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Full Length Research Paper

Comparative study on characteristics of natural dyes extracted from plants as high dose chemical dosimeters

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In the present work aqueous solutions of three natural dyes, that is, Red cabbage, Turmeric and Coriander leaves were irradiated by Cs-137 gamma source in the range of 0-100 kGy. The standard aqueous solutions were scanned by UV/VIS spectrophotometer for the determination of maximum wave length (λ_{max}) and the absorbance (A) of irradiated samples was measured in UV region. The plot between concentrations (C) and absorbance (A) gave approximate linear relationship and hence verified Beer's Law. By comparing dosimetric characteristics of all three natural dyes, red cabbage dye was found to be ideal among all. Dosimetric parameters such as effect of concentration and pH values was also studied which proved that these dye solutions are strongly dependent on dye concentration and pH value. Useful dose range for natural dyes to be used as a chemical dosimeter was found to be 60 to 100 kGy.

Key words: Aqueous solutions, natural dye, chemical dosimetry, gamma irradiation, optical density (OD).

INTRODUCTION

Ionizing radiation incident on certain compounds produce physical and chemical changes. These radiation induced changes can be used as a method to measure absorbed dose. Many dye solutions are used for this purpose. Since most dyes are colored in nature, it is relatively easy to monitor their color change during the course of experiment. In the early age, animals and plant sources were used for dyeing purposes, but due to the variety of different shades and colors in synthetic dyes, the use of natural dyes was eliminated. Now the world's attention is again diverted towards natural dyes as they are biodegradable, health curing and have no disposal problem due to their compatibility with environment. On the contrary, some of the synthetic dyes are non-biodegradable, carcinogenic and allergic. The research work on aqueous solution of brilliant green used as low dosimeters (Khan et al., 2002) and radiation effects on some dyes in non-aqueous solvents and in some polymeric films (Barakat et al., 2001) have been reported.

To date there is limited information on chemical dosimetry using natural dyes. Hence, in this paper the development of a new γ-ray dosimeter was reported by comparing dosimetric behavior of different natural dyes extracted from red cabbage, turmeric and coriander leaves. Red cabbage contains a pigment called anthocyanine which changes color over different PH ranges. Because of this property, red cabbage juice is used to monitor levels of ionic hydrogen in solutions (Khan et al., 2013a). Turmeric has anti-viral effect and anti-bacterial effect. As a result of its anti-oxidant and anti-inflammatory characteristics, researchers are attracted to working in the fields of Alzheimer's Disease, Memory Deficits, Arthritis, Cancer, including Breast Cancer and Diabetes. Coriander leaves contains antioxidants, which can delay or prevent the spoilage of food (Khan et al., 2013b). Some chemicals derived by coriander have antibacterial activity against *Salmonella choleraesuis*. The aim of this work was to explore the fact that the natural dyes can be used as dosimeter. The overall objective of this work was to compare spectrophotometric readouts of these three natural dyes and select the best possible dosimeter in the specified range. Furthermore, the other parameters studied were

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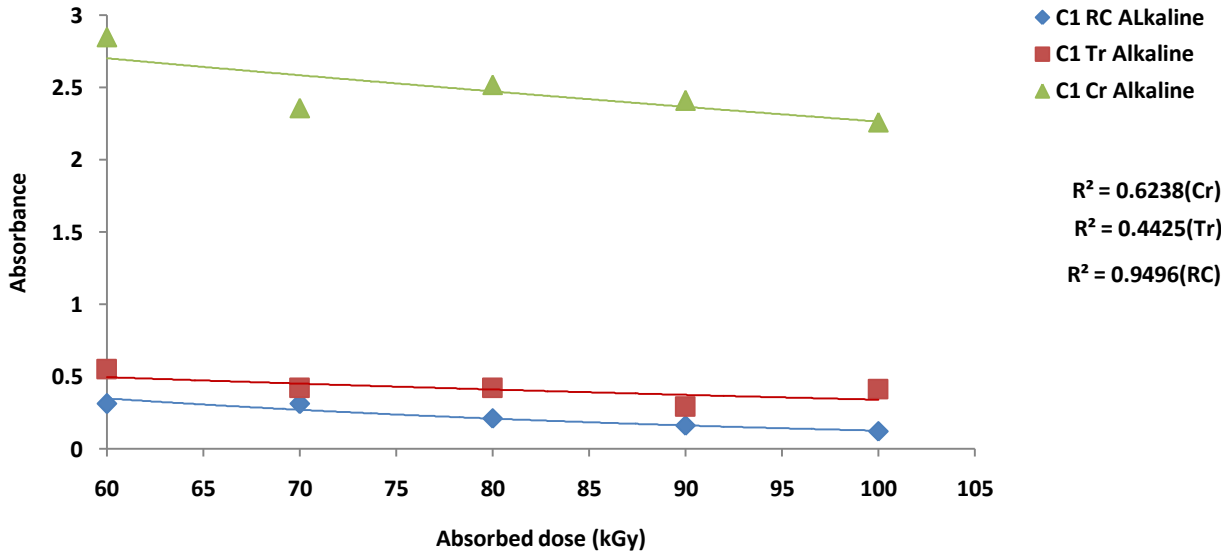

Figure 1. Absorbance versus absorbed dose for red cabbage (RC), turmeric (Tr) and Coriander (Cr) for alkaline samples of concentration c1.

the effect of dye concentration and pH value on the gamma response and the verification of Beer's Law in order to find the suitability of natural dye to be used for dosimetric studies in 0-100 kGy dose range.

MATERIALS AND METHODS

Red cabbage leaves, turmeric and coriander leaves were dried at room temperature and ground to make fine powder. The fine powder of each natural source was boiled for 20 min in 400 ml of water having a temperature of 80°C. Solutions were filtered and different concentrations of the solution were prepared at different pH values by using 1 molar solution of Sodium Hydroxide (NaOH) and Hydrochloric acid (HCl). In dosimetric studies, those dye dosimeters are considered to be satisfactory which show a linear relationship between the concentrations (C) of the dye in the solutions and absorbance (A) measured at the primary absorption peak maxima that is actually a verification of Beer's Law (Ahmad and Pausa, 2007; Baker et al., 2007; Barakat et al., 2001; Buenfil et al., 2002; Ebraheem et al., 2003; El-Assy et al., 1991; Emi et al., 2007; Farah et al., 2004; Galante et al., 2006; Hasan et al., 2002; Hussain et al., 2009a, b; Kattan et al., 2007; Khan et al., 2002). For irradiation, the dye solutions were placed in 5 ml glass ampoules having internal diameter of 1.03 cm and thickness of 0.18 cm with fit in ground stoppers. Cs-137 gamma radiation source (Mark IV Irradiator) available at Nuclear Institute of Agriculture and Biology (NIAB), Faisalabad and having dose rate of 1 kGy/1.5 h was used to irradiate the samples ((Khan et al., 2012)). All the samples were irradiated at room temperature by placing them inside the irradiation chamber at fixed positions in the gamma flux with the help of a fixed stand. The samples were irradiated according to pre-selected doses, that is, 60, 70, 80, 90 and 100 kGy. The samples were scanned for optical wavelength (λ_{max}) and the absorbance (A) measured by T80 UV/VIS spectrophotometer having band pass setting of 1 mm. Beer's Law was verified by plotting the absorbance (A) versus concentration (C).

RESULTS AND DISCUSSION

Stability

Gamma radiations' incident on different natural dyes changed their color and provided the evidence of structural changes in natural dyes. To check the stability of response of dosimeter during the post irradiation storage, five sets of the solution were irradiated to a known dose levels. The color of the controlled and irradiated samples remained stable and exposure to visible light did not cause any impact on the color of the dye up to several days. Hence it was concluded that all aqueous solutions of these natural dyes were stable for a longer period of time.

Absorbance as a function of absorbed dose

Graphs between absorbed dose versus absorbance of different concentrations and different pH values were plotted (Figures 1 to 6), which show the decrease in absorbance at the primary peak as a function of absorbed dose D. The exponential decay of absorbance versus absorbed dose was found for all dyes which showed that some samples of red cabbage dye were more ideal as compared to turmeric or coriander dye solutions. In water, the radiation induced loss due to

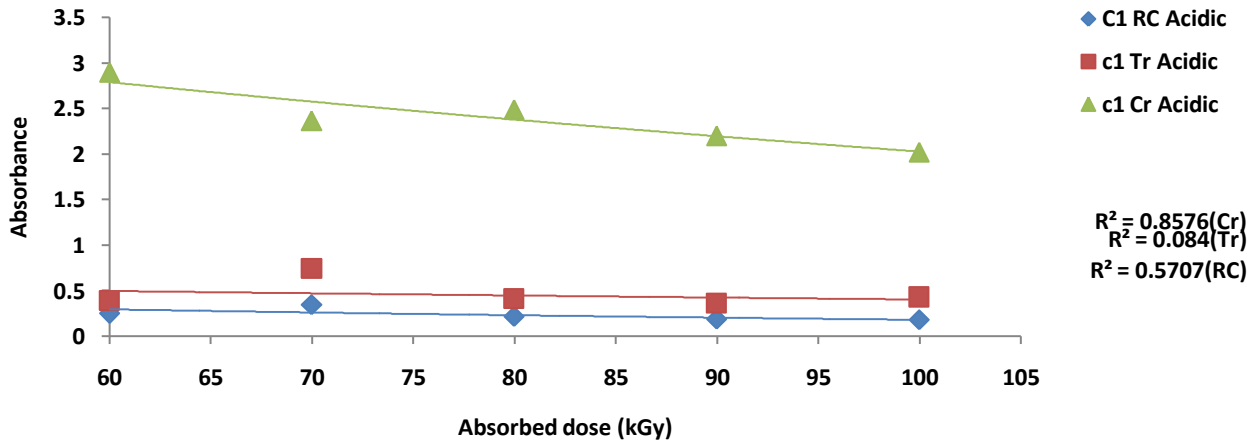

Figure 2. Absorbance versus absorbed dose for red cabbage (RC), turmeric (Tr) and Coriander (Cr) for acidic samples of concentration c1.

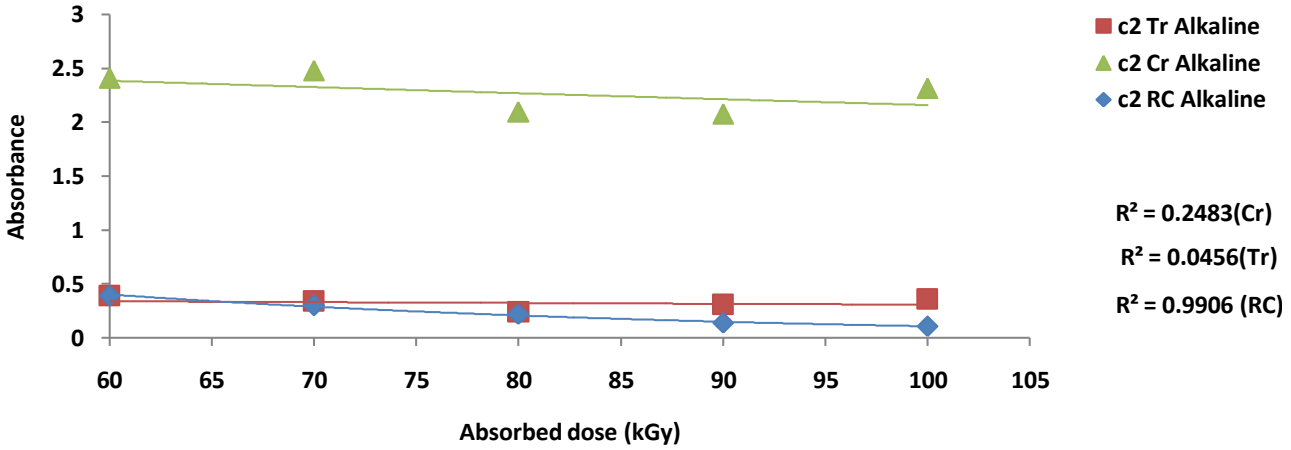

Figure 3. Absorbance versus absorbed dose for red cabbage (RC), turmeric (Tr) and Coriander (Cr) for alkaline samples of concentration c2.

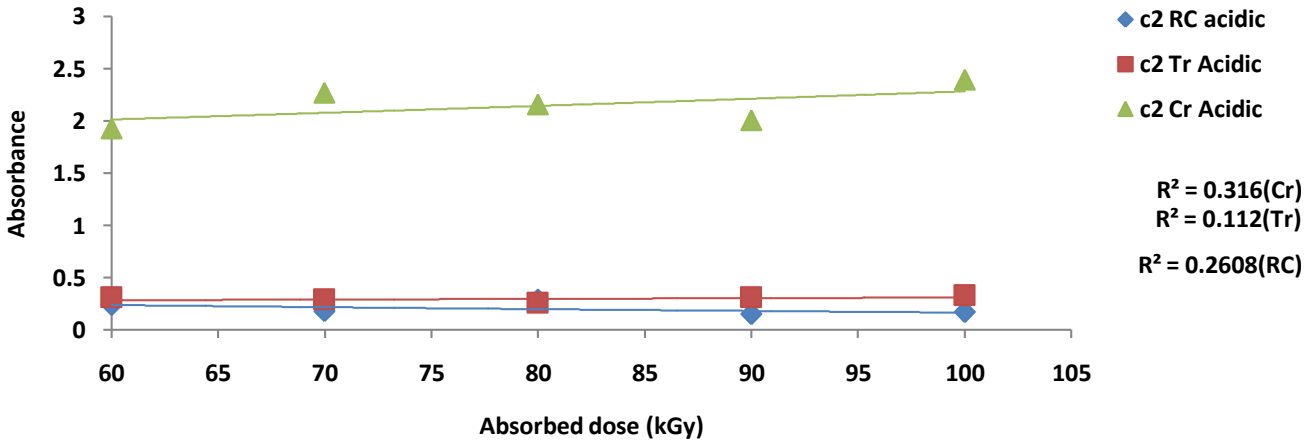

Figure 4. Absorbance versus absorbed dose for red cabbage (RC), turmeric (Tr) and Coriander (Cr) for acidic samples of concentration c2.

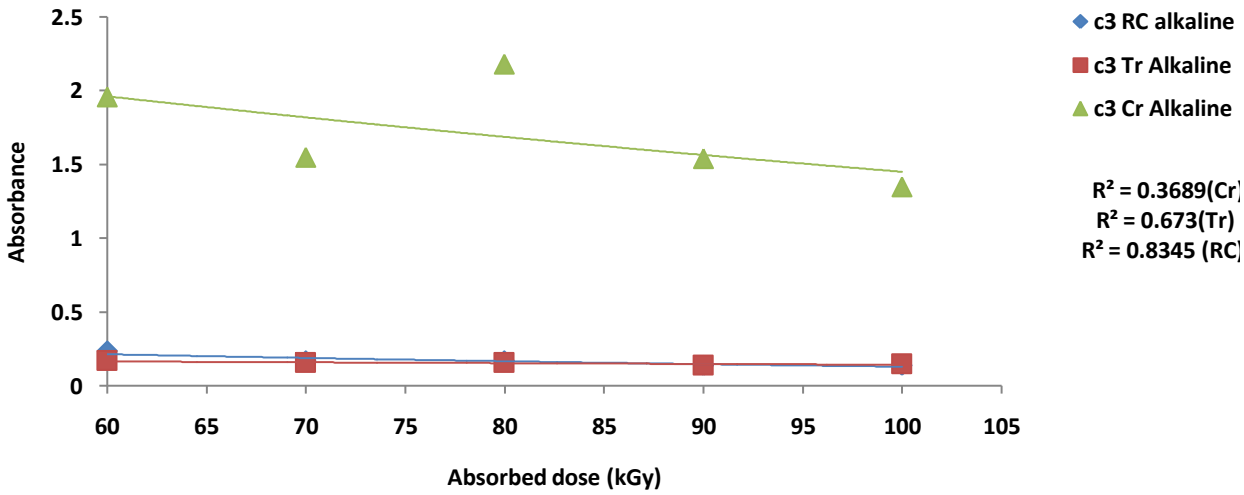

Figure 5. Absorbance versus absorbed dose for red cabbage (RC), turmeric (Tr) and Coriander (Cr) for alkaline samples of concentration c3.

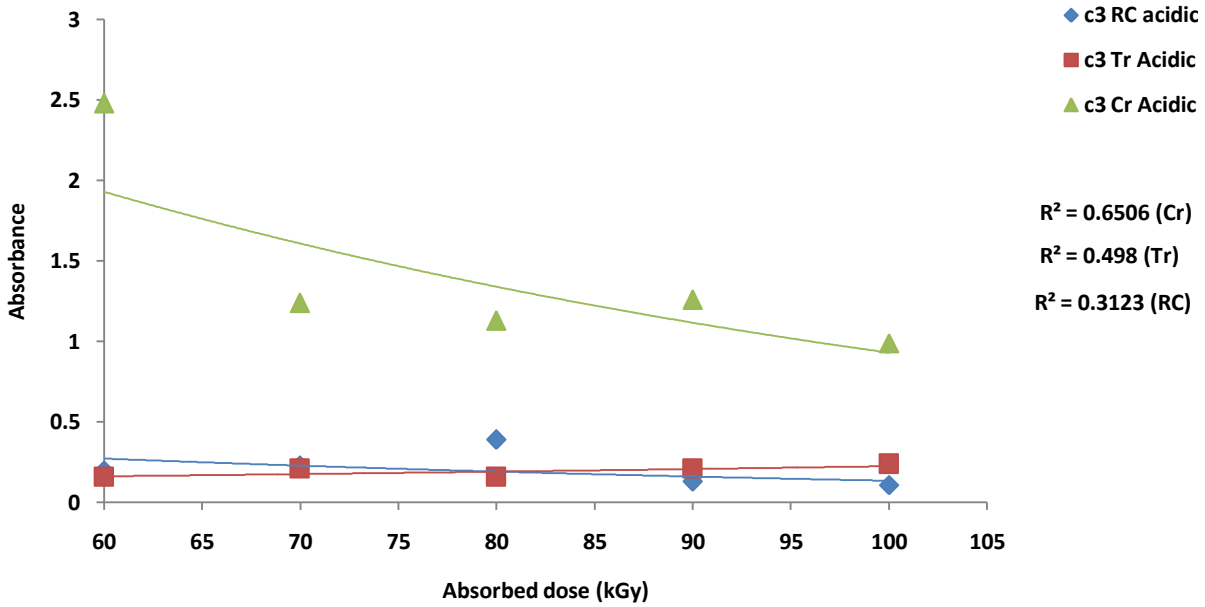

Figure 6. Absorbance versus absorbed dose for red cabbage (RC), turmeric (Tr) and Coriander (Cr) for acidic samples of concentration c3.

absorbed dose in dye concentration showed a non-linear curve on a semi-logarithmic plot.

Concentration and acidity

From Figure 1, it is clear that for C1 concentration, red cabbage and coriander leaves dye show decay of absorbance as a function of absorbed dose providing a good dosimetric response, while turmeric could not show good dosimetric behavior in this concentration. Ideal behavior in C1 concentration was seen in the acidic sample of coriander leaves. In Figure 3, absorbance versus absorbed dose of C2 concentration was plotted. For this concentration, none of the acidic samples could give a better result.

In Figure 5, absorbance versus absorbed dose of C3 concentration was plotted, and it was observed that the acidic sample of coriander dye gave satisfactory response for this concentration. However, turmeric solutions also gave satisfactory dosimetric response for

this concentration.

Concentration and alkalinity

Figure 2 shows the absorbance for C1 concentration of red cabbage and coriander leaves dye as a function of absorbed dose providing a good dosimetric response, while turmeric failed to show such behavior. Nevertheless, ideal behavior in C1 concentration was seen in the alkaline sample of red cabbage dye.

In Figure 4, absorbance versus absorbed dose of C2 concentration showed that again alkaline samples of red cabbage (RC) possess good dosimetric response, whereas in Figure 6, absorbance versus absorbed dose of C3 concentration was plotted. Alkaline solutions of red cabbage dye show exponential decrease with absorbed dose, that is, feasibility as dosimeter. Moreover, turmeric solutions gave satisfactory dosimetric response for this concentration too.

Conclusion

A comprehensive comparison on dosimetric response of different natural dyes extracted from plants has been demonstrated. The linear relationship found between absorbance and concentration verified Beer's Law which confirmed that apart from synthetic dyes, natural dyes can also be used as a dosimeter over a small range of gamma dose ranging from 60-100 kGy. The pH of sample solutions being a great factor to affect the response of the solutions should also be carefully handled. It was found that alkaline samples of red cabbage dye and acidic samples of coriander leaves dye show good dosimetric response for specific concentrations. Turmeric dye was found to be satisfactory for very low concentration, that is, 3 g/L. Overall, the red cabbage dye gave the ideal dosimetric response among all three different dyes, which implies that this dye can satisfactorily be used as a chemical dosimeter for dose range of 60-100 kGy.

FUTURE PROSPECTS

Dye dosimetry is an active area of research at the present time, though it should be checked that the whole process of extraction and dying must not only be ecologically safe but also extremely less damaging for human health. No doubt, there is a large scope of dye dosimetry for obtaining multi color shades as per requirement of the textile and painting industry, using different doses and eco-friendly textile industrial procedures with proper dose delivery check up, enhancement of shelf life, sterilization and pasteurization, waste management without opening boxes, drums and sacs using color change technique. The above said future objectives will only be achieved by getting proper knowledge of radiation protection and safety, documentation and dose assessment techniques.

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REFERENCES

Ahmad AL, Pausa SW (2007) Reactive dyes decolourization from an aqueous solution by combined coagulation/micellar-enhanced ultrafiltration process. Chem. Eng. J., 132: 257-265.

Baker C, Sharifeh AD, Kudrimoti M, Shahid BA, Ali SM (2007) Dosimetric evaluation of a newly designed low dose rate brachytherapy applicator for treatment of cervical cancer with extension into the lower vagina. J. Appl. Clin. Med. Phys., 8(2): 37-46.

Barakat MF, Salamawy KE, Banna ME, Abdel-Hamid M, Abdel-Rehim AT (2001) Radiation effects on some dyes in non-aqueous solvents and in some polymeric films. Radiat. Phys. Chem., 6: 129-136.

Buenfil AE, Ruiz-Trejo C, Gamboa-deBuen I, *et al*. (2002) Response of radiochromic dye films to low energy heavy charged particles. Nuc Instrum Meth Phys Res B. 197:317-22. http://dx.doi.org/10.1016/S0168-583X(02)01488-X

Ebraheem S, Beshir WB, Eid S, Sobhy R, Kov AA (2003) Spectrophotometric readout for an alanine dosimeter for food irradiation applications. Radiat. Phys. Chem., 67: 569-573. http://dx.doi.org/10.1016/S0969-806X(03)00107-5

El-Assy NB, El-Wakeel ES, Fattah AA (1991). The degradation of triazo dye chlorantine fast green BLL in aqueous solution by gamma radiation–III. Int. J. Radiat. Appl. Instrum. A, 42: 89-96.

Emi RG, Andras K, Fletcher JJ (2007). Dosimetry characterization of tetrazolium violet polyvinylalcohol films. Radiat Phys Chem. 76: 1519-22. http://dx.doi.org/10.1016/j.radphyschem.2007.02.064

Farah K, Kuntz F, Kadri O, Ghedira L (2004) Investigation of the effect of some irradiation parameters on the response of various types of dosimeters to electron irradiation. Radiat. Phys. Chem., 71: 337-341. http://dx.doi.org/10.1016/j.radphyschem.2004.05.041

Galante AMS, Rzyski BM, Campos LL, Villavicencio AL (2006). The response of potassium nitrate for high-dose radiation dosimetry. Radiat. Phys. Chem., 63(3): 719-772. http://dx.doi.org/10.1016/S0969-806X(01)00605-3

Hasan MK, Mohammad A, Zahid SC (2002) Dosimetric characterisation of aqueous solution of brilliant green for low-dose food irradiation dosimetry. Radiat. Phys. Chem., 63: 713-717. http://dx.doi.org/10.1016/S0969-806X(01)00640-5

Hussain MY, Islam-ud-Din, Hussain T, Nasim-Akhtar, Ali S, Inam-ul-Haq (2009b). Response of Sandal Fix Red C4BLN dye solutions using Co^{60} γ-Radiation source at

intermediate doses. Pak. J. Agric. Sci., 46(3): 224-227.
Hussain MY, Shad NA, Nasim-Akhtar, Ali S, Hussain T, Inam-ul-Haq (2009a). Commercial SFG Yellow CRL dye aqueous solutions for gamma dosimetry. Pak. J. Agric. Sci., 46(1): 78-81.
Kattan M, Daher Y, Alkassiri H. (2007) A high-dose dosimeter-based polyvinyl chloride dyed with malachite green. Radiat. Phys. Chem., 76(7): 1195-1199. http://dx.doi.org/10.1016/j.radphyschem.2006.12.004
Khan HM, Anwer M, Chaudhry ZS (2002). Dosimetric characterisation of aqueous solution of brilliant green for low-dose food irradiation dosimetry. J. Radiat. Phys. Chem., 63: 713-717. http://dx.doi.org/10.1016/S0969-806X(01)00640-5
Khan MAK, Kousar N, Akhtar N, Hussain T,Awan MS, Mubashir A, Bashir B, Javed A (2012). Dosimetry Characterization of Unknown Dye Polyvinyl Alcohol Films. J. Basic Appl. Sci., 8: 508-512
Khan MAK, Mubashir A, Bashir B, Mansoor N (2013a). Spectrophotometric analysis and gamma irradiation effects on dosimetric properties of Brassica oleracea dye aqueous solutions. Int. J. Chem. Mater. Sci., 1(8): 195-200.
Khan MAK, Mubashir A, Bashir B, Mansoor N (2013b). Concentration dependent dosimetric evaluation of Coriandrum Sativum dye solution under gamma irradiation. Int. J. Applicable Chem., 2(4): 922-926.