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Appraisal of marigold flower based lutein as natural colourant for textile dyeing under the influence of gamma radiations

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HIGHLIGHTS

- Optimum absorbed dose for tuning cotton surface is 30 kGy.
- Good colour strength is obtained at 70 °C keeping M:L=1:50.
- Darker shades are obtained by dyeing for 85 min using dye bath of 5 pH.
- Optimal pre-mordant is 7% tannic acid (TA) and post-mordant is 5% Cu.
- At these condition colour characteristics has been enhanced.

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ABSTRACT

Maintaining colour strength and fastness of the fabrics dyed with natural colourants had been the major constraint of utilizing plant based dyes in modern textile practices. The present study was concerned with the extraction of lutein dye from marigold (*Tagetes erecta* L.) flowers and role of gamma radiation in improving colour strength and fastness characteristics of the extracted dye. The investigation of dyed fabric in spectraflash showed that gamma ray treatment of 30 kGy was the optimum absorbed dose for surface modification to improve its dye uptake ability. Good colour strength was obtained when irradiated cotton (RC, 30 kGy) was dyed with extract of radiated marigold flower powder (RP) at 70 °C for 85 min, keeping M:L of 1:50 using dye bath of pH 5.0. The results from mordanting experiments revealed that 7% of tannic acid as pre-mordant and 5% of Cu as post-mordant were the best treatments to improve colour strength. It was found that gamma ray induced extraction of lutein from marigold flowers had a potential to be utilized as natural dyes in textile sector to produce yellowish green shades.

1. Introduction

Since bronze age, dyeing has been considered as the most important part in textile industry. European Union (EU) and the world's renowned associations such as, Global Organic Textile Standards (GOTS), Food and Agriculture Organization (FAO) and Environmental Protection Agencies (EPA), etc. have warned that many intermediates of synthetic dyes used during textile processing are causing water pollution and disturbing the eco-balance of the globe (Das and Mondal, 2013; Islam et al., 2013). These synthetic dyes can also cause skin diseases, damage to eyes, bones and liver (Haji et al., 2014; Sinha et al., 2012). Many consumers have faced different problems regarding their health after the use of synthetic textile products. Considering the situation, different countries such as Germany, Canada, USA, etc. have imposed the ban on the frequent use of these dyes in textiles, foodstuffs and other related fields (Guinot et al., 2006; Komboonchoo and Bechtold, 2009; Kanchana et al., 2013). Moreover, due to environmental consciousness, the people are also moving towards eco-friendly natural dye stuffs (Kamel et al., 2011; Shahid and Mohammad, 2013). These dyestuffs are non-toxic, easily biodegradable (Meksi et al., 2012), soothing to eyes with brilliant shades and attract the people towards nature (Haddar et al., 2014a; Shahid et al., 2013). In addition, many dye yielding plants also exhibit

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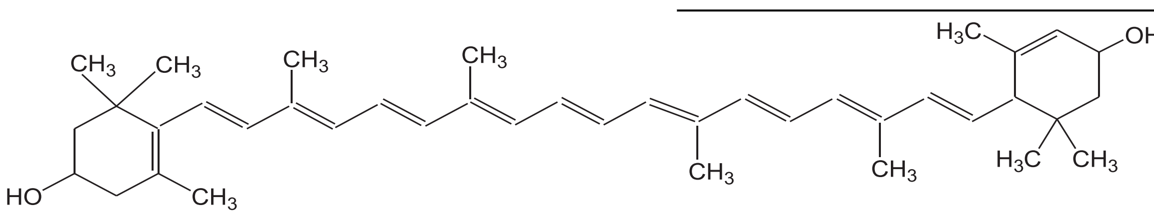
antimicrobial (Haji, 2013; Riaz et al., 2012) and antioxidant activities (Siva et al., 2011), thus attracting the attention of researchers for revival of natural dyes in textiles (Riaz et al., 2014; Shahid et al., 2013).

The main problem associated with wide utilization of natural dyes in textile is their poor colour strength and fastness properties. Textile researchers are trying to improve colour strength and fastness properties of different natural and synthetic fabrics using natural dyes through various dyeing techniques. These techniques include biopolishing, cationization, mercerization and ultrasonic treatments (Haji and Shoushtari, 2011; Kamel et al., 2005), microwave (Nourmohammadian and Gholami, 2008) and UV radiation (Bhatti et al., 2016). Among these techniques, gamma rays treatment has emerged the most effective to be utilized for surface modification of fabrics (Ajmal et al., 2014; Khan et al., 2014). Researchers have used gamma ray treatment to improve cross linking and grafting of fabrics (Wojnarovits et al., 2010), degradation (Kozmér et al., 2016; Wojnarovits and Takacs, 2008), alkali treatment of cotton (Takacs et al., 2000) and radical scavenging as well as in extraction of colourant from plants (Ajmal et al., 2014). The frequent use of gamma rays treatment in modern textile dyeing is also due to its efficient results, easy to use and cost effectiveness (Ferrero and Periolatto, 2012). It has also been reported that gamma ray treatment also improves the resistance of fabrics to shrink, enhance water repellency and the tinctorial strength (Saxena and Raja, 2014; Gulzar et al., 2015; Bhatti et al., 2014a).

Marigold (*Tagetes erecta* L.), a common ornamental plant in most part of the world has medicinal and commercial values. The extract of marigold flowers is very effective in healing scabies and warts. It has good anti-cancer, antioxidant, anti-septic and anti-fungal properties and is one of the active gradients used in textiles, food and veterinary fields. Marigold flowers contain lutein as natural carotenoid dye along with flavonoids and vitamin C (Vankar and Shanker, 2009; Prabhu and Bhute, 2012).



Lutein

The main focus of the present study is to improve the dyeing behavior of marigold flower by enhancing its dye uptake ability of cotton fabric and improving colour strength and fastness characteristics through gamma rays treatment.

2. Materials and methods

Marigold (*Tagetes erecta* L.) flowers, collected locally from Faisalabad, Pakistan, were washed with distilled water and dried under shade. The dry powder of uniform particle size was obtained by grinding the dried petals finely and then passing through a sieve. Raw grey cotton fabric was procured and subjected to pretreatment prior to dyeing by the documented methods (Bhatti et al., 2012).

Pre-treated cotton and marigold flower dye powder were exposed to absorbed doses of 10, 15, 20, 25 and 30 kGy using Cs-137 gamma irradiator (Gamma Cell 3000 (Canada Noradoan) Cs-137) at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan. The irradiated (RP) and un-irradiated (NRP) marigold flower powder were boiled for one hour in distilled water and alkaline solution to get heat and alkali solubilized extracts, respectively. After boiling the crude mixture was filtered through cotton cloth and residues were discarded. The obtained aqueous (heat solubilized) and alkaline (alkali solubilized) extracts were used for dyeing of irradiated (RC) and un-irradiated fabrics (NRC) (Batool et al., 2013).

Different dyeing parameters such as temperature, time, pH, material to liquid ratio and salt concentration were optimized. In order to observe the effect of dyeing temperature on colour strength of marigold flower colourant, dyeing was carried out at 30, 40, 50, 60, 70 and 80 °C. Optimum dyeing time was recorded after dyeing of cotton with marigold flower extract for 25, 30, 40, 55, 70 and 85 min. Varying pH (4, 5, 6, 7, 8 and 9) of dye bath were tested using material to liquid ratios of 1:10, 1:20, 1:30, 1:40, 1:50 and 1:60 in a series of experiments (Leitner et al., 2012). The salt concentration was optimized using dye solutions with 1, 3, 5, 7 or 9 g/L of salt (Na_2SO_4 and K_2SO_4) concentration (Khan et al., 2014). For improvement of colour strength and colourfastness properties, different conc. (3%, 5%, 7%, 9%) of pre- and post-mordanting was carried out using Cu^{2+}, Al^{3+}, Fe^{2+} and TA (tannic acid) as mordants.

Spectraflash SF 650 with an illuminant of D 65 10° observer was used to investigate for colour strength (%) of all dyed irradiated and un-irradiated fabrics. The mordanted fabrics dyed at optimal conditions were tested for colourfastness properties. ISO standard methods were used to observe the effect of gamma ray treatment on colourfastness. ISO 105 CO3 for Wash fastness using Rota wash, ISO BO2 for light fastness using fadometer and ISO X-12 for rubbing fastness using crock meter were employed.

3. Results and discussion

The results indicated that dyeing of irradiated fabric (RC) with marigold flower lutein depended on media of dye bath, when Aqueous (heat) or alkali solubilized extracts were used for dyeing of irradiated or un-irradiated fabrics. The data displayed in Fig. 1 showed that gamma ray treatment of fabric promisingly changed its dyeing behavior. However, it did not show any significant effect on dyeing powder used for extraction of lutein. Extraction of dye using un-irradiated powder (NRP) in aqueous medium showed maximum strength as compared to extraction at alkaline pH. The irradiated powder did not give significant improvements in colourant extraction in alkaline medium. This might be due to isomerization of colourant during extraction as well as sensitivity to alkaline medium, which resulted in loss of colourant ability of lutein .

The results revealed that irradiated fabric (RC) sorbed more dye