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Study on the Possibility of Ginger Juice Extract in Methyl Orange Decolorization

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Abstract

In this research work, the authors investigated the potential of ginger juice as a natural and eco-friendly agent for the decolorization of an azo dye under varying pH conditions. Specifically, the study focused on the probability of dye decolorization at pH 6 and pH 8 to understand the influence of acidic and alkaline environments. Additionally, the effect of hydrogen peroxide (H_2O_2) as a co-treatment agent was assessed. For each pH condition, experiments were conducted both in the presence and absence of H_2O_2 to evaluate its role in enhancing the decolorization process. The decolorization efficiency was quantified by measuring the percentage decolorization based on absorbance values obtained at the dye's wavelength maximum using a UV-Vis spectrophotometer. The study was carried out over a significant duration of 60 days to ensure a comprehensive evaluation of the dye degradation process. The results showed that at pH 6, the percentage of decolorization was 26.9% in the presence of H_2O_2 and 25.35% in its absence. At pH 8, slightly higher decolorization efficiency was observed, with values of 27.56% in the presence of H_2O_2 and 23.09% in its absence. These findings suggest that ginger juice exhibits potential for dye decolorization, with pH and the presence of hydrogen peroxide influencing the efficiency of the process. These results need more research and may be further optimized for better results with different factors, plant and microbial sources, and use of nutrients etc.

Keywords: Azo dye decolorization, ginger juice, hydrogen peroxide, natural treatment, pH effect, eco-friendly technology, absorbance measurement, dye degradation, green chemistry

INTRODUCTION

Plants are a blessing to humanity due to their various roles in human life. Various plants are recognized for their high values in the fields of food and nutrition, pharmaceuticals, industries, nanotechnology, scientific research and goals, and so forth [1–3]. Plants are extremely valuable in protecting the environment from various forms of pollution by stabilizing, converting, destroying, or deactivating them. These are just a few of the many benefits that plants have for human life. For the treatment of various pollutants, including heavy metals [4], petroleum wastes [5], water pollutants [6], and dyes [7, 8], plants can be significantly used either alone or in combination with microbes and other biological sources. The study on the bioremediation of toxic dye (methyl orange) using a plant source (ginger) is the focus of this paper.

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Use of plants in the detoxification of dyes has been done previously by various researchers. El-Sadaawy et al. [9] analyze the role and effectiveness of plants in textile dye's removal. Stanciu and Teacă [10] show the role and importance of natural polysaccharides-based hydrogels in dye elimination. Garg and Roy [11]

showed that plants are an alternative source for the removal of dyes.

One promising plant that has been actively utilized to cure textile azo dyes is *Bacopa monnieri* (L.) Pennell. Shanmugam et al. [12] conducted a significant study that demonstrated the plant species' potential in treating 14 distinct azo dyes. They got encouraging findings, with decolorization ranging from 90% to 100% following two weeks of *in vitro* hydroponic culture incubation. A study on the function and capacity of *Tinospora cordifolia* for malachite green degradation was conducted by Shah et al. in 2019 [13]. They employed UV-visible spectroscopy to examine the breakdown of malachite green and conducted many trials with varying amounts of this dye. Additionally, they investigated conductivity and pH during pre-and post-*Tinospora cordifolia* treatment studies. Within 72 hours, they discovered that *Tinospora cordifolia* had caused a drop in these values. According to Shah et al. [13], their experiment indicates this species may have a possible use in dye decolorization. In 2019, Priyanka and Krishnaswamy [14] conducted research on the phytoremediation of combined reactive azo dyes by utilizing the plant species *Ceratophyllum demersum*. For more details on the phytoremediation of dyes, the work of Chaurasia and Bharati [15] could be visited. In this paper, juice of ginger has been used for checking its potential in the decolorization of methyl orange, an azo dye, at pH 6 as well as at pH 8 and in the absence and presence of hydrogen peroxide in both pH cases.

MATERIALS AND METHODS

Materials

Phosphate buffer (pH 6), $NaH_2PO_4.H_2O$ (ACS grade, EMPARTA), Na_2HPO_4 (ACS grade, EMPARTA), digital pH meter, deionized/demineralized water (NICE), K-Roy electronic balance (0.0001 g), ginger juice extract (*Zingiber officinale* L.), UV-Visible spectrophotometer**,** and two pH phosphate buffers (pH 6 and pH 8). Ginger has been obtained from the local market of the Muzaffarpur, Bihar (India).

Methods

Phosphate Buffer Preparation

Phosphate buffers were prepared from the solutions of $NaH_2PO_4.H_2O$ (50 mM) and Na_2HPO_4 (50 mM). The pH 6.0 and pH 8 were adjusted using digital pH meter.

Preparation of Hydrogen Peroxide (H_2O_2) Solution

A 6 mM H_2O_2 stock solution was made in distilled water specifically for the purpose of reaction in the presence of hydrogen peroxide solution. During the reaction an appropriate amount of this 6 mM hydrogen peroxide was used in the reaction solution.

Ginger Juice Extraction

Ginger was purchased from the local market of Muzaffarpur, Bihar, properly washed, and then dried to remove water from the surface of the ginger that appeared due to washing. Now, ginger was ground using a grinder machine, and then the ginger juice was filtered, and its liquid extract was collected in a 100 mL flask. This liquid juice, (Figure 1), was stored in the freezer.

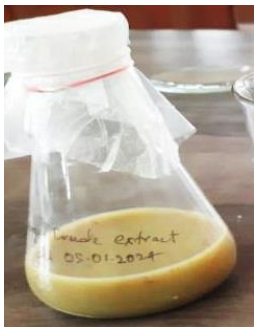


Figure 1. Ginger juice.

Preparation of Methyl Orange (MO) Solution

Methyl orange (MO) solution was prepared in the buffer solution (phosphate buffer, pH 6, and pH 8). The 0.0035 g of MO were weighed up and dissolved into the 30 mL of the already prepared phosphate buffer of pH 6 as well as pH 8. Solution was stirred continuously until MO becomes completely dissolved. Each pH solution was divided into two parts in two small beakers/flasks (each 15 mL) for carrying out the two types of decolorization/degradation study.

Preparation of Reaction Mixture

Two types of reaction solutions for each pH value were prepared for the study of the decolorization/degradation of MO. The 30 mL of MO solution (pH 6) was divided into two parts in two flasks. Similarly, 30 mL of MO solution (pH 8) was also divided into two parts in two flasks. In each case, flask 1 contains 15 mL of MO solution made in the respective phosphate buffer and 1000 µL of prepared ginger juice, while flask 2 contains 15 mL of MO solution made in the respective phosphate buffer, 1000 µL of ginger juice, and 1500 µL of hydrogen peroxide. Reaction mixtures were stirred, and progresses of the reactions (start, progress, and end of the reaction) were studied with the help of a double-beam UV-Visible spectrophotometer at different time intervals (days).

Calculation

Different literatures are available on dye decolorization using fungi [16–20]. Percentage decolorization or degradation was calculated by using the absorbance initial and final values as follows:

$\%D_{MR} = [(A_{Initial} - A_{Final})/A_{Initial}] \times 100$

where, $\%D_{MR}$ = Percentage degradation/decolorization of methyl red, $A_{Initial}$ = Initial absorbance value, A_{Final} = Final absorbance value.

RESULTS AND DISCUSSION

Degradation study of methyl orange has also been done using various methods [21–25]. UV-Visible spectrum of methyl orange was taken to know its wavelength maximum which was found around 467 nm at pH 6. Spectrum appeared between approximately 360–525 nm (Figure 2).

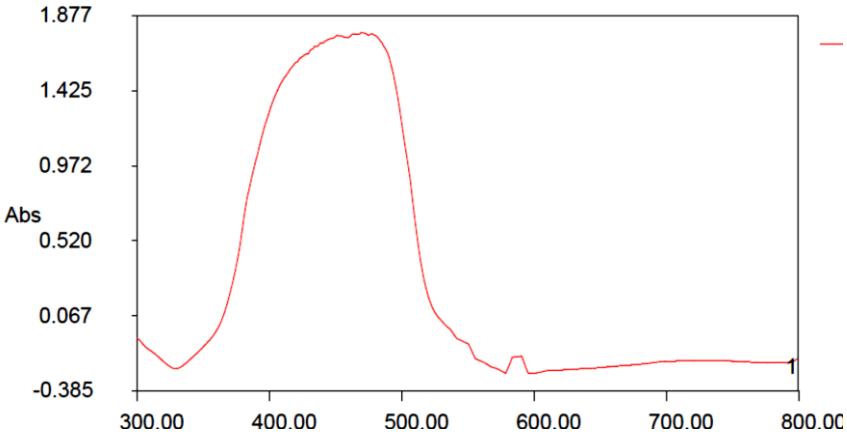
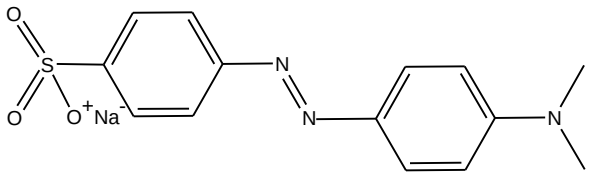


Figure 2. UV-Visible spectrum of methyl orange.

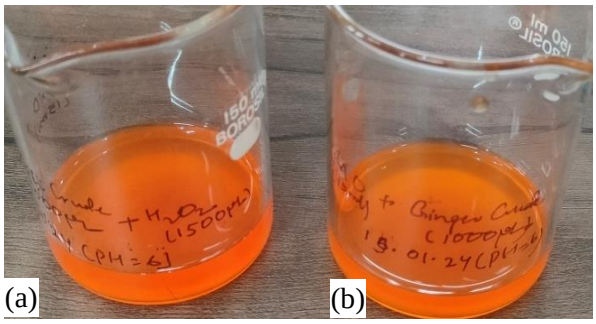
Decolorization reaction of MO were performed in slightly acidic (pH 6) as well as basic phosphate buffer solution (pH 8) with the ginger crude extract (juice). Use of ginger was done to know the efficiency of its juice in the decolorization reaction of MO. Figure 3 shows the MO solution in phosphate buffer (pH 6 and pH 8). Color of the solutions was almost same in both cases (color in images may differ from original color obtained due to camera and light variations of room). Figure 4 shows a slightly decolorized reaction solution of MO where Figure 4(a) shows the slightly decolorized MO reaction solution in pH 6 + ginger juice + H_2O_2 while Figure 4(b) shows the slightly decolorized MO reaction solution in pH 6 + ginger juice.



(Chemical structure of methyl orange MO)

MO in pH 8 MO in pH 6

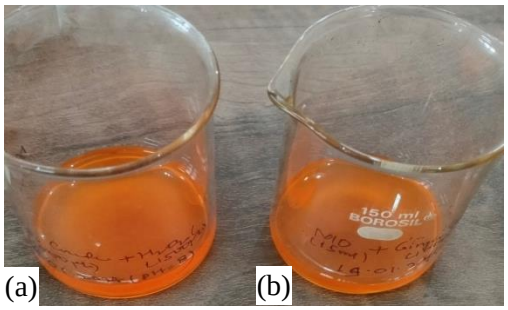
Figure 3. MO solution in phosphate buffer with pH 8 and pH 6.



(a) (b)

Figure 4. MO reaction solutions (a) MO solution in pH 6 + ginger juice + H_2O_2 and (b) MO solution in pH 6 + ginger juice.

Figure 5 shows the slightly decolorized reaction solution of MO where Figure 5(a) shows the slightly decolorized MO reaction solution in pH 8 + ginger juice + H_2O_2 while Figure 5(b) shows the slightly decolorized MO reaction solution in pH 8 + ginger juice.



(a) (b)

Figure 5. MO reaction solution (a) MO solution in pH 8 + ginger juice + H_2O_2 and (b) MO solution in pH 8 + ginger juice.

The physical appearance of the solutions clearly shows the small level of decolorization of MO in pH 6 as well as pH 8, in both conditions, either in the presence of H_2O_2 or in the absence of H_2O_2. It was also physically observed that in both pH conditions, reaction solutions without H_2O_2 showed delayed decolorization in comparison to with H_2O_2 (Figures 4 and 5).

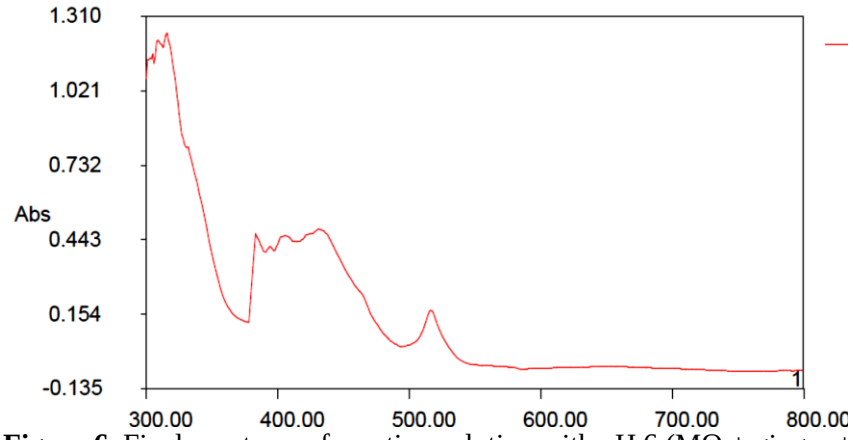


Figure 6. Final spectrum of reaction solution with pH 6 (MO + ginger + H_2O_2).

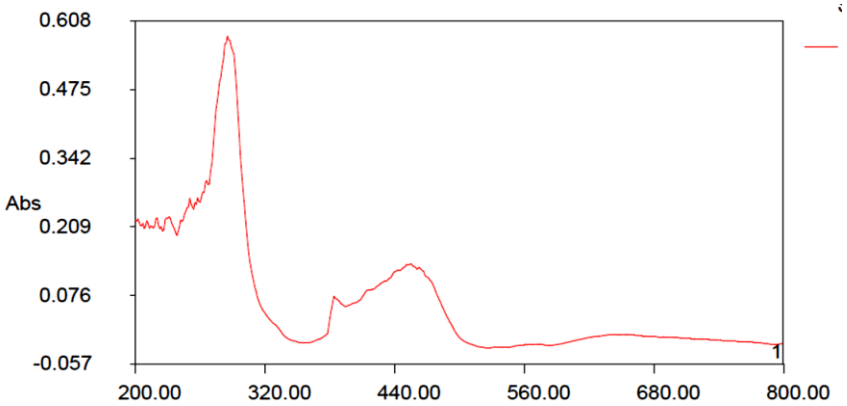


Figure 7. Final spectrum of reaction solution with pH 8 (MO + Ginger + H_2O_2).

Reactions were observed for 60 days (maximum) for all the reactions. Observations suggest that the use of ginger in decolorization of MO was not very effective. However, UV-Visible spectra taken for the decolorized reaction solutions for hydrogen peroxide mediated decolorization at pH 6 and 8 (around 50 days) showed the some degree of degradation of MO in the reaction solution (Figures 6 and 7). The percentage degradation calculated for hydrogen peroxide mediated MO reaction solutions of pH 6 and pH 8 were 26.9% and 27.56%, respectively which is not a very promising degradation result. Here, degradation in basic conditions (27.56%) was slightly greater than the acidic conditions (26.9%). In between 50–60 days, there were not any noteworthy changes either in physical appearance of the reaction solutions or in spectrum study.

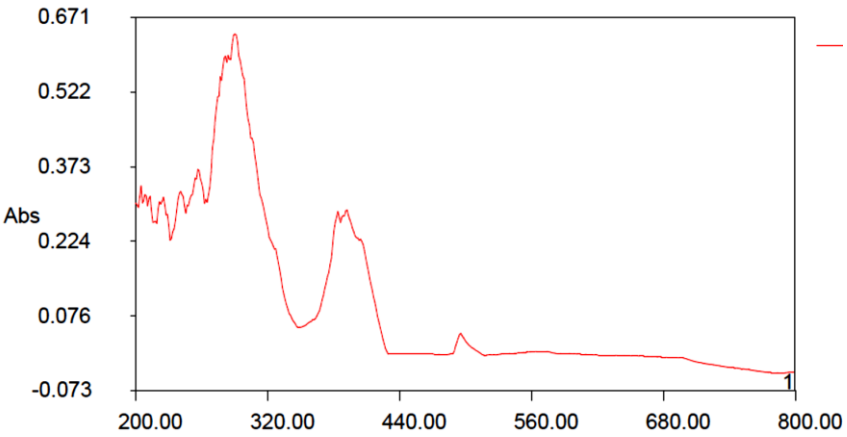


Figure 8. Final spectrum of reaction solution with pH 6 (MO + ginger).

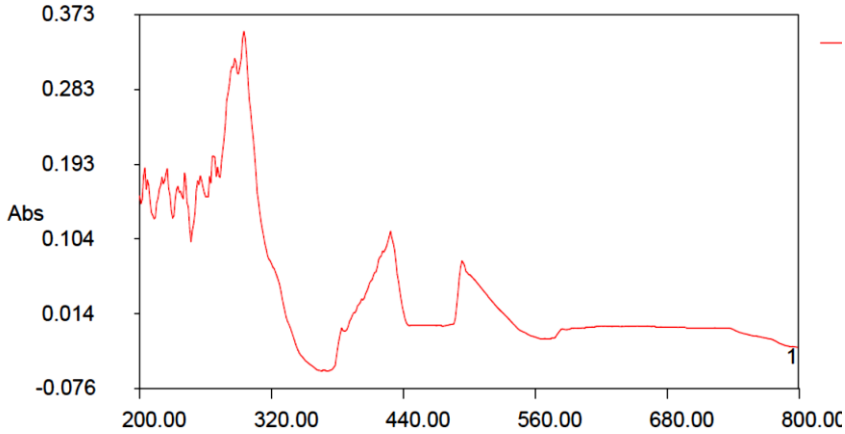


Figure 9. Final spectrum of reaction solution with pH 8 (MO + ginger).

Figures 8 and 9 show the degradation spectrum for the MO reaction solution with ginger in the absence of hydrogen peroxide. During the study, it was observed that these reaction solutions were not very effectively degraded in the initial days. These reactions were studied for up to 60 days. Around the 60-day mark, percentage calculations for the MO reaction solutions of pH 6 and pH 8 were 25.35% and 23.09%, respectively, in the absence of H_2O_2. These decolorization percentages are nearly the same as the reaction solution with hydrogen peroxide. Observations for these studies are also done up to a maximum of 60 days. Due to the very low decolorization percentages, these reaction solutions were not characterized by any other spectral techniques.

CONCLUSIONS

During the MO decolorization and degradation study, it was observed that ginger juice is not very effective in the dye degradation process of the MO solution. Degradation or decolorization studies for both pH values show insignificant differences either in the presence or absence of hydrogen peroxide solutions. In pH 6 condition, percentage decolorizations were 26.9% and 25.35% in the presence of H_2O_2 and without H_2O_2, respectively. On the other hand, in pH 8 condition, percentage decolorizations were 27.56% and 23.09% in the presence of H_2O_2 and without H_2O_2, respectively. Thus, it can be concluded that the use of ginger in the decolorization of dyes may not be an effective way due to very poor degradation efficiency. During the reaction, reaction conditions were not optimized, so optimization of reaction conditions, study at a wide range of pH, use of other mediators, variation of temperature, and/or the combined study of ginger juice and mushroom juice may be interesting steps in the high rate of MO decolorization study in comparatively fewer days.

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Conflict of Interest

Authors declare that there is not any conflict of interest.

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