature from 25° to 70 °C. Valduga et al. (2009) found that temperature significantly affected the carotenoid production, as this factor increase the pigments concentration decrease. However, microwave assisted extraction resulted in higher anthocyanin extraction but lower carotenoid content. This may be due to partial degradation of carotenoids in high temperature. Partial degradation of β-carotene and lutein is reported to be as high as -17 to -29% and -3 to -27%, respectively due to high temperature (Abushita et al., 1997; D’Evoli et al., 2013).

Effect of temperature on the anthocyanin content of flower pigments: In case of anthocyanin content from the pigments it was noted that two types of trend were observed. Pigment extracted from the blue flowers showed maximum anthocyanin content in soaking and maceration in hot water (M₁) whereas rest of the pigments showed maximum anthocyanin content in microwave assisted extraction. Temperature significantly increases the extraction of anthocyanin (Fig. 3).

Like carotenoid, time of extraction also played a significant role in anthocyanin content. The yield and total anthocyanin content from Clitoria flowers may vary depending on the standard solvent extraction methods used, the kind of solvent used, the substrate: solvent ratio, the extraction temperature, the extraction duration, and the soaking time (Rocha et al., 2020). Ternatins are the major polyacylated anthocyanins present in Clitoria responsible for the blue pigmentation polyacylated derivatives of delphinidin 3, 30, 50-triglucoside (Vidana et al., 2021).

Temperature more than 80 to 100 °C resulted in degradation of anthocyanin in Clitoria flower pigments (Escher et al., 2020; Lee et al., 2011). In this study, the anthocyanin content varies significantly in different temperature incorporated during extraction. The maximum anthocyanin content was recorded at extraction temperature of 50 °C followed by 40 °C and the content is getting lesser as the temperature increased to more than 100 °C and then increased up to 120 °C (Fig. 3). Earlier studies reported that the most ideal extraction temperature and duration for extracting anthocyanins from blue pea flowers are about 50–60 °C and 20–60 min, respectively since higher temperatures and longer extraction
times may cause anthocyanins to degrade (Loypimai et al., 2016; Aprodu et al., 2020).

Different studies reported that aqueous extraction of anthocyanin from dried petals of Clitoria at 60 °C to 90 °C found best (Ahmed et al., 2020; Voss et al., 2020; Vuong and Hongsprabhas, 2021; Chusak et al., 2018). According to Vidana et al. (2021) successful anthocyanin extraction from dried petals of Clitoria can be done through hot water extraction. Kalt et al. (2000) reported that extraction of fruit at 60 °C resulted in higher recovery of anthocyanins and antioxidant capacity, compared to extracts obtained at 25 °C. Boiling in water takes more time for extraction than hot water maceration and microwave assisted extraction which leads to lower recovery in anthocyanin. Higher microwave intensity generates higher temperatures during treatment within a short period of time which promoted extraction of anthocyanin (Nhon et al., 2022). However, due to sugars connected to the aromatic rings in their structure, anthocyanin compounds quickly breakdown at high temperatures and when exposed to prolonged microwave irradiation (Garofulie et al., 2013). Therefore anthocyanin recovery was significantly influenced by very low or very high temperature along with increased extraction time. Pap et al. (2012) reported that medium microwave obtained the best anthocyanin content from black currant residue. Solvent molecules may get extremely heated with prolonged microwave treatment. The continuous dielectric rises cause the cell’s temperature and pressure to reach critical levels. As a result, undesired active compounds were released, the anthocyanin content dropped, and recovery effectiveness was decreased. The ideal MAE parameters for red raspberry anthocyanins were reported by Sun et al. (2007) to be 55 °C, 12 minutes of microwave exposure, and 366 W. The optimal conditions, according to Liaziel et al. (2007) who extracted anthocyanins from grape skins, were temperature of 100 °C, irradiation period of 5 minutes, and microwave power of 500 W.

Conclusion

On the basis of the result obtained in the present investigation it is concluded that flowers can be explored and exploited as a source of anthocyanin and carotenoids. Blue flowers of Clitoria yielded 64.44 mg l⁻¹ of anthocyanin in microwave assisted extraction which was the maximum content extracted in the experiment whereas Amaranthus mangostanus, a leafy vegetable contains 50.9±0.82 (µg g⁻¹) of anthocyanins (Han and Xu, 2014). Red flowers of Delonix regia yielded the maximum carotenoid (99.60 µg g⁻¹) in cold water extraction whereas purple and yellow carrot contains 469 to 605 µg g⁻¹ of carotenoids (Nicolle et al., 2004). Bio-chemical constituent of pigments from flowers is highly influenced by extraction condition. The yield of the anthocyanin and carotenoids were greatly influenced by the temperature where partial degradation might have occurred in high temperature. Thus these flowers can be used potentially in the extraction of anthocyanin and carotenoid, hence wastage of these flowers can be converted into wealth and further study still needed for their applicability on food, textile and cosmetics which can lead to commercialization of these pigments.

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