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Research Article

POTENTIAL USE OF *BRASSICA OLERACEA* L. (PURPLE CABBAGE) WASTE AS A VALUABLE SOURCE OF NATURAL COLORANT FOR THE TEXTILE INDUSTRY

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ABSTRACT

Wastes of domestic, organic, temple and agricultural origins such as rotten fruits, vegetable peels, flower trimmings and agricultural residues generate large amount of wastes. These wastes must be managed and disposed in an eco-friendly manner for a healthy well-being. If such wastes are not managed by proper means, they lead to various impacts on the environment and also on human beings or mankind. Hence, the main purpose of this work was to study the application of natural dyes obtained from *Brassica oleracea* L. (purple cabbage) waste extract on cotton fabrics. The components of *Brassica oleracea* L. were extracted using water and the extract was analysed for the qualitative phytochemicals. The amount of flavonoids and total antioxidant capacity of the extract were identified. Stability of the extract was checked against pH and temperature. The dyeing process was carried out using three different mordant techniques. The test for color fastness was assessed by subjecting the dyed cloth to sunlight and laundering. From our analysis, it was found that the purple cabbage waste extract showed good coloration out of the three different techniques. Pre-mordanting method gave significant results when compared to the normal cotton fabric. Thus, cotton dyeing using the natural extract exhibited moderate result on laundering with hot water and good colour fastness property with sunlight.

Keywords: Wastes, Natural dyes, Phytochemicals, Colour fastness, *Brassicia oleracea* L.

1. INTRODUCTION

Fruits and vegetables in processing industries generate large amounts of waste, thus constituting a matter of great concern. Fruit and vegetable wastes (FVW) include the various inedible portions of food sources that are discarded during collection, management, transportation and processing. The improper storage and handling of these waste residues may cause high levels of environmental contamination because of their high biodegradability associated with a high moisture content and microbial load [1]. The exponential growth of plant waste production from the agro food industry was found to possess major environmental impact on environment. However, the use of plant wastes or its by-products for the recovery of value-added products offers a new way for industrial growth and waste management. The research and development of latest functional foods and health products from low-cost raw materials play a major significant role in nutraceutical, cosmetic, pharmaceutical and agribusiness sectors. The proper management of wastes could serve as reserve constituents for a range of processes in industries like bio char from agricultural waste and colour extract from domestic and temple wastes [2].

Generally, dyes are used in colouring fabrics. Dyeing is one of the traditional methods and can be suitable for different types of textile materials, namely fibre, yarn, fabric or a finished textile product including garments and apparels [3]. Natural dyes, those originated in ancient times have been employed in colouring textile industry. The basic method of dyeing involves sticking plants to fabric or rubbing crushed pigments on cloth. Natural dyes are extracted from various natural sources like plants, minerals, microbial and animal origins are used as natural colorants for various textile materials. Also, commercially India is regarded as the second largest exporter of dyestuff, after China [4].

In particular, vegetable sources are generally used as dyes or colorants in fashion and textile industries (for yarns, fabrics and garments). A lot of applications for dyes from vegetable sources in textile industry exists. The main reason behind the wide range of applications is the eco-friendliness of the product. Whole plant (e.g. marigold), leaves (e.g. tea/henna), seeds (e.g. annatto), rinds (e.g.

pomegranate) or skin (e.g. onion) etc.can be the sources of vegetable dyes [5]. Natural dyes are biodegradable without the mixture of any oxidant or reductant agents, whereas, the synthetic dyes are degraded by reductant agents and directly or indirectly affect the human health. It is tentative that natural dyes totally degrade under natural conditions in a healthier way [6].

Brassica oleracea L. is one of the variety of cabbage, which is distinguished by its colour. The leaf of purple cabbage is reddish purple, orbicular and tightly wrapped with waxy leaves. *Brassica oleracea L.* is a rich origin of anthocyanin and it is water soluble. Its colour is pH-dependent with red to blue colour over a broad range of pH. [7] The *Brassica oleracea* L. possess various medicinal properties and also extended to serve as a source of natural colorant for textile industry which may offer an eco-friendly alternative for synthetic colorants.

2. MATERIAL AND METHODS

2.1. Collection of the *Brassica oleracea* L. (purple cabbage) waste extract

The outer layer of the selected *Brassica oleracea* L. wastes were collected. The dirts were washed in running tap water followed by distilled water and used for the extraction process.

2.2. Preparation of the extract

The samples were weighed and ground using a blender. 10 g of purple cabbage waste was extracted with 25 ml of water. The extract was filtered using Whatman No 1 filter paper. The filtered extract was used for further study.

2.3. Preliminary phytochemical analysis of *Brassica oleracea L.* (purple cabbage)waste extract

Preliminary phytochemical analysis of the *Brassica oleracea* L.(purple cabbage) waste extract was carried out which include tests for the presence of carbohydrates, proteins, glycosides, saponins, polyphenols, alkaloids, flavonoids and terpenoids [8].

2.4. Estimation of flavonoids

An aliquot (200 μl) of *Brassica oleracea* L. (purple cabbage) waste extract and standard (quercetin) at varying concentrations were pipetted out into a series of test tubes. To this 0.03 ml of 5% sodium nitrate was added and incubated for 5 minutes at 25ºC. After incubation, 0.03 ml of 10% aluminium chloride was added and again incubated for 5 minutes at 25ºC. Finally, 0.2 ml of 1 mM sodium hydroxide was added and made up the volume to 1 ml with distilled water. The absorbance readings at 510 nm were noted. A standard curve was constructed by calculating regression value using scientific calculator. From the curve, the amount of flavonoid present in the sample was estimated and expressed as mg of quercetin / ml of *Brassica oleracea* L. (purple cabbage) waste extract [9].

2.5. Estimation of total antioxidant capacity

Different concentrations of working standard ranging from 20-100 μg/ml and the *Brassica oleracea* L. (purple cabbage) waste extract were pipetted into a series of test tubes and combined with 1 ml of the reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate). The tubes were capped and incubated at 95ºC for 90 minutes, cooled to room temperature and the absorbance was recorded at 695 nm against blank. The total antioxidant capacity was calculated in terms of mg of GAE/ml of sample [10].

2.6. Stability to pH and Temperature

The pH of the extract were adjusted using 0.1M HCl and 0.1M NaOH. The pH ranges of 2.0, 4.0, 6.0, 8.0, and 10.0 were attained. The absorbance of the *Brassica oleracea* L. (purple cabbage) waste extract was read at 520 nm.

Heat stability was evaluated by exposing the coloured extract to different temperatures such as 20ºC, 40ºC, 50ºC, 60ºC, 80ºC and 100ºC for 30 minutes. After every treatment, the samples were immediately cooled and the absorbance was read at 450 nm [11].

2.7. Applications of *Brassica oleracea* L. (purple cabbage) waste extract on textile industry

2.7.1. Dyeing process

Weighed cotton samples were treated with metal salts and subjected to premordanting (cotton was dyed with mordant and then treated with natural dye) and simultaneous mordanting (cotton was simultaneously treated with mordant and natural extract) was carried out. The percentage of mordant used is 2 % solution (aluminium sulphate). For pre-mordanting, the fabric was immersed in the solution containing aluminium sulphate and then it was brought to heating and the temperature of the solution was raised to 60ºC in half an hour and maintained at this temperature for 30 minutes. Mordanted cotton fabric should be used immediately, because some mordants are very sensitive to light. For simultaneous mordanting, the fabric was immersed in the solution containing both aluminium sulphate and vegetable extracts.

2.7.2. Dyeing

The conventional dyeing technique was used for the dyeing of mordanted as well as for the non-mordanted fabric samples. The cotton fabric samples were dyed directly with the dye extract by keeping the material: liquor ratio as 1:40. The dyeing process was carried out for 2 hours in a water bath at 85ºC. After the completion of dyeing; the samples were washed with cold water and dried at room temperature [12].

2.7.3. Determination of cotton fabric weight and thickness

Fabric weight is defined as the relative weight of the fabric expressed in grams per square meter or ounce per square yard. The weight of the fabric was determined as weight per unit area.

A sample (10 cm x 25 cm) was cut using a GSM cutter and electronic weighing balance was used to find out the weight of the samples. The inference obtained was calculated using the formula:

Grams per square meter (GSM) = (Weight of the fabric X Square meter)/ Area of square

Weight of the fabric = x (g)

Square of the fabric = 100 cm x 100 cm = 10000 cm^2

Area of square = length x breath square unit

The same procedure was followed to find out the cotton fabric weight of the dyed fabrics which should be carefully recorded and calculated.

The thickness tester has a broad anvil, upon which a pressure foot is pressed by spring. The dial indicates the thickness of the material in thousands of an inch between the anvil and the pressure foot. Each division of the dial reads 0.01mm. The samples were placed on the anvil without tension or creases and the presser foot was lowered onto the sample by releasing the rising level very slowly and allowed into rest upon the sample for two seconds at 2 kg pressure. The dial reading was recorded and the value calculated.

2.7.4. Colour and washing fastness test

The dyed samples were washed and the colour fastness test was done. The samples were allowed for washing in detergent with hot and cold water and colour fading was seen by visual inspection. Samples were allowed to be exposed in sunlight for 3 hours and the results were noted by visual appearance.

3. RESULTS AND DISCUSSION

3.1. Preliminary phytochemical analysis of *Brassica oleracea* L.(purple cabbage) waste extract

Phytochemical screening was carried out in the *Brassica oleracea* L. (purple cabbage)waste extract and the results are depicted in Table 1.

Table 1: Preliminary phytochemical analysis of *Brassica oleracea*L.(purple cabbage)waste extract

S.No	Phytochemicals	*Brassica oleracea L.* waste extract
1.	Carbohydrates	+
2.	Proteins	+
3.	Phenols	+
4.	Glycosides	+
5.	Saponin	+
6.	Alkaloids	+
7.	Flavonoids	+
8.	Anthocyanin	+
9.	Terpenoids	+

Preliminary phytochemical analysis showed the presence of carbohydrates, proteins, phenols, glycosides, saponins, alkaloids, phenols, flavonoids, anthocyanins and terpenoids in the *Brassica oleracea* L. (purple cabbage) waste extract.

Similar findings have indicated that the phytochemical screening of aqueous extract of *Cuminum cyminum* revealed the presence of alkaloids, anthraquinone, coumarin, flavonoids, glycosides, proteins, saponins and steroids [13]. The phytochemical screening of methanolic extract of *Wedelia chinensis* revealed the presence of terpenoids, flavonoids and reducing sugars [14].

3.2. Flavonoid and total antioxidant capacity of *Brassica oleracea* L. (purple cabbage) waste extract

The quantitative estimation of flavonoids and total antioxidant capacity in the *Brassica oleracea* L. (purple cabbage) waste extract is indicated in Table 2. The total antioxidant potential in terms of gallic acid equivalence (mg/g) was calculated and the results were represented in Table 2.

Flavonoids are well-known antioxidant constituents of plants and possess a broad spectrum of biological activity and radical scavenging properties [15]. The total flavonoid was found to be 0.12 mg/ml. From table 2 it is evident that the total antioxidant capacity was found to be 0.20 mg/ml for the aqueous extracts of *Brassica oleracea*L.(purple cabbage) waste extract.

Table 2: Flavonoid and total antioxidant capacity of *Brassica oleracea* L. (purple cabbage) waste extract

S. No	Quantitative estimation (mg/ml)	*Brassica oleracea L.* waste extract
1.	Flavonoid	0.12 ± 0.004
2.	TAC	0.20 ± 0.004

Previous studies reported that the *Plumbagozeylancia Linn* leaf extract contains 2.41±0.32 mg/g of flavonoid content [16]. The flavonoid content in ethanol extract of *Rhododendron konori* was found to be 3.59±0.32 mg QE /g of dry powder [17].

Earlier reports showed that the antioxidant activity for the crude extracts of *Arrabidaeea chica* was found to be 0.4378±0.04662 [18]. Antioxidant capacity of *Abution-pannosum* and *Grewiatenax* plant leaves of aqueous extract gives 0.42 and 0.68 absorbance at 734 nm [19].

3.3. Effect of pH on *Brassica oleracea* L. (purple cabbage) waste extract

The effect of different pH on retention of pigments derived from *Brassica oleracea L.* (purple cabbage)waste extract is illustrated in Fig. 1.

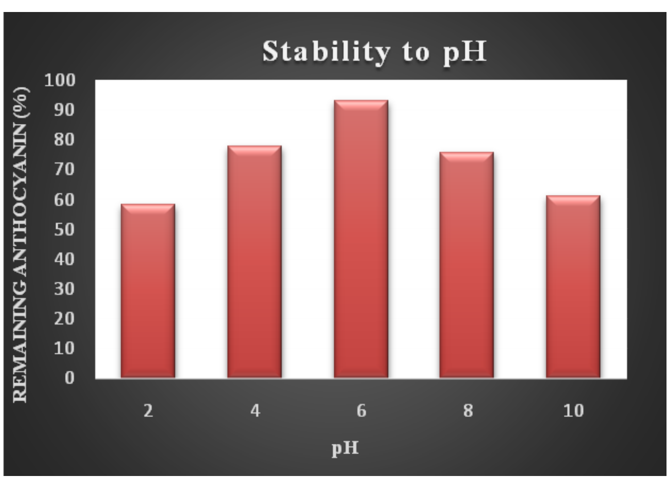

Fig. 1: Effect of pH on *Brassica oleracea* L. (purple cabbage) waste extract

The results showed that increase in pH caused greater destruction of anthocyanin in *Brassica oleracea* L.(purple cabbage) waste extract which was shown by the differences in the color with varying pH. From the table and figure it can be inferred that the optimum pH for maximum retention of anthocyanin pigment was pH 6.0 since it recorded a value of 92.97%, followed by pH 4.0 which gave a value of 77.9%. With gradual increase in the pH 7.0, the colour gradually changed towards bluish colour. The anthocyanin pigments present in *Brassica oleracea* L. (purple cabbage) extract had light pinkish colour at the lowest pH values.

The results were similar to the results of [20] where the *musaa acuminata* extract shows blue color above pH 7.0. Betalain pigment was stable at pH (3.0-7.0) and this was degraded beyond this range [21].

3.4. Effect of temperature on *Brassica oleracea* L. (Purple cabbage) waste extract

The effect of different temperature on retention of pigments derived from *Brassica oleracea* L.waste extract is depicted in Fig. 2.

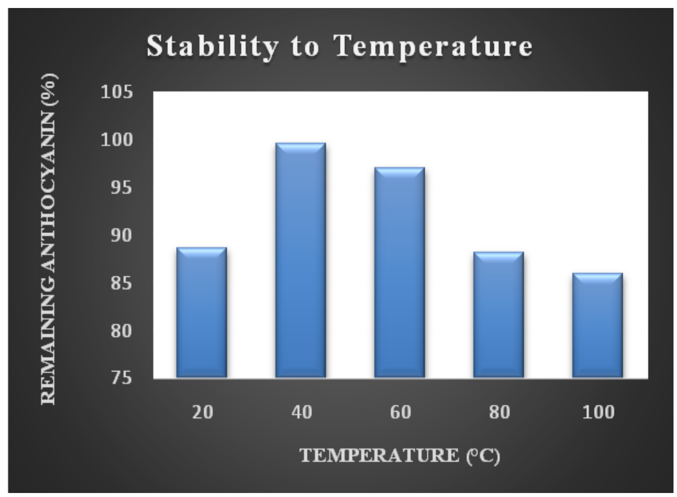

Fig. 2: Effect of temperature on *Brassica oleracea L.* (purple cabbage) waste *extract*

The speedy destruction of *Brassica oleracea* L. (purple cabbage) waste extract at higher temperatures is proved in the present study. *Brassica oleracea* L. (purple cabbage) waste extract degrades when the temperature is raised to 100°C, which is evident by the decrease in absorbance. The optimum temperature for maximum retention of anthocyanin pigment was at 40°C since it recorded a value of 99.59% followed by temperature 60°C which have a value of 96.94%. It was determined that the anthocyanins degraded more rapidly at higher temperatures, particularly when the samples were heated at 90°C.

Analogous results have been reported in *Cocculus hirsutus* fruits, wherein the effects of temperature on the destruction of anthocyanin extracts was noted [22]. Thermal treatment of plum juice with water extract at 100°C for 20 minutes caused a decrease in anthocyanin content [23].

3.5. Applications of *Brassica oleracea* L. (purple cabbage) waste extract in Textile industry

3.5.1. Dyeing of Brassica oleracea L. (purple cabbage) waste extract on cotton fabric

3a. Control **3b. Without mordant**

3c. Pre-mordating **3d. Simultaneous mordanting**

Fig. 3: Dyeing of *Brassica oleracea* L.(purple cabbage) waste extract on cotton fabric

It is concluded from the figure that pre-mordanting gave the best colour (violet) to the fabric dyed with the *Brassica oleracea* L.(purple cabbage) waste extract. On the other hand simultaneous mordanting gave a pink colour and without mordant gave a light pink colour as compared to the control. Hence it can be concluded that the pre-mordanting method is the best method.

This findings were similar to that of earlier reports and showed that the bark of *Acacia leucophloea* dye uptake was found to be good in pre-mordanting [24]. The extraction of *Curcuma longa* and *Tagetus erecta* were applied as natural dyes in the presence of iron and aluminium sulphate as mordant. They concluded that the experimentally used alum was found to be the best mordant for enhancing the shade of colour [25]

3.5.2. Fabric weight and thickness

The weight and thickness of the cotton fabric samples before and after dyeing were evaluated and represented in Table 5.

Among the four mordanting methods, post dyeing showed an increase in fabric weight as well as thickness.

The tests for colour fastness were assessed by subjecting the samples to sunlight for 3 hours and laundering in hot and cold water.

3.5.3. Colour fastness property of Brassica oleracea L. (purple cabbage) waste extract on cotton fabric

The fabric samples dyed with the extract of purple cabbage waste showed good colour fastness property with respect to sunlight and showed moderate result for laundering in hot water. These results were shown in Fig. 4.

The results of the present study are in accordance with those of previous work and stated that the Eucalyptus Bark dyed cottons mordanted with aluminium sulphate, stannous chloride and ferrous sulphate exposed to sunlight showed very good resistance. Among the mordants used, 10% of aluminium sulphate with samples exhibited very good fastness to sunlight [26]. The dyeing of cotton fabric using pomegranate peel with oxalic acid give fair wash fastness property [27].

Table 5: Fabric weight and thickness

Techniques	Before dyeing		After dyeing	
	Fabric weight	Fabric thickness	Fabric weight	Fabric thickness
Control	2.12	0.25	2.12	0.25
Without mordant	2.01	0.23	2.08	0.33
Pre- mordant	2.02	0.26	2.05	0.33
Simultaneous mordant	2.07	0.27	2.12	0.31
Post mordant	2.12	0.23	2.20	0.30

4a: Laundering using hot water 4b: Laundering using cold water 4c: Exposure to sunlight

Fig. 4: Colour fastness property of *Brassica oleracea* L.(purple cabbage) waste extract on Cotton fabric

4. CONCLUSION

The present study confirmed that the *Brassica oleracea* L. (purple cabbage) waste extract is an excellent source of bioactive compounds with the availability of phyto-chemicals. The optimum pH and temperature for maximum retention of *Brassica oleracea* L. (purple cabbage) waste extract was found to be 6.0 and 40°C, respectively. The dye extracted from the *Brassica oleracea* L. (purple cabbage) waste extract shown good dyeing and colour fastness properties. There is a need for replacement of the artificial dyes with natural dyes, because of the toxicity released by the artificial dyes. Hence, the present work concluded that the waste extract of *Brassica oleracea* L. (purple cabbage) waste extract showed a valuable source of natural colorant for the textile industry.

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