Effects of process parameters on the color quality of anthocyanin-based colorants from conventional and microwave-assisted aqueous extraction of sweet potato (*Ipomoea batatas* L.) leaf varieties

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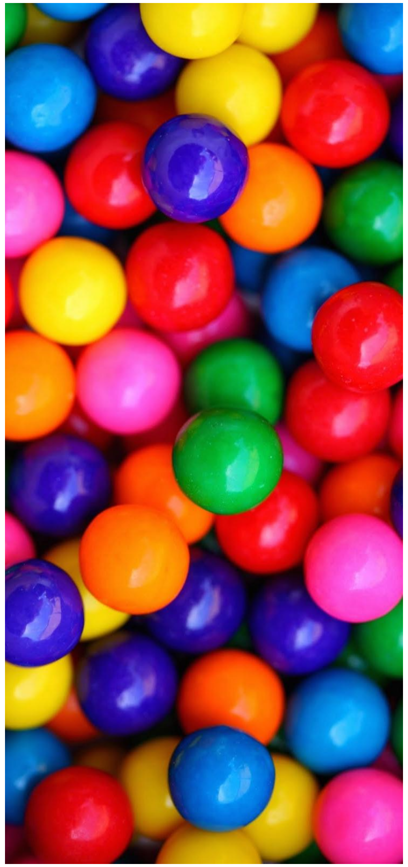
Rationale

- Color is a significant trait of sensory quality evaluation and a key attribute that affects the perception of an individual to foods. Colorants are to make food products more appealing and desirable to consumers
- Natural colorants are more preferred because of the detrimental issues on safety and health by synthetic colorants.



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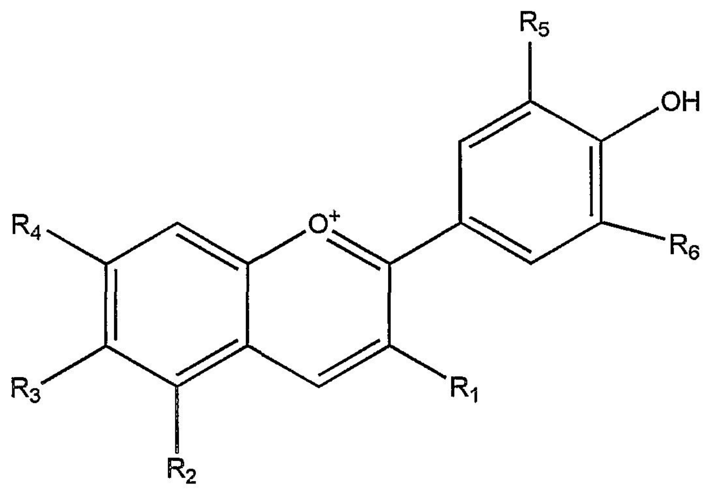
Rationale



- **Anthocyanins**
  - Approved natural food colorant which is also the most important water-soluble natural pigments among group of flavonoids
  - known for their excellent antioxidant properties which can protect the human body from oxidative stress thereby decreasing the risk of chronic disease such as aging, diabetes, cardiovascular diseases, and cancer
  - A wide range of color hues such as red, violet, purple and blue in plants like fruits, flowers, leaves, and tubers can be produced by anthocyanins at varying pH
  - Applied to foods and beverages such as yogurt, jellies, juices, and wine
  - pH, temperature, light, oxygen, and metal ions affect the stability of anthocyanins

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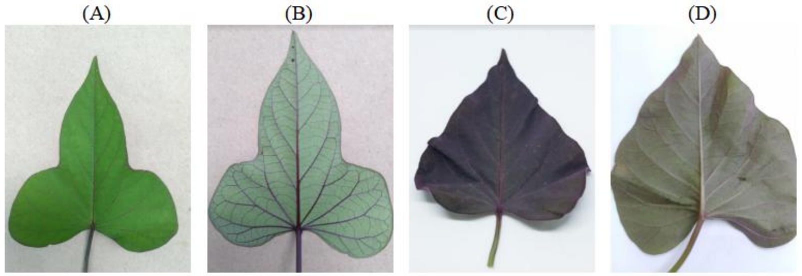
Rationale

- One of the potential sources of anthocyanins is sweet potato (Ipomoea batatas L.), the seventh most important food crop and the second root and tuber crop grown next to cassava.
- In comparison with the other parts of sweet potato, the leaves contain significantly higher amounts of anthocyanins
- The anthocyanins in sweet potato leaf (SPL) have high potential that they can be used as natural colorants in foods
- They have superior shelf life and equal stability in light and heat as those in red cabbage

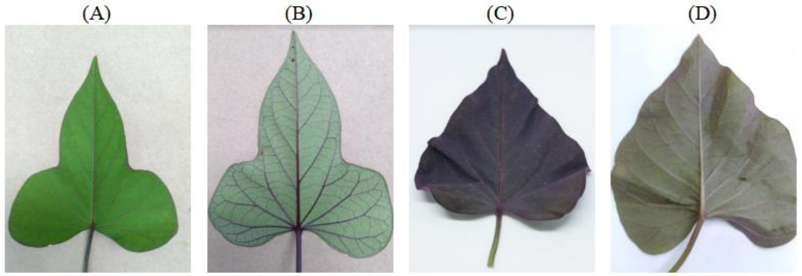


Objective of the Study

To evaluate the effects of process parameters (time and raw material weight[RMW]) of conventional and microwave-assisted aqueous extraction on the color quality (i.e. lightness [L^*], chroma [C^*] and hue [$H°$])of anthocyanin –based colorants of red and Inubi sweet potato (*Ipomoea batatas* L.) leaves

Materials and Methods

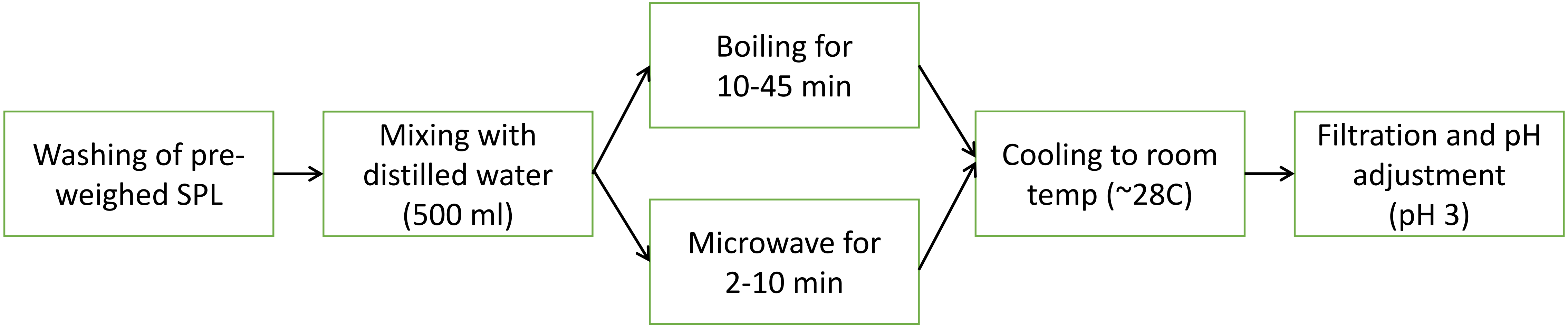
- Inubi and red SPL variety were used
- Red and violet pigments can be observed throughout the leaf blade and veins of red SPL while those of Inubi SPL can only be seen on the veins.
- Inubi SPL were obtained from Sapang Multipurpose Cooperative, Moncada, Tarlac while red SPL was procured from Fresh-Q Industries, Brgy. Sulucan, Angat, Bulacan.
- Leaves were procured at the age of 3 months and transported to the laboratory where it was stored inside the chiller (~4°C) prior to analysis.



Materials and Methods

Extraction Methods

- Conventional (boiling) and Microwave-assisted



Materials and Methods

Table 2.1. Actual values of process parameters of the 14 Runs in the central composite design.

Standard Order	Block	Point Type	X_1, RMW(g per 500 ml d'H_2O)	X_2, BT (min)[a]	X_2, MT (min)[b]
1	Block 1 (Day 1)	Factorial	50.00	10.00	2.00
2		Factorial	125.00	10.00	2.00
3		Factorial	50.00	45.00	8.00
4		Factorial	125.00	45.00	8.00
5		Center	87.50	27.50	5.00
6		Center	87.50	27.50	5.00
7		Center	87.50	27.50	5.00
8	Block 2 (Day 2)	Axial	34.47	27.50	5.00
9		Axial	140.53	27.50	5.00
10		Axial	87.50	2.75	0.76
11		Axial	87.50	52.25	9.24
12		Center	87.50	27.50	5.00
13		Center	87.50	27.50	5.00
14		Center	87.50	27.50	5.00

[a]BT- Boiling time for conventional extraction

[b]MT- Microwave extraction time for microwave-assisted extraction (MAE)

Materials and Methods

Table 2.2. Central composite experimental design showing independent variables with actual and coded values.

Factor	Parameter	Units	Actual Values		Coded Values	
			Minimum	Maximum	Minimum	Maximum
X_1	Raw material weight(RMW)	g per 500 mL water	50	125	-1	1
X_2[a]	Boiling time (BT)	min	10	45	-1	1
X_2[b]	Microwave extraction time (MT)	min	2	8	-1	1

[a]For conventional extraction
[b]For microwave-assisted extraction (MAE)

Materials and Methods

Modelling of Responses

- Different RMW-BT and RMW-MT combinations were generated using Design-Expert® Application V.7.0.0 (DX7, Stat-Ease Inc.).
- Central composite rotatable response surface methodology (RSM) design

$$Y = \beta_0 + \sum_{i=1}^{n} \beta_1 X_1 + \sum_{i=1}^{n} \beta_{ii} X_j^2 + \sum \sum_{i<j=1}^{n} \beta_{ij} X_j , \qquad (1)$$

Materials and Methods

Color Measurement

- Using a bench spectrophotometer (ColorFlexEZ, Hunter Associates Laboratory Inc., Virginia, USA)

$$Chroma(C^*) = \sqrt{a^{*2} + b^{*2}}\ , \qquad (2)$$

$$Hue(H^\circ) = \arctan\left(\frac{b^*}{a^*}\right), \qquad (3)$$

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Results and Discussion

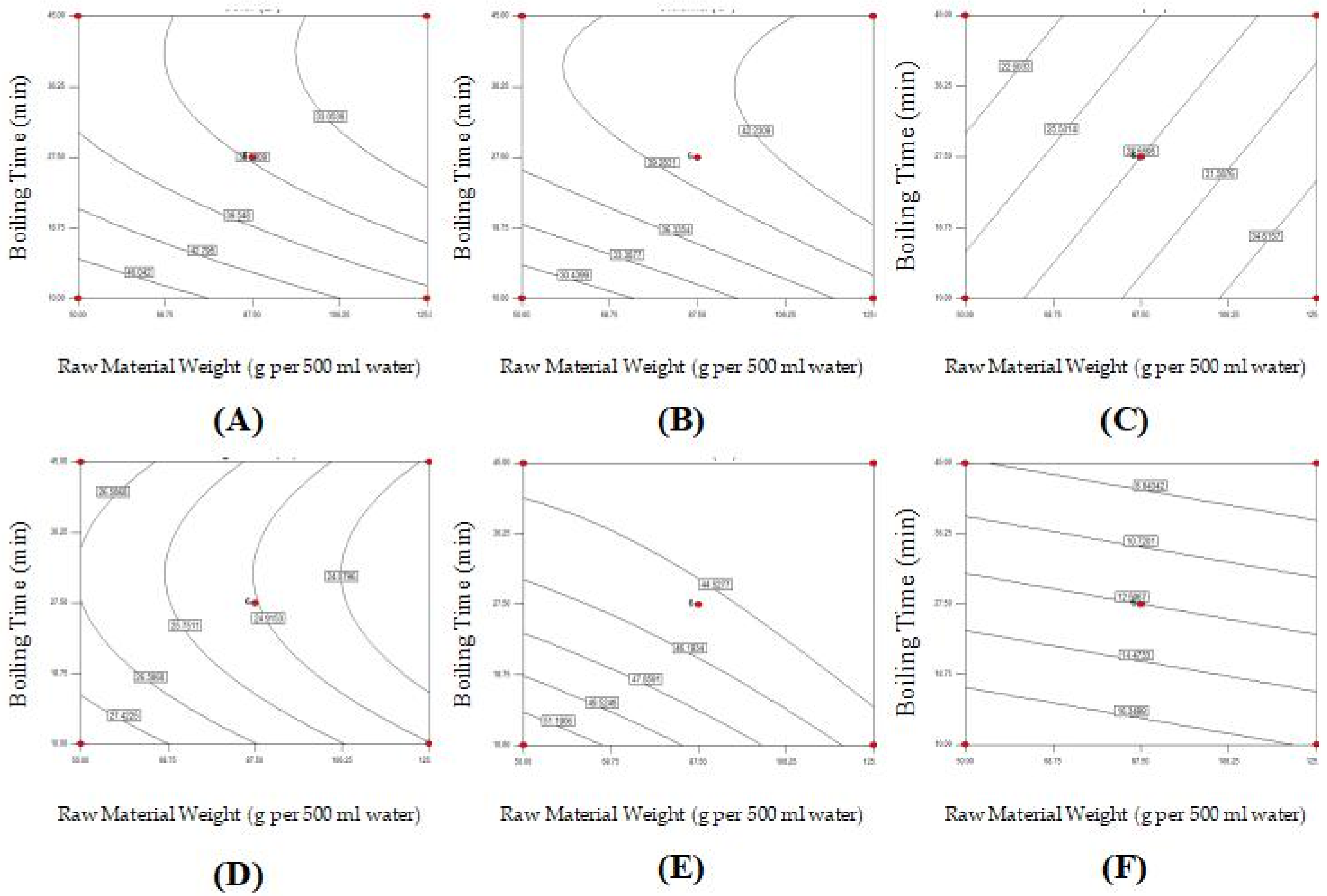

Figure 3.1. Contour plot showing the effect of raw material weight and boiling time on the color of *Inubi*(A-C) and red (D-F) SPLC: (From left to right) lightness, chroma and hue of SPLC.

Results and Discussion

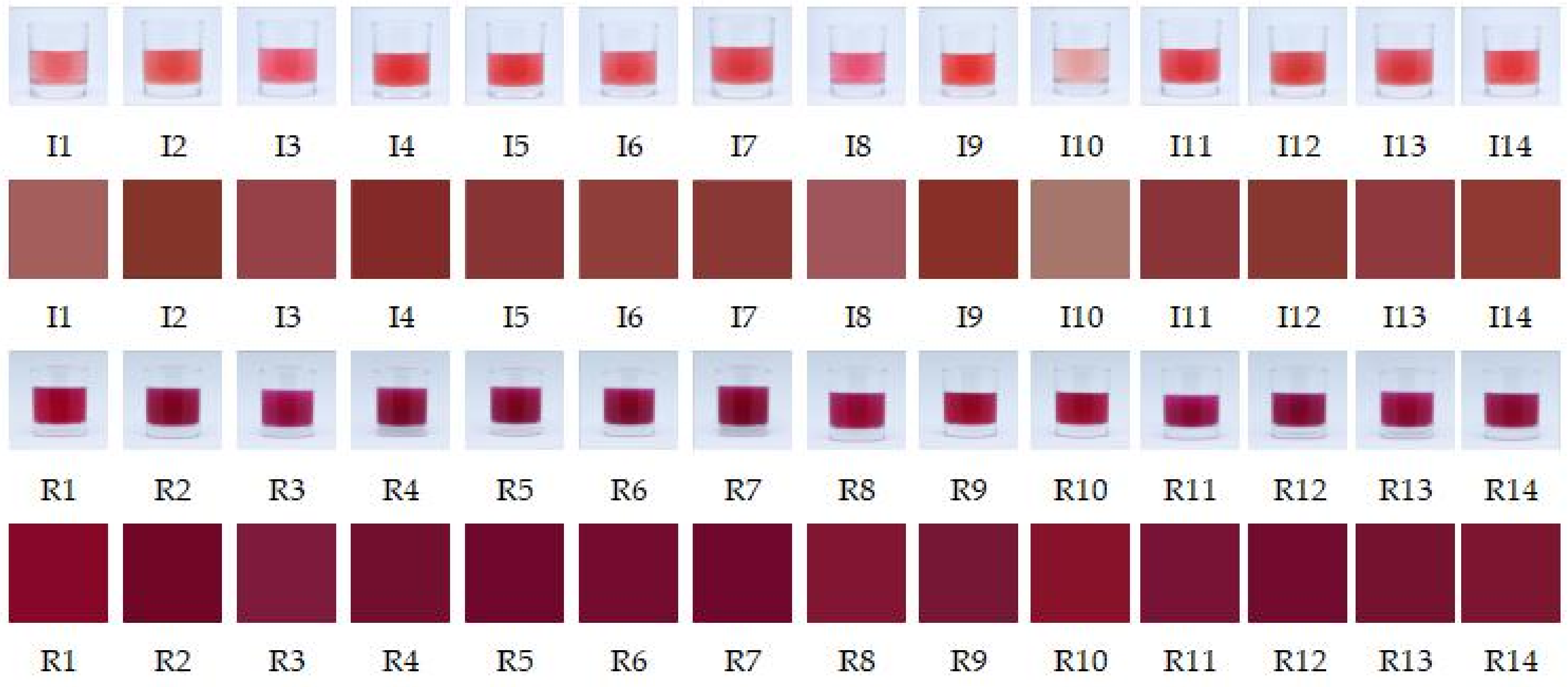

Figure 3.2. Actual images and color swatches of SPLC samples extracted through conventional method arranged according to standard number: (I1-I14) Inubi SPLC and (R1-R14) red SPLC.

Results and Discussion

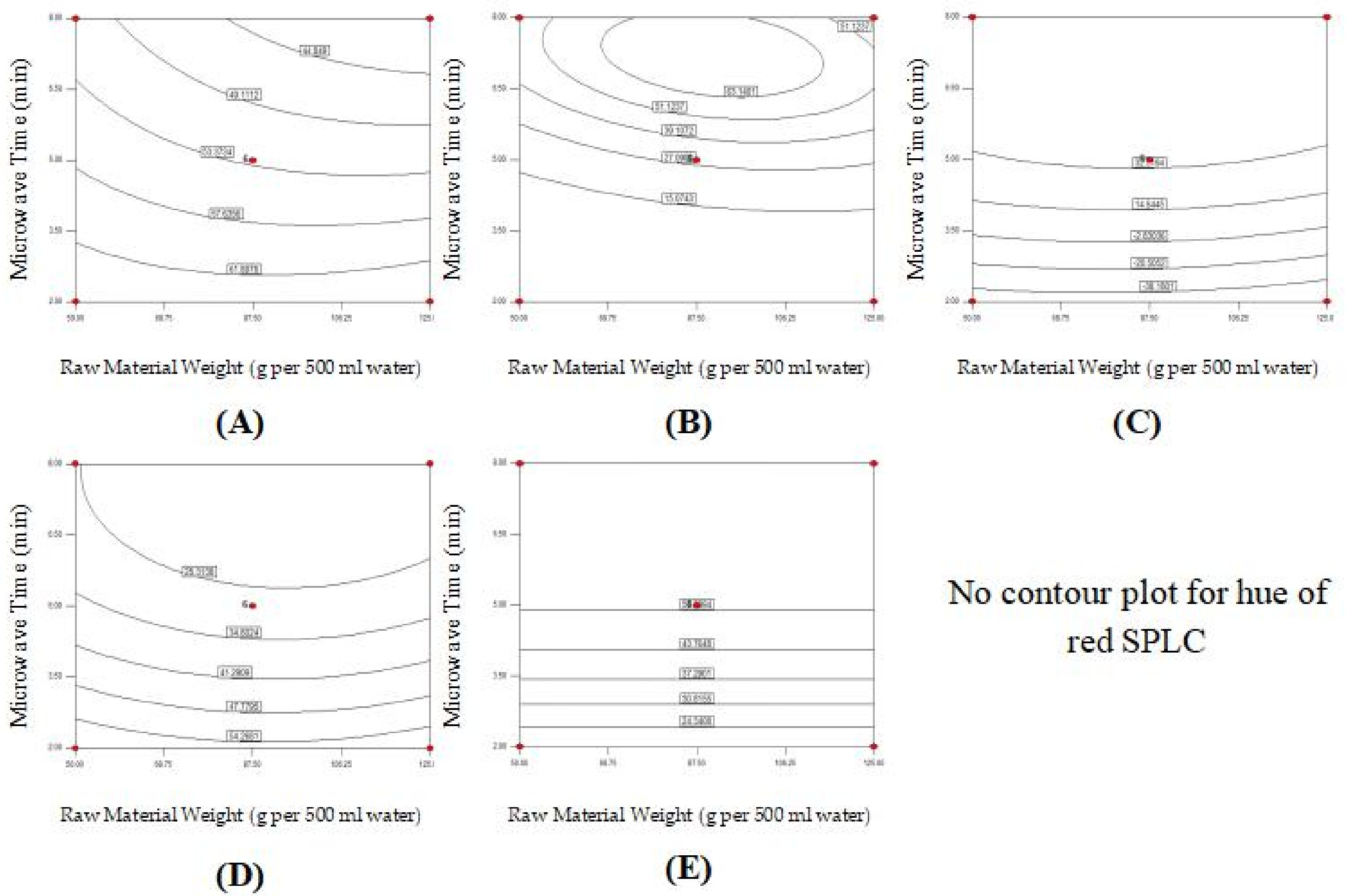

Figure 3.3. Contour plot showing the effect of raw material weight and microwave time on the color of *Inubi*(A-C) and red (D-E) SPLC: (From left to right) lightness, chroma and hue of SPLC.

Results and Discussion

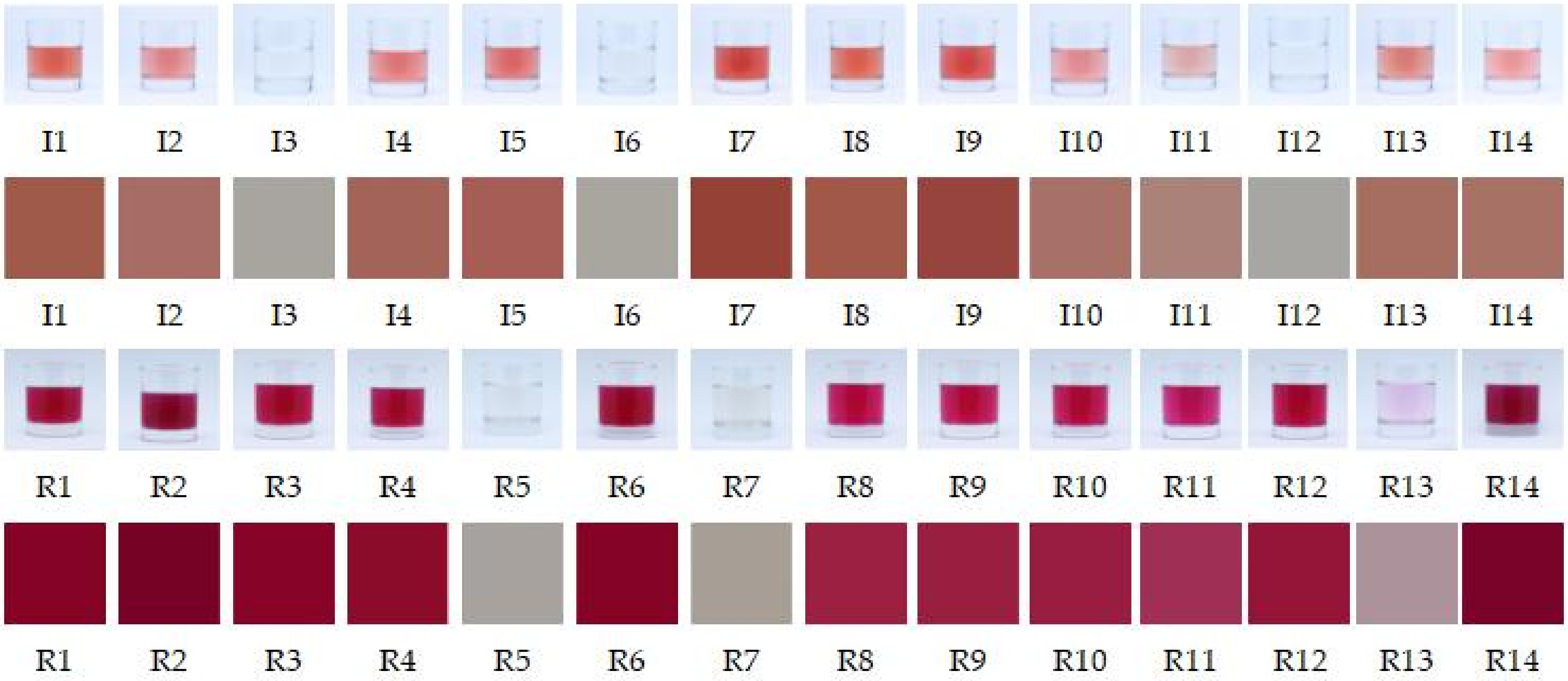

Figure 3.4. Actual images and color swatches of SPLC samples extracted through MAE arranged according to standard number: (I1-I14) Inubi SPLC and (R1-R14) red SPLC.

Results and Discussion

Table 3.3. Summary of verification experiment results.

Response[c]	Conventional Extraction		Microwave Assisted Extraction	
	Inubi SPLC-A[1]	Inubi SPLC-B[2]	Inubi SPLC-A[4]	Inubi SPLC-B[5]
Lightness (L^*)	35.04±1.93[b]	39.97±1.89	81.23±0.01[ab]	88.01±0.01[ab]
Chroma (C^*)	41.34±0.56[b]	40.12±1.91	15.46±0.01	8.65±0.01[ab]
Hue ($H°$)	26.54±3.71	33.38±0.88[b]	-82.14±0.05[ab]	75.15±0.06[ab]
	Red SPLC-A[2]	Red SPLC-B[3]	Red SPLC-A[4]	Red SPLC-B[6]
Lightness (L^*)	23.41±0.81	23.90±0.16[b]	39.70±3.71	25.00±0.95
Chroma (C^*)	46.57±0.20	45.08±0.36[b]	46.60±4.99	49.90±0.79
Hue ($H°$)	15.09±0.57	8.20±1.36[b]	5.60±1.47[b]	18.60±1.64

[1]Conditions: 75 g of SPL per 500 mL distilled water boiled for 20 min
[2]Conditions: 125 g of SPL per 500 mL distilled water boiled for 10 min
[3]Conditions: 50 g of SPL per 500 mL distilled water boiled for 30 min
[4]Conditions: 34.5 g of SPL per 500 mL distilled water extracted through MAE for 5 min
[5]Conditions 50 g of SPL per 500 mL distilled water extracted through MAE for 2 min
[6]Conditions 125 g of SPL per 500 mL distilled water extracted through MAE for 8 min
[a]Significantly different from the predicted value based on prediction interval.
[b]Significantly different from the predicted value based on confidence interval.
[c]Expressed as mean ± standard deviation.

Conclusion and Recommendation

- Boiling time/microwave time and raw material weight affected the color quality of Inubi and red SPLC
- RMW and BT and MTgenerally had a significant ($p<0.05$) effect on the color (L*, C*, H°) of both SPLC varieties.
- A more in-depth analysis on the possible effects of process parameters on the extraction of anthocyanin-based colorants from sweet potato leaves
- Useful on the possible optimization as well as exploring more on the nature of colorants found in SPLC
- It is recommended that the effect of process parameters of other extraction methods on the quality of SPLC and other possible sources of anthocyanin-based colorants to be explored.

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