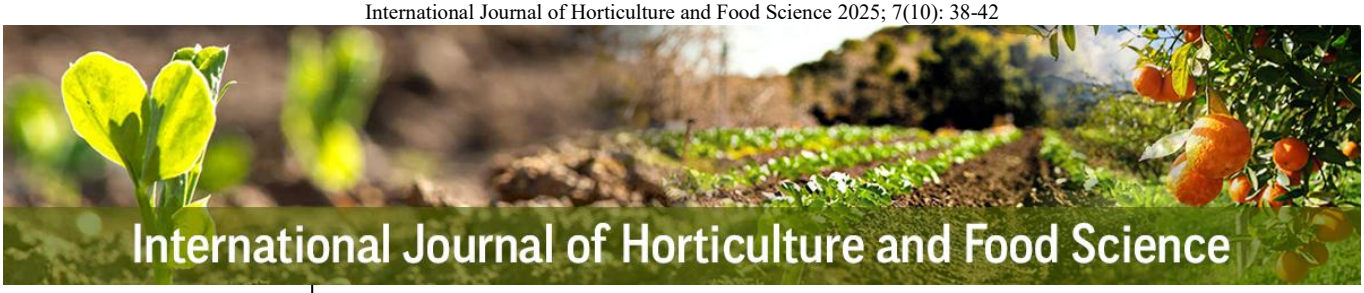

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Kamaleshwaran Nanjundapuram Karunamoorthy
Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

Sundharaiya K
Department of Fruit Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

Rajadurai KR
Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

Amirtham D
Department of Plant Biotechnology, CPMB & B, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Sivakumar KP
Department of Food science and nutrition, Community Science College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India

Corresponding Author:
Kamaleshwaran Nanjundapuram Karunamoorthy
Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

Assessment of natural dye extracted from *Ixora coccinea* L. flowers for commercial textile utilization using bio-mordant

Kamaleshwaran Nanjundapuram Karunamoorthy, Sundharaiya K, Rajadurai KR, Amirtham D and Sivakumar KP

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Abstract
The study aimed to assess the dyeing potential of *Ixora coccinea* L. flower extract on cotton fabric using eco-friendly bio-mordants for sustainable textile applications. Shade-dried flowers were subjected to aqueous and ethanol extraction, and dyed cotton fabrics were evaluated for color fastness properties, including resistance to light, washing, rubbing, and perspiration. Among the mordants tested—myrobalan, pomegranate rind, majuphal seed powder, and alum—pomegranate rind powder demonstrated superior performance with solvent extract, exhibiting excellent color fastness (scores up to 6 for light and 5 for washing). Solvent extraction consistently produced better results than aqueous extraction, indicating higher dye-fibre binding efficiency. The findings highlight *Ixora coccinea* ethanol dye extract along with pomegranate rind powder as a bio-mordant, as a promising source of natural dye with significant commercial potential in eco-textile industries, promoting sustainable and non-toxic alternatives to synthetic dyes.

Keywords: *Ixora coccinea*, natural dye, bio-mordant, color fastness, sustainable textiles

1. Introduction
Synthetic dyes are extensively utilized in textile industry which pose environmental and health risks due to their non-biodegradable nature, toxicity, and the pollution. Consequently, there is an increasing interest in natural dyes derived from plants, which are renewable, biodegradable, and generally considered safer. Natural dyes also have other properties, such as repelling insects, neutralizing odours, acting as antifeedants and inhibiting the growth of microorganisms. It also protects from UV rays and possesses qualities like luminescence (1). Flowers are rich sources of pigments like anthocyanins, carotenoids, flavonoids and betalains that impart color, which can be employed as potential sources for natural dye (2). Many research has been done on underutilized flowers like *Delonix regia*, *Ceasalpinnia pulcherimma*, Lantana, Plumeria and Bougainvillea for textile colorant (3). *Ixora coccinea* L., is one such underutilized ornamental shrub in tropical areas, produces a large number of red-pink flowers rich in anthocyanins. Ixora (red color) is grown in Karur, Tiruchirappalli, Dindigul and Salem districts of Tamil Nadu for loose flower purposes. The peak season of flowering is April-May (4). While the ornamental and medicinal benefits of Ixora have been studied, its potential for dyeing textiles has not been thoroughly evaluated under conditions relevant to commercial use, particularly with eco-friendly bio-mordants. This study seeks to assess the dyeing potential of *Ixora coccinea* flowers on cotton fabric by examining color fastness properties with various bio-mordants to determine its commercial feasibility.

2. Materials and Methods
2.1 Plant material and extraction
Ixora coccinea (Red type) flowers were collected from the Botanical Garden of Tamil Nadu Agricultural University, Tamil Nadu, India. The flowers were shade-dried for ten days at room temperature until they reached a moisture content of 20 percent, then ground into powder. Two methods of extraction; Aqueous and Ethanol method was carried out. Aqueous extraction was done using water bath at 80 °C for three hours with a solvent-to-sample ratio of 30 mL/g. Ethanol extraction was performed in a Soxhlet apparatus at 80 °C for three hours

with a solvent-to-sample ratio of 10 mL/g. The extract was filtered (Whatman No.1) and concentrated using a rotary evaporator to create a usable dye bath (5).

2.2 Fabric preparation
100% cotton knitted fabric (10 × 10 cm) was scoured in 5% NaOH at 60 °C for one hour to eliminate impurities, then rinsed with distilled water and shade-dried.

2.3 Mordanting treatments
Cotton samples were pre-mordanted with the following treatments (6 replicates per treatment). Mordanting was carried out by immersing fabrics in mordant solution (material: liquor ratio 1:20) at 60 °C for 1 h, followed by rinsing and shade drying.

Table 1: Bio-Mordants used in dyeing

Treatment	Bio-Mordant	Concentration (%)
T_1	Control (no mordant)	-
T_2	Myrobalan seed powder (*Terminalia chebula*)	10
T_3	Pomegranate rind powder (*Punica granatum*)	10
T_4	Majuphal seed powder (*Quercus infectoria*)	10
T_5	Alum	4

2.4 Dyeing procedure
The cotton fabric was dyed using the dye extracted from Ixora flowers as outlined by (6). Mordanted fabrics were dyed with Ixora extract under the same ratio (1:20) at 80 °C for 1 h. Then it was soaked overnight in the dye bath for better absorption. Overnight-soaked fabric was treated with dye fixative by dipping in lime water for 15 minutes. After dyeing, fabrics were washed until wash-off was minimal, then shade dried.

2.5 Evaluation of color fastness
The dyed cotton fabrics were tested for color fastness at the South India Textile Research Association (SITRA), Coimbatore.

2.5.1. Color fastness to light
This test adheres to the standardized protocol ISO 105-B02. A piece of dyed cotton fabric of a standard size is cut and mounted on a card next to a blue wool reference standard, which includes eight strips with predetermined light fastness ratings (1 = very poor, 8 = excellent). Both the sample and the reference are subjected to an artificial light source, usually a xenon arc lamp, which mimics natural sunlight. The exposure time varies according to the standard, ranging from a few hours to several days. The test chamber maintains specific temperature (40-60°C) and humidity (30-65%) conditions. After exposure, the fabric's color change is evaluated using a grey scale (ISO 105-A02).

2.5.2. Color fastness to washing
The test follows the standardized procedure ISO 105-C06. A standard-sized fabric sample is sewn with an adjacent multifiber fabric (comprising wool, cotton, polyester, nylon, acetate, and acrylic) to evaluate both color loss and staining. The sample is placed in a laundrometer with a detergent solution, typically containing sodium perborate and a non-ionic detergent, at a specified temperature (30-95 °C), duration (30-45 minutes), and agitation level, depending on the intended washing conditions. After washing, the sample is rinsed and dried under controlled conditions. The degree of color change is assessed using a grey scale for color change (ISO 105-A02), while staining on the adjacent fabric is evaluated with a grey scale for staining (ISO 105-A03). The results are rated on a scale from 1 (poor) to 5 (excellent).

2.5.3. Color fastness to rubbing
This test adheres to the standard procedure ISO 105-X12. During the test, a fabric sample is placed on a testing apparatus, and a white cotton cloth is rubbed against it with controlled pressure and strokes. The test is performed under two conditions *viz*., dry rubbing and wet rubbing, where the cloth is dampened with water. After the rubbing process, the white cotton cloth is examined for color transfer using a grey scale for staining (ISO 105-A03). The results are rated from 1 (poor) to 5 (excellent).

2.5.4. Color fastness to perspiration
This test follows the standard method ISO 105-E04. A fabric sample is sewn to a multi fiber adjacent fabric and immersed in two solutions *viz*., acidic (pH ~ 4.3, using acetic acid and sodium chloride) and alkaline (pH ~8.0, using sodium carbonate and sodium chloride), to replicate human sweat conditions. After a 30 minute soak, the sample is placed under a fixed pressure of 4.5 kg between glass or acrylic plates and incubated at 37°C for 4 hours to simulate body heat. The sample is then air-dried. The extent of color change is evaluated using a grey scale for color change (ISO 105-A02), and staining on the adjacent fabric is assessed with a grey scale for staining (ISO 105-A03). The results are rated from 1 (poor) to 5 (excellent).

3. Results and Discussion
Cotton fabrics dyed with Ixora flower extract exhibited shades of colors ranging from brown to pale pink with different mordants. The shades of color obtained after dyeing with aqueous and ethanol dye extract with different bio-mordants are presented in Fig. 1 and 2. The dyed fabrics were tested for their fastness properties and the results are enclosed below.

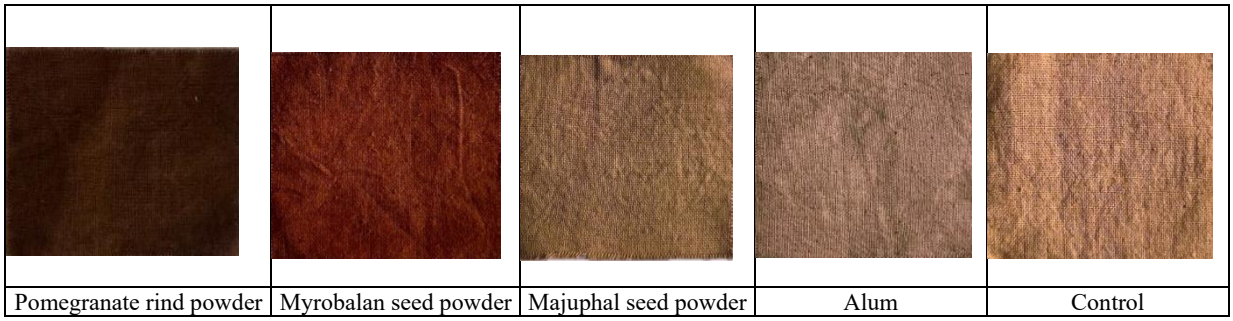

Fig 1: Dyeing of cotton fabric with Ixora aqueous dye extract using different mordants

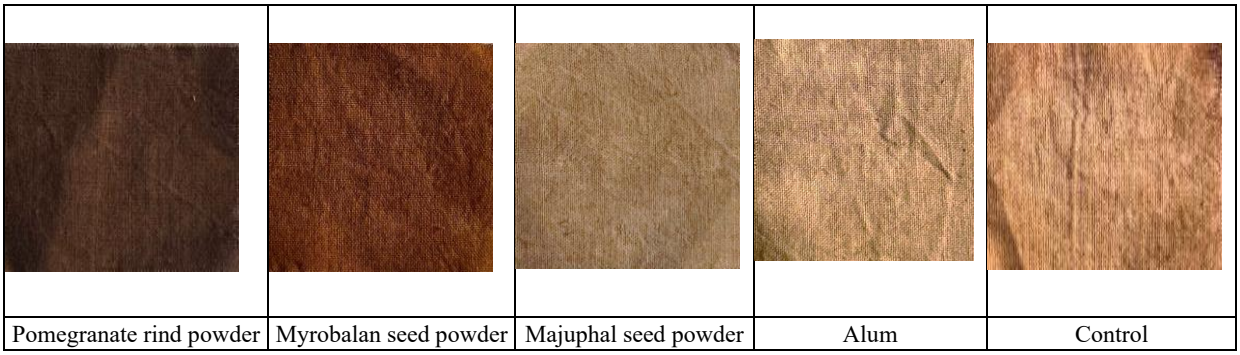

Fig 2: Dyeing of cotton fabric with Ixora solvent dye extract using different mordants

3.1. Color fastness to light

The light fastness of cotton fabrics dyed with Ixora flower dye (both aqueous and solvent) was assessed based on ISO 105-B02 standard. Fastness ratings were assigned based on blue wool standard fabrics, and the results are detailed in Table 2. There were notable differences among the treatments. The cotton fabric treated with pomegranate rind powder as a mordant achieved the highest color fastness, scoring 6 with the solvent extract and 5 with the aqueous extract. This effectiveness is mainly due to the high tannin content in pomegranate rinds, which forms stable complexes with dye molecules. Adeel, Ahmad (7) noted that tannin-rich mordants provide protective coordination complexes that safeguard natural dye chromophores from photodegradation. Myrobalan seed powder also resulted in good fastness, with scores of 5 and 4 faor solvent and aqueous extracts, respectively based on previous research by Punrattanasin, Nakpathom (8) where natural tannin mordants enhance dye-fibre interactions through multiple bonding mechanisms. Fabric treated with alum showed moderate results, scoring 4 with solvent and 3 with aqueous extract. The moderate performance of alum (ratings 4 and 3) indicates a simple metal ion bonding mechanism, which offers less comprehensive protection against light degradation compared to polyphenolic mordants. The control (without mordant) recorded the lowest, with scores of 2 for solvent and 1 for aqueous extracts, indicating poor color retention. The findings suggest that using pomegranate rind powder and myrobalan seed powder as mordants significantly enhanced color retention under light exposure, especially with solvent dye extract. This observation is consistent with the study by Shams-Nateri, Hajipour (9), who found that ethanol generally extracts more light-stable compounds from plant materials. Aqueous dye extract exhibited slightly lower fastness ratings across all treatments.

Table 2: Color fastness of fabric dyed with Ixora flower extract to light

Mordants	Light (ISO 105-B02)	
	Solvent dye extract	Aqueous dye extract
Control	2	1
Myrobalan seed powder	5	4
Pomegranate rind powder	6	5
Alum	4	3
Majuphal seed powder	3	3

The scale ranges from 1 (Poor) to 8 (Excellent), reflecting the extent of color change due to light exposure.

3.2. Color fastness to washing

The evaluation of color fastness to washing for dyed fabrics was assessed based on ISO 105-C06 standards. Assessment of color retention involved measuring the extent of staining and color change and the results are detailead in Table 3. Fabrics treated with pomegranate rind powder demonstrated the highest color fastness to washing, achieving a score of 4 for both solvent and aqueous dye extracts. This finding aligns with research by Jabar, Adedayo (10), who studied the effect of solvent on natural dye extraction. They also found that the choice of solvent impacts color yield, while mordant selection remains the main factor in determining washing fastness properties. These findings are further supported by Adeel, Yameen (11), whose comparative research on extraction methods demonstrated that solvent polarity significantly influenced the binding affinity of the extracted compounds with bio-mordants, with solvent extractions showing enhanced washing fastness when

combined with tannin-rich natural mordants like pomegranate. Following this, myrobalan seed powder-treated fabrics scored 4 and 3, for solvent and aqueous dye extracts respectively. The control showed the lowest fastness, with a score of 2 for both the dye extracts. Fabrics treated with alum showed moderate color fastness, scoring 3 for solvent dye extract and 2 for aqueous dye extract. The consistently lower washing fastness observed with aqueous extracts in alum mordanted samples (rating of 2 compared to 3 for solvent extract) correlates with observations by Phan, Van Den Broeck (12), who found that water extracts the compounds with different binding affinities for metallic mordants compared to ethanol extraction. Their comprehensive study on the effects of solvents in natural dyeing revealed that solvent extraction typically yields compounds with greater affinity for metal-coordination complexes, which translates to enhanced washing durability. Majuphal seed powder-treated fabrics received a score of 3 for both dye extracts. These findings suggest that pomegranate rind powder was the most effective mordant for improving color fastness to washing.

Table 3: Color fastness of fabric dyed with Ixora flower extract to washing

Mordants	Washing (ISO 105-C06)	
	Solvent dye extract	Aqueous dye extract
Control	2	2
Myrobalan seed powder	4	3
Pomegranate rind powder	4	4
Alum	3	2
Majuphal seed powder	3	3

Grey Scale rating, where 5 indicates no staining and 1 indicates heavy staining.

3.3. Color fastness to rubbing

The grey scale rating for rub fastness demonstrated that the performance of dyed fabric varied according to the mordant used as mentioned in Table 4. In the case of solvent dye extract, fabrics treated with pomegranate rind powder achieved the highest dry rub fastness score of 5. Vankar and Shukla (13) found that the superior performance of pomegranate was due to its high content of gallic acid and ellagitannin, which form stable coordination complexes with dye molecules, enhancing abrasion resistance. This was followed by fabrics treated with myrobalan seed powder, alum and majuphal seed powder, each receiving a score of 4. The control, with a score of 3, showed moderate staining. Under wet rubbing conditions, pomegranate rind powder-treated fabrics excelled with a score of 4, while the control scored the lowest of 2, indicating a higher degree of color transfer. For aqueous dye extracts, fabrics mordanted with pomegranate rind powder exhibited the highest dry rub fastness, rate of 4, followed by the control, myrobalan seed powder, alum and majuphal seed powder, all scoring 3. In wet conditions, pomegranate rind powder achieved the highest fastness score of 4, whereas the control had the lowest score of 1, indicating significant color loss. Benli (14) explains that wet rub fastness scores were consistently lower than dry scores because water acts as a plasticizer during wet rubbing tests, with tannin-rich bio-mordants offering better protection against this effect.

Table 4: Color fastness of fabric dyed with Ixora flower extract to rubbing

Mordants	Rubbing (ISO 105-X12)			
	Solvent dye extract		Aqueous dye extract	
	Dry	Wet	Dry	Wet
Control	3	2	3	1
Myrobalan seed powder	4	3	3	3
Pomegranate rind powder	5	4	4	4
Alum	4	3	3	2
Majuphal seed powder	4	2	3	2

Grey scale rating 1 (Poor) to 5 (Excellent)

3.4. Color fastness to perspiration

The assessment of color fastness for fabrics dyed with Ixora flower extract was performed under perspiration conditions, adhering to the IS/ISO 105 E04-2008 (RA 2019) standard for both acidic and alkaline environments. The color fastness was evaluated using a grey scale, and the results are summarized in Table 5. Fabrics treated with pomegranate rind powder achieved the highest color fastness of 5 in acidic conditions with solvent dye extract and 4 in myrobalan seed powder and alum. This demonstrates that pomegranate rind powder had superior resistance to fading due to perspiration. The control resulted in the lowest scores (3 in acidic and 2 in alkaline conditions for both dye extracts), emphasizing the role of mordants in color retention, which aligns with the findings of Rani, Guru (15), who found that non-mordanted natural dyes form weak hydrogen bonds that are easily disrupted by perspiration. Among other mordants, myrobalan seed powder and majuphal seed powder exhibited moderate fastness scores, ranging from 3 to 4 across different conditions in both dye extracts. Alum, on the other hand, showed the lowest fastness score of 2, particularly in alkaline conditions with aqueous dye extract supporting the study of Singhee (16), who found that aluminium-based mordants form coordinate bonds that are less stable in alkaline environments. Enaru, Drețcanu (17) demonstrated that anthocyanin-based dyes exhibit greater stability in acidic environments that maintain their molecular structure, while alkaline conditions induce structural changes that weaken dye-fibre bonds.

Table 5: Color fastness of fabric dyed with Ixora flower extract to perspiration

Mordants	Perspiration (ISO 105-E04)			
	Solvent dye extract		Aqueous dye extract	
	Acid	Alkaline	Acid	Alkaline
Control	3	2	3	2
Myrobalan seed powder	4	3	3	4
Pomegranate rind powder	5	4	4	4
Alum	4	3	3	2
Majuphal seed powder	3	3	4	3

Grey scale rating 1 (Poor) to 5 (Excellent)

4. Conclusion

The study confirms *Ixora coccinea* flower extract as a viable natural dye for cotton fabrics using bio-mordants. Solvent dye extract generally yielded better color fastness results compared to aqueous dye extract across all mordant treatments, suggesting solvent-based extraction may be preferable for textile applications. Among those tested, pomegranate rind powder is the most efficient mordant, delivering superior fastness properties. Fabrics generally showed better color retention in acidic perspiration conditions compared to alkaline conditions, particularly with solvent dye extracts, suggesting pH sensitivity of the Ixora dye-fabric interaction. The findings support commercial application potential. Future work should test color retention under prolonged exposure, and explore cost and scalability.

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References

1. Kumar J, Sinha AK. Resurgence of natural colourants: a holistic view. Natural Product Research. 2004;18(1):59-84.
2. Tanaka Y, Sasaki N, Ohmiya A. Biosynthesis of plant pigments: anthocyanins, betalains and carotenoids. The Plant Journal. 2008;54(4):733-49.
3. Datta DB, Das D, Sarkar B, Majumdar A. *Lantana camara* flowers as a natural dye source for cotton fabrics. Journal of Natural Fibers. 2023;20(1):2159604.
4. Reshma R, Ganga M, Visalakshi M. Standardization of post-harvest management techniques for *Ixora* (*Ixora* spp.). International Journal of Environment and Climate Change. 2023;13(10):1267-80.
5. Jha CK, Ratan Kumar RK, Kumar S, Rajeswari V. Extraction of natural dye from marigold flower (*Tagetes erecta* L.) and dyeing of fabric and yarns: colorimetric analysis and fastness properties. 2015.
6. Kulkarni S, Gokhale A, Bodake U, Pathade G. Cotton dyeing with natural dye extracted from pomegranate (*Punica granatum*) peel. Universal Journal of Environmental Research and Technology. 2011;1(2).
7. Adeel S, Ahmad S, Habib N, Mia R, Ahmed B. Coloring efficacy of *Nyctanthes arbortristis* based yellow natural dye for surface-modified wool. Industrial Crops and Products. 2022;188:115571.
8. Punrattanasin N, Nakpathom M, Somboon B, Narumol N, Rungruangkitkrai N, Mongkholrattanasit R. Silk fabric dyeing with natural dye from mangrove bark (*Rhizophora apiculata* Blume) extract. Industrial Crops and Products. 2013;49:122-9.
9. Shams-Nateri A, Hajipour A, Dehnavi E, Ekrami E. Colorimetric study on polyamides dyeing with weld and pomegranate peel natural dyes. Clothing and Textiles Research Journal. 2014;32(2):124-35.
10. Jabar JM, Adedayo TE, Odusote YA. Eco-friendly dyeing of cotton fabric using *Mucuna slonaei* F extract: effects of metal salts pre-mordanting on color strength and fastness properties. Current Research in Green and Sustainable Chemistry. 2021;4:100151.
11. Adeel S, Yameen M, Asghar F, Amin N, Ozomay M, Mirnezhad S. Extraction and application of plant-based tannins as sources of natural colourants. Natural Dyes and Sustainability. 2024:103-26.
12. Phan K, Van Den Broeck E, Van Speybroeck V, De Clerck K, Raes K, De Meester S. Anthocyanins from blueberries as a natural dye for cotton: experimental and theoretical study. Dyes and Pigments. 2020;176:108180.
13. Vankar PS, Shukla D. New Trends in Natural Dyes for Textiles. Woodhead Publishing; 2019.
14. Benli H. Bio-mordants: a review. Environmental Science and Pollution Research. 2024;31(14):20714-71.
15. Rani J, Guru R, Singh J, Santhanam S. Eco-dyeing and finishing of cotton fabric using colour derived from lotus seed: enhanced fastness with chitosan. Textile and Leather Review. 2024;7:1039-60.
16. Singhee D. Review on natural dyes for textiles from wastes. Chemistry and Technology of Natural and Synthetic Dyes and Pigments. IntechOpen; 2020.
17. Enaru B, Drețcanu G, Pop TD, Stănilă A, Diaconeasa Z. Anthocyanins: factors affecting stability and degradation. Antioxidants. 2021;10(12):1967.