



## Free Radicals Scavenging and Protein Protective Property of *Ocimum sanctum* (L)

Anand Kumar Keshari<sup>1</sup>, Atul Srivastava<sup>1</sup>, Akhilesh Kumar Verma<sup>1</sup>  
and Ragini Srivastava<sup>1\*</sup>

<sup>1</sup>Department of Biochemistry, Institute of Medical Sciences, Banaras Hindu University, Varanasi, UP-221005, India.

### Authors' contributions

This work was carried out in collaboration between all authors. Authors AKK and AS performed all the experimental work and wrote the first draft of the manuscript. Author AKV performed the statistical data analysis. Author RS designed the study and coordinated the whole research work. All authors read and approved the final manuscript.

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### ABSTRACT

*Ocimum sanctum* (L) is a well-known herbal plant used for the treatment of bronchitis, malaria, diarrhea, dysentery, skin disease, arthritis, eye diseases and insect bites. It is proposed to have anticancer, antidiabetic, antifungal, antimicrobial, cardio protective, analgesic and antispasmodic action. In our present study, we have tried to explore its antioxidant, free radical scavenging and its ability to prevent damage to protein from free radicals. The antioxidant and free radical scavenging activity of *Ocimum sanctum* leaves was determined using ferric thiocyanate, thiobarbituric Acid, 2, 2-diphenyl-1-picrylhydrazyl, hydrogen peroxide, hydroxyl radical and superoxide radical scavenging methods. Further, its protein protective property was evaluated using UV- VIS spectrophotometer methods. The results of ferric thiocyanate and 2, 2-diphenyl-1-picrylhydrazyl methods were determined that *O. sanctum* have strong antioxidant activity (92.12%) and free radicals scavenging property (50.74%) respectively. Further, hydrogen peroxide, hydroxyl radical and superoxide radical scavenging methods determined that extracts (100 µg/ml) have hydrogen peroxide (20.12%), hydroxyl radicals (12.68%) and superoxide radicals (21.68%) scavenging

\*Corresponding author: E-mail: [ragsriv@gmail.com](mailto:ragsriv@gmail.com);

activity respectively. Hemoglobin is a standard protein which was damaged by hydrogen peroxide treatment and this damage was confirmed by UV-VIS spectrophotometer. The extract showed the significant pre and post protein protective action against hydrogen peroxide induced hemoglobin damage. Thus the study concluded that *O. sanctum* leaves have strong antioxidant, free radicals scavenging and pre and post proteins protective property.

**Keywords:** Oxidants; antioxidants; FTC; DPPH; hemoglobin; *Ocimum sanctum* (L).

## 1. INTRODUCTION

In organisms, including humans, free radicals are generated during metabolic and immune system functions [1]. Reactive oxygen species (ROS) have beneficial role at certain concentration in phagocytosis, apoptosis, and necrosis. When concentration of ROS increases beyond a certain limits, it will damage the biomolecules such as DNA, RNA, proteins, lipids, carbohydrates and poses serious problems in humans [2]. In the humans various ROS such as hydroxyl radical, superoxide, and hydrogen peroxide are generated. Due to longer longevity and compartmentalization of hydrogen peroxide it can react with biomolecules which contain transition metals ( $\text{Cu}^+$ ,  $\text{Fe}^{2+}$ ) and form hydroxyl radicals via Fenton's reaction [3-7].



Antioxidants are those substances which neutralize the effect and action of free radicals [8]. In the humans, several endogenous antioxidants are present (superoxide dismutase (SOD), glutathione peroxidase, glutathione reductase, thioredoxin, Vitamin E, Vitamin C, carotenoids, flavonoids and related polyphenols,  $\alpha$ -lipoic acid, and glutathione) which protect the biomolecules from free radical injuries [9-10]. It is present in natural sources such as leaves, fruits, and roots of various plants. Some Indian medicinal plants such as *Aegle marmelos*, *Allium cepa*, *Allium sativum*, *Aloe vera*, *Azadirachta indica*, *Camellia sinensis*, *Cinnamomum verum*, *Curcuma longa* and *Ocimum sanctum* have antioxidant properties [11] and therefore scavenge the free radicals from the human body and protect them from cell injuries [12].

Imbalance between production of free radicals and antioxidants causes oxidative stress [13]. Some researchers have proved that oxidative stress enhances or develops the disease in humans, such as Parkinson's disease [14-15], atherosclerosis [16], Alzheimer's disease [17], major depression [18], diabetic nephropathy, end

stage renal disease [19], cardiovascular disease [20], non ulcer dyspepsia [21] and so forth.

The plants of genus *Ocimum* belongs to family Labiatae. It has two species, *Ocimum sanctum* Linn. (Krishna Tulasi) and *Ocimum gratissium* (Ram Tulasi) and the leaves are black and green in color respectively [22]. *O. sanctum* (L) contains some important compounds such as linalool, eugenol, methyl charicol and cineole. It has the antioxidants property due to presence of eugenol [23]. Several studies have proved that *Ocimum sanctum* contains therapeutic property to treat the gastrointestinal [24-25], cardiovascular [26-27], antitumor [28], antifertility [29] and anti-inflammatory [30] diseases. Thus in our present study, we tried to explore the antioxidant, free radical scavenging activity of *Ocimum sanctum* leaves and its protein protective property, pre and post the exposure to damage caused by hydrogen peroxide of protein. Hemoglobin was used as the standard protein.

## 2. MATERIALS AND METHODS

All the reagents were purchased from Sigma Aldrich India.

### 2.1 Plant Material

Fresh *O. sanctum* leaves were obtained from Botanical garden of Banaras Hindu University, Varanasi, India. Leaves were dried under shade at room temperature for one week and powdered using the grinder. The powder was stored in the desiccator for further use.

### 2.2 Preparation of Plant Extract

Aqueous extract of *O. sanctum* (5% w/v) was prepared by adding 5 grams leaves powder in the Erlenmeyer flask containing 100 ml deionized water and this mixture was heated for 2 hours on magnetic stirrer at 70°C. Extracts were obtained by centrifuging the filtrates at 5000 rpm for 15 min followed by filtrations using whatman no. 1

filter paper. This filtrate was concentrated by evaporation at 40°C and stored at 4°C for further use [31].

### 2.3 Antioxidant Assay

The total antioxidant activity of extract was tested by two methods, ferric thiocyanate (FTC) and thiobarbituric acid (TBA) methods. FTC method was used to determine the peroxide level in the beginning of lipid peroxidation whereas TBA method used to determine the free radicals present after peroxide oxidation.

#### 2.4 Ferric Thiocyanate (FTC) Method

FTC method was performed according to Kikuzaki and Nakatani methods [32]. 4 mg *O. sanctum* leaves was dissolved in 4 ml absolute ethanol and mixed with 4.1 ml linoleic acid (2.5% in absolute ethanol), 8 ml of phosphate buffer (50 mM, pH= 7.0), and 3.9 ml of distal water to make final volume 20 ml and stored in dark oven at 40°C. 100 µl of this mixture was added to 9.7 ml ethanol (75%), 100 µl ammonium thiocyanate (30%), 100 µl ferrous chloride (20 mM in 3.5% HCl). Exactly after 3 min the absorbance of red color was determined at 500 nm using UV- VIS spectrophotometer (Systronics, AU-2701). The mixture was stored in dark oven at 40°C and the absorbance of mixture was determined after every 24 h for 7 days.

Butylated Hydroxy Toluene (BHT) was used as positive control while the mixture without leaves powder used as negative control and absolute ethanol used as blank. The lipid peroxidation inhibition was calculated as follows:

$$\text{Percentage inhibition} = 100 - \left[ \frac{ZA}{ZS} \times 100 \right]$$

Where ZA and ZS represent the absorbance of sample and control respectively.

#### 2.5 Thiobarbituric Acid (TBA) Method

TBA method was used according to Ottolenghi [33]. 1 ml of sample solution (as prepared in FTC method) was mixed to 2 ml of trichloroacetic acid (20%) and 2 ml of thiobarbituric acid (0.67%). This mixture was placed in water bath at 100°C for 10 min followed by centrifugation at 3000 rpm for 20 min and the absorbance of supernatant were determined at 552 nm using UV- VIS spectrophotometer (Systronics, AU-2701). The

antioxidant activity was based on the absorbance on the final day of FTC method (i.e. for 7 days).

### 2.6 Free Radical Scavenging Activity

#### 2.6.1 2, 2-diphenyl-1-picrylhydrazyl (DPPH) method

The method was performed according to Burits and Bucar methods [34]. Free radicals scavenging activity of *O. sanctum*, BHT and Vitamin C was determined with the help of stable radical DPPH in terms of hydrogen atom or electron or radical scavenging activity. 1 ml of different fraction at different concentration of leaves powder (25-500 µg/ml in ethanol) was mixed with 4 ml DPPH (0.004% in methanol) solution.

Incubate at room temperature for 30 minutes and the absorbance was determined at 517 nm using UV- VIS spectrophotometer (Systronics, AU-2701) against blank. Lower the absorbance of sample indicates the higher free radical scavenging activity. BHT and Vitamin C was used as standard while methanol was used as blank solution. The scavenging activity of *O. sanctum* was determined (based on % of DPPH radical scavenged) by the following formula:

$$\text{Percentage scavenging} = \frac{Z_p - Z_q}{Z_p} \times 100$$

Where Z<sub>p</sub> is absorption of control (all the reagent except the test sample) while Z<sub>q</sub> absorption of test/ standard sample.

#### 2.6.2 Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) scavenging activity

H<sub>2</sub>O<sub>2</sub> scavenging activity was determined according to the method by Ruch et al. [35]. 2 mM H<sub>2</sub>O<sub>2</sub> solution was prepared in phosphate buffer (50 mM, pH= 7.4). 100 µl of different concentration (25- 250 µg/ml in 50 mM phosphate buffer, pH= 7.4) of *O. sanctum* solution was added to 300 µl phosphate buffer (50 mM, pH= 7.4). 600 µl H<sub>2</sub>O<sub>2</sub> solution was added to it and the mixture was vortexed. The absorbance was determined at 230 nm against blank using UV- VIS spectrophotometer (Systronics, AU-2701) after 10mins. Vitamin C was used as standard and phosphate buffer (50 mM, pH= 7.4) used as blank. The H<sub>2</sub>O<sub>2</sub> scavenging activity was calculated as:

$$\text{Percentage scavenging} = \frac{A_s - A_z}{A_s} \times 100$$

Where  $A_s$  is the absorbance of control (all the reagent except the test sample) and  $A_z$  absorbance of test sample/ standard.

### **2.6.3 Hydroxyl radical (OH<sup>•</sup>) scavenging activity**

The effect of *O. sanctum* on OH<sup>•</sup> radicals was determined according to the Khan et al. [31] method. 75 µl *O. sanctum* solution (50-250 µg/ml in methanol), 450 µl sodium phosphate buffer (200 mM, pH= 7.0), 150 µl 2-deoxyribose (10 mM), 150 µl FeSO<sub>4</sub>-EDTA (10 mM), 150 µl H<sub>2</sub>O<sub>2</sub> (10 mM) and 525 µl distilled water were mixed. This mixture was incubated at 37°C for 4 hour. The reaction was stopped by the addition of 750 µl trichloroacetic acid (2.8%) and 750 µl TBA (1% in 50 mM NaOH solution). The mixture was placed in boiling water bath for 10 min and cooled by tap water. The absorbance of solution was determined at 520 nm. Vitamin C was used as standard while methanol was used as blank. The hydroxyl radical scavenging activity was calculated as:

$$\text{Percentage scavenging} = \frac{Z_r - Z_s}{Z_r} \times 100$$

Whereas  $Z_r$  is the absorbance of control (all the reagent except the test sample) and  $Z_s$ , absorbance of test/ standard sample.

### **2.6.4 Superoxide (O<sub>2</sub><sup>•-</sup>) radical scavenging activity**

Superoxide scavenging activity of *O. sanctum* was determined according to the Liu et al. method [36]. Superoxide radicals are generated in Nicotinamide adenine dinucleotide (NADH) – phenazinemethosulphate (PMS) system by oxidation of NADH and it was determined by the reduction of Nitro Blue tetrazolium (NBT). 200 µl of *O. sanctum* (100-500 µg/ml in methanol), 1 ml of 16 mM Tris- HCl buffer (pH= 8), 1 ml of 50 µM NBT, 1 ml of 78 µM NADH, and 1 ml of 10 µM PMS solution were mixed. The reaction mixture was kept at 25°C for 5 min. absorbance was determined at 560 nm using UV- VIS spectrophotometer (Systronics, AU-2701). Vitamin C was used as standard antioxidant. Percentage inhibition of superoxide generation was calculated as:

$$\% \text{ Inhibition} = \frac{Z_s - Z_t}{Z_1} \times 100$$

Whereas  $Z_s$  is the absorbance of control (the entire reagent except the sample),  $Z_t$  is absorption of test sample/standard.

## **2.7 Determination of Total Phenolic Content**

Total phenolic content of leaves powder was determined according to the Khan et al. [31] method. Calibration curve was prepared by mixing 1 ml Gallic acid at different concentration (25-400 µg/ml) with 5 ml Folin-Ciocalteu reagent (1:10 dilution). The mixture was kept for 5 min at room temperature and then 4ml sodium carbonate (115 µg/ml) was added. The absorbance was determined at 765 nm. 1 ml of *O. sanctum* solution of different fraction at different concentration (0.5- 5 mg/ml) was mixed with reagents described above. After 2 hour the absorbance was measured at 765 nm to determine the total plant phenolic content. Total phenolic content in *O. sanctum* was expressed as Gallic acid equivalent (GAE) mg/g of the dry extract.

## **2.8 Protein Protective Property of *O. sanctum***

### **2.8.1 Spectral analysis**

Protein protective property of a substance was determined according to Ali et al. [37] method. Hemoglobin solution, *O. sanctum* extract and mixture (hemoglobin, H<sub>2</sub>O<sub>2</sub> and *O. sanctum*) were prepared followed by spectral analysis to determine the normal hemoglobin peaks. Effect of *O. sanctum* on hemoglobin damaged by H<sub>2</sub>O<sub>2</sub> was measured in the range of 350 – 500 nm using UV-VIS spectrophotometer (Systronics, AU-2701) in time dependent manner (1-60 min).

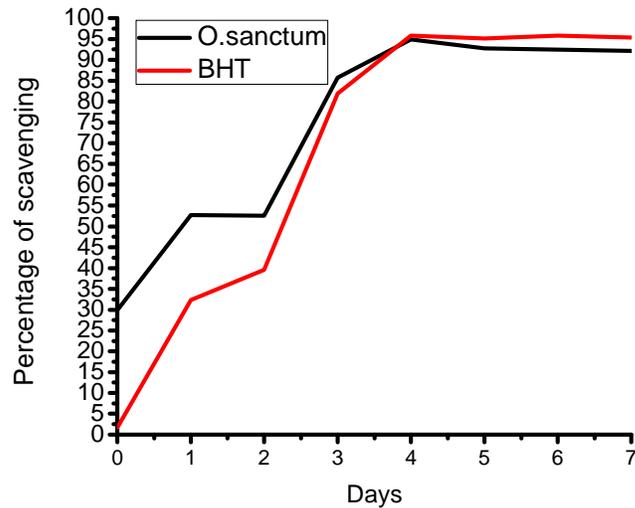
## **3. RESULTS**

### **3.1 Antioxidant Assay**

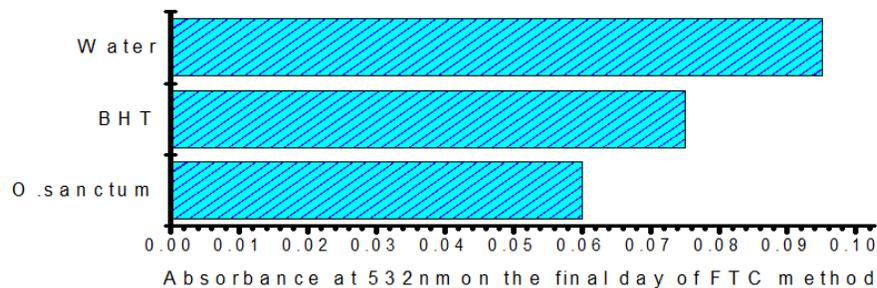
FTC and TBA results proved the antioxidant activity of *O. sanctum* leaves extracts (Table 1). The extract showed the strong antioxidant activity which represented by lower absorbance value. *O. sanctum* showed the higher antioxidant property against the standard antioxidant BHT as 92.12% and 95.36% respectively (Fig. 1 and Fig. 2).

**Table 1.** Table shows the FTC, TBA, DPPH, percentage of H<sub>2</sub>O<sub>2</sub>, O<sub>2</sub><sup>-</sup>, OH<sup>-</sup> scavenging activity of sample (*O. sanctum*) and standard (ascorbic acid, BHT) and total phenolic content of *O. sanctum*

S.N	Sample/standard	FTC (%)	TBA (%)	DPPH (%)	Percentage of H <sub>2</sub> O <sub>2</sub> scavenging (100 µg/ml)	Percentage of O <sub>2</sub> <sup>-</sup> scavenging (100 µg/ml)	Percentage of OH <sup>-</sup> scavenging (100 µg/ml)	Total phenolic content
1	<i>O. sanctum</i>	92.12	92.90	50.74	20.12	21.95	12.68	200 mg GAE/g dry extract
2	Ascorbic Acid	----	----	49.94	10.52	19.51	9.55	----
3	BHT	95.36	95.68	----	----	----	----	----



**Fig. 1.** Antioxidant property of *O. sanctum* and BHT by FTC method



**Fig. 2.** Antioxidant activity of *O. sanctum* and BHT by TBA method

### 3.2 Free Radicals Scavenging

#### 3.2.1 DPPH scavenging activity

The result of DPPH determined the total free radicals scavenging activity of *O. sanctum* and standard BHT was 50.74% and 49.94% respectively (Table 1 and Fig. 3).

#### 3.2.2 Hydroxyl radical scavenging assay

*O. sanctum* and BHT (100 µg/ml) has 12.68% and 9.55% hydroxyl radicals scavenging activity respectively (Table 1 and Fig. 3).

#### 3.2.3 Hydrogen peroxide scavenging activity

*O. sanctum* and Vitamin C (100 µg/ml) determined the 20.12% and 10.51

hydrogen peroxide scavenging. (Table 1 and Fig. 3).

### 3.2.4 Superoxide radicals

*O. sanctum* and Vitamin C (100 µg/ml) have 21.95% and 19.51 superoxide radicals scavenging activity (Table 1 & Fig. 3).

### 3.3 Phenolic Content

The result proved that *O. sanctum* leaves extract contained the total phenolic content was 200 mg GAE/g dry extract (Table 1).

### 3.4 Spectral Analysis

The results of spectral analysis are represented in the Fig. 4 showing the spectra of normal hemoglobin (Fig. 4A) and hemoglobin treated with H<sub>2</sub>O<sub>2</sub> (Fig. 4B). Fig. 5 shows normal peaks of aqueous extract of *O. sanctum* leaves (Fig. 5A) and the effect of H<sub>2</sub>O<sub>2</sub> on *O. sanctum* extract (Fig. 5B). Fig. 6 shows the scavenging (Fig. 6A), and protective effect of *O. sanctum* leaves (Fig. 6B) against H<sub>2</sub>O<sub>2</sub> damaging.

## 4. DISCUSSION

Oxidative stress develops with the imbalance between the oxidants and antioxidants. The major oxidative factors are free radicals (H<sub>2</sub>O<sub>2</sub>, ·OH, O<sub>2</sub><sup>-</sup>) which damage the biomolecules such as DNA, proteins and lipids [1]. In the present

study we have observed that the aqueous extract of *Ocimum sanctum* (L) leaves have strong antioxidant activity as compared with BHT on the final day of reaction (7<sup>th</sup> days) (Figs. 1 & 2 ). *O. sanctum* has more antioxidant activity as compared with BHT from starting day to fourth day of reaction after that negligible changes were observed. The percentage of free radicals scavenging property of *O. sanctum* and vitamin C were 50.74 and 49.94 respectively. This scavenging property of *O. sanctum* was slightly greater than vitamin C (Table1). The percentage of hydrogen peroxide scavenging activity of *O. sanctum* and vitamin C was 20.12 and 10.52 respectively. The percentage of superoxide scavenging activity of *O. sanctum* and vitamin C was 21.95 and 19.51 respectively. The percentage of hydroxyl radicals scavenging activity of *O. sanctum* and vitamin C was 12.68 and 9.55 respectively. These values confirmed that the *O. sanctum* have greater free radicals scavenging activity as compared with vitamin C (Table 1 and Fig. 3). Spectral analysis confirmed that the normal hemoglobin has peak at 410 nm while the peak was quenched and shifted from 410 to 420 nm when damaged by hydrogen peroxide (Fig. 4) while the extract property was not affected by hydrogen peroxide (Fig. 5). Further, the pre addition of extract have more protein protective role against hydrogen peroxide while post addition of extract have less protein protective activity and they were sifted peaks towards their original place (Fig. 6). This was

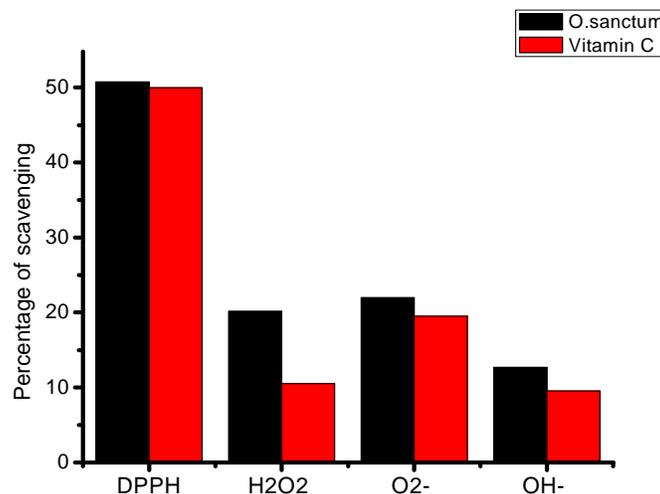
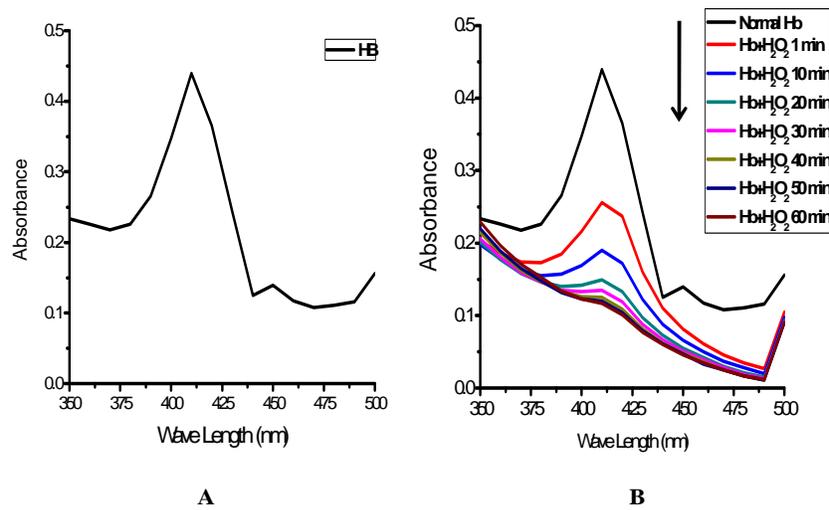
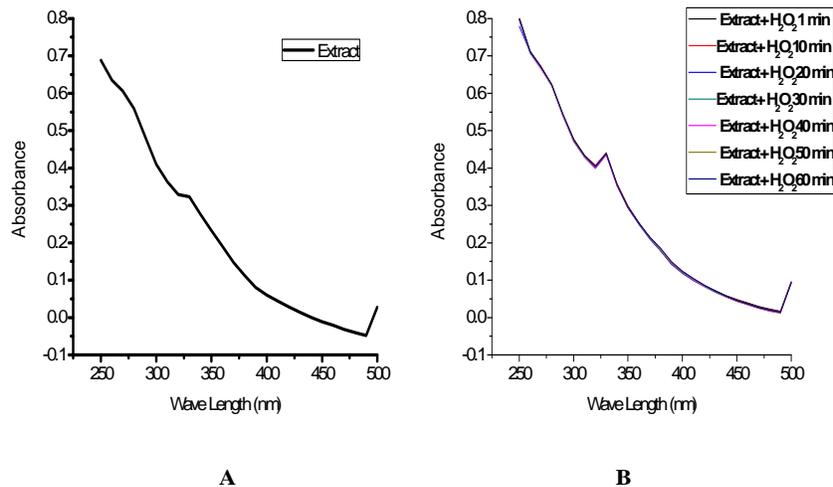


Fig. 3. Total free radicals and individual free radicals (H<sub>2</sub>O<sub>2</sub>, O<sub>2</sub><sup>-</sup>, OH<sup>-</sup>) scavenging property of *O. sanctum* and vitamin C



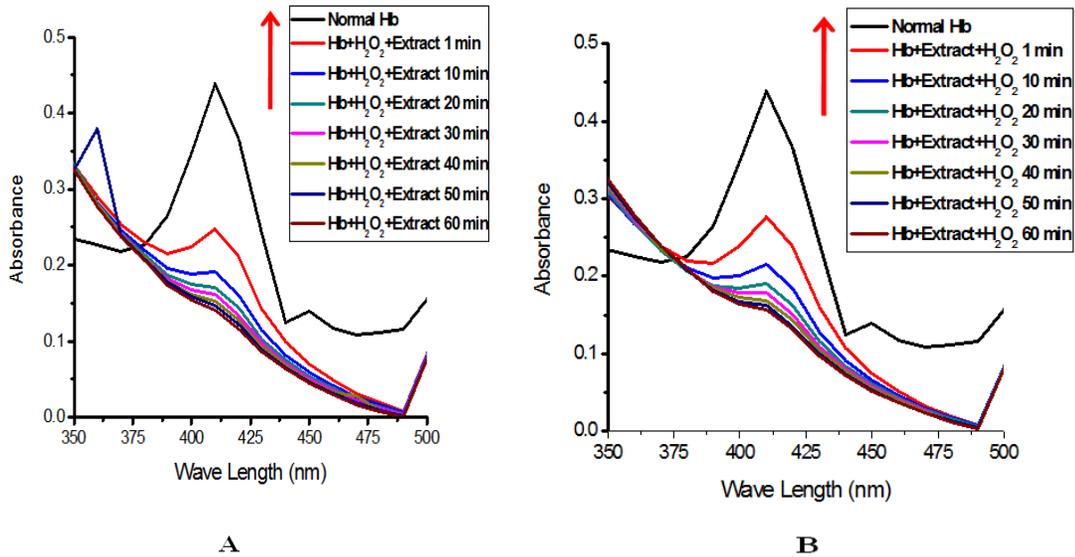
**Fig. 4. Spectra showing normal hemoglobin peaks (Fig. 4A) and hemoglobin treated with H<sub>2</sub>O<sub>2</sub> in 1-60 min (every 10 minute of intervals, Fig. 4B)**



**Fig. 5. Spectra showing normal aqueous extract of *O. sanctum* peaks (Fig. 5A) and effect of H<sub>2</sub>O<sub>2</sub> on aqueous extract of *O. sanctum* (Fig. 5B) in 1-60 min of every 10 minutes of intervals**

confirmed that the pre addition of extract (before the treatment of hydrogen peroxide to hemoglobin) given better protein protective as compared to post addition of extract (after the treatment of hydrogen peroxide to hemoglobin). It is well accepted in literature that the phytochemicals have medicinal value that having protecting properties against free radicals injuries [35], anti cancer [36] induced apoptosis in precancerous and cancerous cells [37-38],

hypoglycemic [39], and prevent liver, kidney and brain injury and protect against the genetic, immune and cellular damaged caused by pesticides, pharmaceuticals and industrial chemicals waste [40]. Thus, it seems that this antioxidants, free radicals and pre and post proteins protective properties of *O. sanctum* leaves might be due to presence of phytochemicals, but it needs more explorative study for better clarification.



**Fig. 6. Spectra showing scavenging effect of *O. sanctum* extract against  $H_2O_2$  (Fig-6A) and protective effect of *O. sanctum* extract against  $H_2O_2$  (Fig-6B) in 1-60 min of per 10 minutes of intervals**

## 5. CONCLUSION

Hydrogen peroxide is an oxidant with its free radical and reactive nature. Due to these properties it is able to denature the hemoglobin protein. Present study revealed that the *O. sanctum* leaves extracts diminished the hydrogen peroxide hemoglobin denaturation and having free radical scavenging property. Thus, it is concluded that the leaves extract of *O. sanctum* have antioxidant and hemoglobin protective property.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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