

Extraction and Characterisation of Betacyanin as a Dye Pigment from Dragon fruit: A review

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Abstract: From past few years due to eco-friendly nature of people, the use of natural dyes has increased several folds. Natural dyes can be obtained from the pigments that contained from various parts of plants like leaves, fruit and rind of the plant. The use of natural colorants in textile is attributed to the increased awareness about environmental contamination created by intermediates and harmful chemicals which are used in synthetic dyeing process. The natural colorants are non carcinogenic, easily biodegradable and non toxic for living organism. Considering energy saving and environmental safety, natural dyes have attracted the attention of researchers and industrialists to be used in textiles and other allied industries. Moreover, plants based natural dyes also exhibit antimicrobial, antioxidant, which make these ideal to be used in the textile and other related industries. A lot of techniques are being used to improve dyeing behaviour of natural dyes and modification of fabric either by improving extraction process or by enhancing dye uptake activity of fabric to get good shades and fastness properties. Normally, pitaya peels are discarded as garbage while processing. The flesh and peel is a potential source of colour for food dye and colorant. Dragon fruit peel consists of betacyanin pigment (0.15 %) and pectin (10.8 %) was high in the peel.

Keywords: Dragon fruit; Pitaya, Betacyanin, Pectin, *Hylocereus polyrhizus*, Antioxidant, Antibacterial, Anti-carcinogenic.

1. Introduction

Dyes from nature have been used in the past for colouration of wool, cotton, silk and fur. The dyes also found applications in cosmetics, ink making and as the paints for artists [1]. Until the 19th century there occurred no changes in the use of the ancient dyestuff. In the Middle Age, it was the peak period for business concerning plantation and further processing of natural dyestuff all over the world. It continued till the appearance of synthetic dyes. The dyes from the nature began losing their market significance with the evolution of synthetic dyes [2]. It is obvious due to the limitations and some technical problems in the procurement of natural dyes. Limitations of natural dyes, rapid increase in demand of dyes and inventions in dye chemistry shifted our focus towards synthetic dyes. As a result, the modern world is made more acquainted to these synthetic dyes. Due to their easy availability, simplicity in application and higher reproducibility in shades, these new dyes have replaced nearly all the natural dyes today. Research reveals that synthetic dyes are suspected to cleave dangerous chemicals. Such chemicals are found to be allergic and carcinogenic in nature. Ultimately these dyes are indirectly detrimental to our health. In this context, Germany has taken the initiative to ban the plausible azo dyes in the year 1996. Soon after that, about 74 azo dyes have been banned worldwide in view of their carcinogenic nature.

Today, interestingly than ever before, the importance of natural dyes has been increased worldwide. There is fair degree of environment consciousness seen among the people. Natural dyes like other natural products are becoming more popular. Most of the natural dyes are non baneful, biodegradable and they are not harmful to environment. Hence, people are getting attracted towards such dyes. The revival of interest towards the use of natural colorants in textile is attributed to the increased awareness about environmental contamination created by intermediates and chemicals being used in synthetic dyeing process. The natural colorants are considered as non carcinogenic, easily biodegradable and non toxic for human health [3].

1.1. Colorants: Definition and types:

Colorants are in use since the prehistoric times. These may be either inorganic or organic in nature. Both these groups do have the examples from natural and synthetic sources. Primarily, there are two types of colorants, viz., pigments and dyes. Pigments consist of small molecules that are practically insoluble in the medium of application [4]. These need binders like polymers for attachment to the substrates. But the dyes are completely or at least partly soluble in the medium of application.

The dyes are categorized in two ways:

(a) chemical composition wise: this classification is exclusively used by dye manufacturers

(b) application wise: especially this classification is used by dyers [5].

Each dye is described based on “Colour Index classification”, an internationally accepted system. It includes a number and a name. The number gives its chemical class whereas the name speaks about its use. The examples of class of dyes defined by an end-user especially a textile dyer are: i) Acid dyes ii) Basic dyes iii) Direct dyes iv) Disperse dyes v) Fluorescent brighteners vi) Reactive dyes vii) Sulphur dyes viii) Vat dyes ix) Pigments dyes x) Solvent dyes. After the invention of “mauvein”, the first synthetic dye by William Perkin in AD 1856, the dyes from nature have been continuously substituted by synthetic dyes [6].

1.2. Advantages of natural dyes:

Because of various problems concerning synthetic dyes, at this stage of the civilization it seems promising for re-entry of the natural dyes. Natural dyes have certain advantages as follows [7-8]:

1. Natural dyes can give soft and subtle as well as the brightest colour to the textiles.
2. With proper mix and match system, dyestuff from natural sources can produce varied colours.
3. Change in mordents can shift the colour of a same dye to a wide range. This is unique feature of natural dyes.
4. Most of the natural dyes being agro based, these are renewable and biodegradable. The synthetic dyes are from non-renewable basic raw materials.
5. There are no disposal problems because of the nature of natural dyes.
6. Many dye yielding plants can be grown on wastelands.
7. In the same land, dye yielding plants can grow along with other crops. So there is no extra requirement of land. Thus the value of agricultural areas is increased.
8. This industry has potential to provide jobs to all those engaged for various related tasks.
9. There are no health hazards on the contrary sometimes health care and cure are the additional benefits.
10. Manufacture of natural dyes involves no or mild chemical reactions.
11. These dyes are very well harmonized with nature.
12. Ecological damage is controlled as natural dyes are from renewable resources.
13. The application of natural dyes has potential to achieve carbon credits as it curtails the use of synthetic dyes from petroleum feedstock, the fossil commodity.

Dragon Fruit (*Hylocereus polyrhizus*) belongs to family Cactaceae fruit of the genus *Stenocereus*. The dragon fruit is cultivated in dry, tropical or subtropical climates where annual rainfall ranges from 20-50 inch per year. As for the fruit production, one plant can produce up to 4-6 cycles of fruits per year and fruits are harvested when they are fully expanded and the skin become 85% red in colour. The pitaya fruit is fleshy berry with red or yellow peels with scales. The pulp may be magenta, white or red depending on the species. The two type of dragon fruits are there depending on fruit peel is yellow pitaya and red pitaya. In red pitaya also two types are there like red pitaya with white flesh and red pitaya with red flesh. They are seeds in the pulp which are very small, black and in ample amount.

Dragon fruit peel consists approximately 30-35% of the whole fruit weight, which is thrown away as garbage. Physico-chemical properties of the discarded dragon fruit peel were determined for recovery of any value-added materials. The moisture content of the peel was approximately 92.7 % and it was low in total soluble solids, protein, fat and ash content. Betacyanin pigment (0.15 %) and pectin (10.8 %) were high in the peel. The red skin fruit is rich source of nutrients and minerals such as vitamin B1, protein, fat, carbohydrate, crude fiber, flavonoid, niacin, pyridoxine, glucose, phenolic, betacyanins, polyphenol, carotene, phosphorus and iron. Red dragon fruit pulp that is beneficial as well as its peel is also highly potential. By the observation it is found that antioxidant activity in the red dragon fruit peel is higher than that of the fruit pulp which helps in reducing cholesterol. The dragon fruit helps the digestive process, prevent colon cancer and diabetes, neutralize toxic substances such as heavy metal, reduce cholesterol levels and high blood pressure and consumed regularly the dragon fruit can help against asthma and cough [9].

2. Material and methods

2.1 Materials:

N. Ramali, P. Ismail and A. Rahmat, et al. [10] used the reagent for spectrophotometric analysis on analytical grade as; absolute ethanol, Folin-Ciocalteu reagent and sodium bicarbonate, 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS), and potassium persulphate, aluminium chloride hexahydrate ($\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$), 2,4,6-tripyridyl-s-triazine (TPTZ), gallic acid, acetate buffer, iron (III) chloride hexahydrate ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$) and rutin a plant pigment (flavonoid) from certain fruit and vegetables.

2.2 Sample preparation:

Dragon fruit (*H. polyrhizus*) is cultivated in various sectors in Maharashtra. The fruit wash with tap water and wipe to dry. The fresh peel then separates from the ripe fruit before cutting into small pieces. The sample further dried at 60 °C in a hot air oven and ground into powder. Sample preparation was conducted by N. Ramali, P. Ismail and A. Rahmat, et al. [10] in reduced light condition in order to minimise pigment loss.

2.3 Colour extraction:

The antioxidant compounds of samples were extracted by N. Ramali, P. Ismail and A. Rahmat, et al. [10] using conventional method or ultrasonic-assisted extraction in order to give more yield.

2.3.1 Conventional Extraction (CV): For the extraction, take 1gm fresh peel powder, 55 ml of distilled water was added to the sample at 1/55 (w/v). The extraction was conducted in triplicate ($n=3$). In shaking incubator at 60 °C, The mixture was shaken at 200 rpm for 120 minutes. From extract, mucilaginous material was separated by use of funnel through Whatman No.1 filter paper to give a coloured solution. The residue was re-extracted for full pigment recovery with water. At room temperature mixture was then centrifuged at 6000 rpm for 15 minutes and supernatant was also saved. Then by the use of supernatants, total phenolic and total flavonoid content, betacyanin content, and antioxidant activity was determined.

2.3.2 Ultrasonic-Assisted Extraction (UE): Take 1 gm fresh peel powder, 55 ml of distilled water was added to the sample at 1/55(w/v). The extraction was conducted in triplicate ($n=3$). At ambient temperature (25 °C), the mixture was then placed in ultrasonic bath and sonicated for 30 minutes at 50 KHz. From mixture, mucilaginous material was separated on a Buchner

funnel through Whatman No.1 filter paper to give a coloured solution. The residue was re extracted for full pigment recovery with water. At room temperature, the mixture was then centrifuged at 6000 rpm for 15 minutes and supernatant was also saved. Then by the use of supernatants, total phenolic and total flavonoid content, betacyanin content, and antioxidant activity was determined.

2.4 Determination of concentration of betacyanin:

Betacyanin content was quantified by the mean molar absorptivity (ϵ) and it is set at 65000 [10-11]. The spectrophotometric method is used for the determination of betacyanin content of dry extracts and expressed as betanin equivalents (mg/100 gm of dry extracts) based on the formula given below:

$$\text{Concentration of betacyanin (mg/100 gm dry extracts)} = \frac{A_{538} (MW) V (DF) \times 100}{(\epsilon LW)} \quad (2.4.1)$$

Where:

A_{538} = absorbance at 538 nm,

L = path length i.e. 1.0 cm,

DF = dilution factor,

V = pigment solution volume (mL),

W = dried pigment weight (g)

For betanin,

ϵ (molar extinction coefficient) = 65,000

Molecular weight (MW) = 550

2.5 Application of the extracted dye on cotton fabric:

All extracted solutions have to dye bleached cotton fabric at the following dyeing condition: at 55 °C temperature, 45 minutes dyeing time, 2:30 material to liquor ratio and 1 gm/l salt concentration. At the completion of dyeing, remove the dyed cotton from the lab dyeing machine and washed with tap water until there was no more colour hemorrhaging followed by air drying under the shade [12].

2.6 Measurement of colour strength values:

Colour strength (K/S) values of dyed samples measure with the help of Spectra flash SF 650 spectrophotometer. These values calculate by using Kubelka-Munk equation given by [12],

$$(K/S)_{\lambda} = (1 - R_{\lambda})^2 / (2R_{\lambda}) \quad (2.6.1)$$

Where, K : is the coefficient of absorption

S : Coefficient of the scattering (S)

2.7. Quality assurance tests of the dyed fabric:

Most dyes are organic compounds and therefore, some natural destructive agencies e.g., weather, oxygen, light and other atmospheric gases can fade and destroy certain dyes. In addition to natural agencies, there are many chemicals used in finishing treatments or in home laundering detergents that may also affect the fastness properties of dyed fabrics [12].

2.8. Optimisation of extracted dyes:

To find the optimised extraction conditions of natural extracted dye response surface methodology is used on the basis of factors affecting the experiment such as extraction PH, extraction time, material to liquor ratio (M:L), colour strength (K/S) of cotton fabric dyed with extracted dye [13].

3. Result on the basis of yield of Betacyanin

As a result of reviewing various topics most relevant to the research title and referring to the work carried out by other researchers in the field, the chapter is ended with some of the important decisions related to the proposed research work. Based on the reviewed literature, the important steps for the actual conduct of the work were initiated. This review work significantly contributed towards deciding the design of experiment for natural dyes extraction.

Table of results by N. Ramali, P. Ismail and A. Rahmat, et al. [10] given below summarizes the extraction yield, betacyanin content from dragon fruit peel.

Table 3.1: Comparison of Betacyanin Extraction

Method	Betacyanin Extraction Yield (%)	Betacyanin Content (mg/100gm dry extracts)
Conventional Extraction	95.25	17.64 ± 0.03
Ultrasonic Extraction	47.07	18.68 ± 0.36

4. Conclusion

Study of these methods suggests that the highest extraction yield was obtained from the peel of red dragon fruit extracted using conventional extraction method (95.25 %), and by ultrasonic extraction method (47.07 %). Thus the application of extraction methods is in order to identify the most efficient extraction techniques for extracting its antioxidants. Furthermore, the dyes were applied on the cotton fabric and the fastness properties for the dyed cotton were carried out by standard test procedures. After that the extracted dyes were characterised using different analytical techniques. Thus the research work was carried out, data analysis was conducted and the results obtained have been discussed. The overall conclusion of the research work is made with suggestions for future work. As regards the contribution of this chapter to the entire research work, it has played vital role in the research activity for the chosen title. The literature review was like a panacea for us at every step of the research exercise.

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