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Quality enhancement of groundnut oil by addition of rice bran oil extract

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ABSTRACT

Lipid peroxidation is a major cause of quality losses in oils during storage. To get rid of this problem antioxidant addition has been in practice. In recent days, awareness about the toxic effects of synthetic antioxidants, has led to the need of identifying natural antioxidants. This work focuses on whether tocotrienol rich fraction, prepared from crude rice bran oil, possesses antioxidant potential strong enough to minimize lipid peroxidation in oil. Lipid peroxidation was studied in groundnut oil stored, under accelerated oxidation conditions, like exposure to elevated temperature of 60°C, aerial oxygen and to UV radiation. The parameters measured were acid value, iodine value, peroxide value and TBARS value. TRF quenches the free radicals and lowers acid value, peroxide value, TBARS value and raises the iodine value. It has been found that the enhancement in the rate of peroxidation under accelerated oxidation conditions could be retarded by addition of natural antioxidant rich TRF. TRF increases the shelf life of the mustard oil by decelerating the process of lipid peroxidation.

KEYWORDS

Oil;
Lipid peroxidation;
Antioxidant;
Free radical;
Tocotrienol.

INTRODUCTION

Vegetable oils and fats play a very important role in our diet. They provide essential fatty acids which are precursors of important hormones such as prostaglandins. They control many physiological factors such as blood pressure, cholesterol and reproductive system[1,2]. Fats and oils present in many foods may easily deteriorate due to oxidation. It occurs in a chain of reactions in which free radicals are formed, propagated and finally converted into stable oxygenated compounds, which are responsible for off flavors and undesirable characteristics[3,4]. Lipid oxidation decreases food safety and nutritional quality by the formation of potentially toxic products during cooking or processing. It results in the losses of nutritional value of food as well as changes in color, texture, sensory and other physiological properties[5]. Due to these changes, consumers do not accept oxidized products and industries suffer from economic losses. The oxidative stability of oils and fats may be influenced by many factors such as light, metal ions, oxygen, temperature and enzymes[6,7]. Antioxidants are sometimes intentionally added to oil to improve oxidative stability. Antioxidants quench the free radicals responsible for lipid peroxidation and delay the onset and extent of lipid peroxidation in food system.

Groundnut oil is widely used in India for cooking. Groundnut oil contains 46 and 32 percent of

monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), respectively[8]. Rice bran oil is a good source of antioxidants like tocotrienol and gamma oryzanol[9]. Tocotrienol is known to possess antioxidant property and also hypocholesterolemic, cardioprotective,neuroprotective, antiadipogenic and anticancer properties[10]. Tocotrienol Rich Fraction (TRF) has been prepared from crude rice bran oil. The present study was undertaken to find whether addition of TRF to groundnut oil could minimize lipid peroxidation of groundnut oil.

MATERIALS AND METHODS

Materials

Sodium hydraoxide (Hi Media), potassium iodide and sodium thiosulphate (Merck),Wij's solution (Nice) were procured. Groundnut oil was obtained from local market. Crude rice bran oil was obtained from local oil mill.

Preparation of TRF

Tocotrienol Rich Fraction (TRF) was prepared from crude rice bran oil by a simple, cost effective, enrichment process. TRF has been prepared from crude rice bran oil (RBO) by the method described in United States Patent 5985344. The process comprises extracting the crude RBO using alcohol at 40° C., obtaining the Tocotrienol Rich Fraction (TRF) from alcohol extracts which contain 74 to 300 percent more antioxidants than the starting crude RBO[11].

Determination of acid value

The acid value of an oil or fat is defined as the number of milligrams of sodium hydroxide required to neutralize the free acidity in 1 gm of sample. The acid value is a measure of the extent to which the glycerides in the oil have been decomposed by lipase or other action. As rancidity is usually accompanied by free fatty acid formation, the determination of acid value is often used as a general indication of the condition and edibility of oils. The acid value is determined by the AOAC method number 28.030,1970,[12].

Determination of iodine value

The iodine value of an oil or fat is defined as the weight of iodine absorbed by 100 parts by weight of the sample. The glycerides of the unsaturated fatty acids unite with a definite amount of halogen and the iodine value is therefore a measure of the degree of unsaturation. The greater the degree of unsaturation (i.e. higher the iodine value), the greater is the liability of the oil or fat to become rancid by oxidation. The iodine value is determined by the AOAC method number 28.021,1970,[13].

Determination of peroxide value

The peroxide value measures the total peroxide and hydroperoxide oxygen content of lipids and lipid containing materials. The peroxide value depends on the reaction of potassium iodide in acid solution with the bound oxygen followed by titration of the liberated iodine with sodium thiosulphate. The peroxide value was determined according to the AOAC official method number 28.024,1970,[14].

Determination of TBARS value

The thiobarbituric test is based on the color reaction of TBA with malondialdehyde, the secondary oxidation product of lipid peroxidation. The direct determination (without distillation) of 2-thiobarbituric acid value in oils and fats is described in IUPAC method 2.531; Pokorny and Dieffenbacher (1989) have given a simpler method of TBARS value determination without distillation[15].

STATISTICAL ANALYSIS

The data are presented as mean ± S.D. (standard deviation) of three replicates (data are not shown). The triplicate data were subjected to Analysis of Variance (ANOVA) using the Microsoft Excel 2007. Comparison of means were analyzed by Fischer's Least Significant Different Test at a significant level $p < 0.05$.

RESULTS AND DISCUSSION

Effect of time at elevated temperature on lipid peroxidation of groundnut oil

The main objective of this investigation was to determine the effect of exposure of groundnut oil to elevated temperature, air and UV on lipid peroxidation and to how much extent TRF can reduce these accelerating effects of lipid peroxidation.

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When subjected to heating at elevated temperature, oils and fats undergo oxidation that results in changes in physical and chemical characteristics. Autooxidation of oils, free radical chain reaction, includes initiation, propagation and termination. The primary oxidation products, lipid hydroperoxides, are relatively stable at room temperature. However, at high temperature, they are readily decomposed to alkoxy radicals and then form aldehydes, ketones, acids, esters, alcohols and short chain hydrocarbons[15].

Acid value is an important indicator of vegetable oil quality. Acid value indicates the proportion of free fatty acid present in oil or fat. Figure 1a shows the effect of time of exposure to elevated temperature on the acid value of groundnut oil. Upon 28 days of exposure to 60 °C, acid value of groundnut oil raises to 4.74 on 7 th day, to 10.132 ons 14 th day, to 15.2 on 21 st day and finally to 21.8 on 28 th day. However TRF addition has been found to improve the oil quality under similar stressed condition. The TRF is able to reduce acid value 21.1% on 7 th day, 22.8% on 14 th day, 15.2% on 21 st day and 12.8% on 28 th day. With increase of time, the effectiveness of TRF in retarding lipid peroxidation decreases.

The iodine value is a measure of the degree of unsaturation in oil. Iodine value is an useful parameter in studying oxidative rancidity of oils since higher the unsaturation the greater is the possibility of the oils to go rancid. Figure 1b shows the effect of time of exposure to elevated temperature on the iodine value of groundnut oil. The iodine value decreases from 103 on

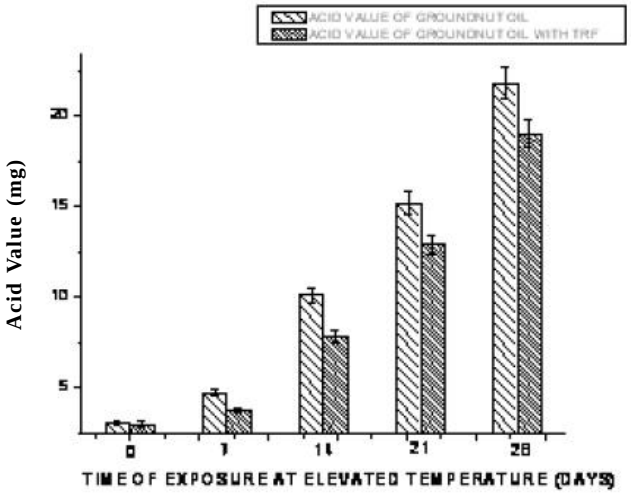

Figure 1a : Effect of time of exposure to elevated temperature on acid value of groundnut oil

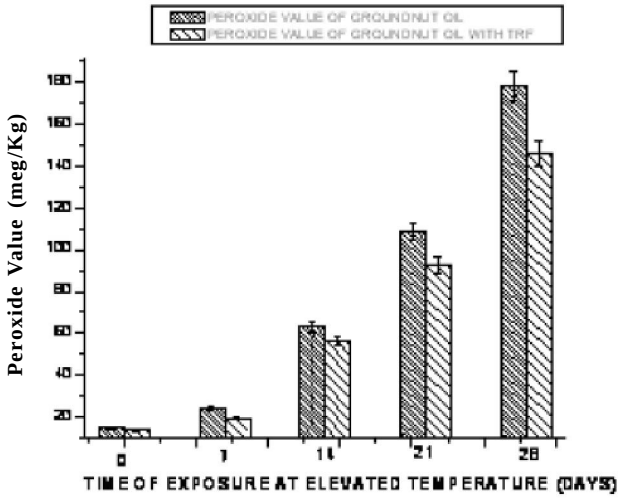

Figure 2a : Effect of time of exposure to elevated temperature on peroxidation value of groundnut oil

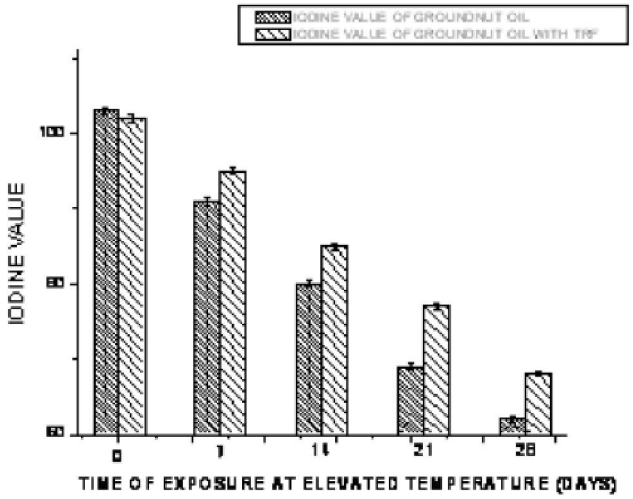

Figure 1b: Effect of time of exposure to elevated temperature on the iodine value of groundnut oil

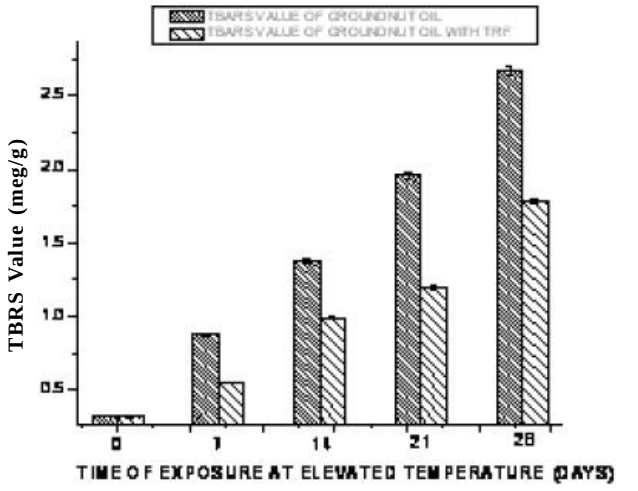

Figure 2b : Effect of time of exposure to elevated temperature on TBARS value of groundnut oil

0th day, to 91 on 7th day, to 80 on 14th day, to 69 on 21st day, to 62 on 28th day when the oil is kept at 60 °C. The iodine value gradually lowers with increase of time of exposure to elevated temperature as the electron loving free radicals attack the electron rich double bonds with increasing lipid peroxidation. However, when TRF is present, the iodine value becomes 95 on 7th day, 85 on 14th day, 77 on 21st day and 68 on 28th day. TRF, when added, protects the double bonds by quenching the free radicals, thereby lowering the decrease of iodine value or, retaining the iodine value.

The oxidative status of oil samples is determined preferably by analysis of the peroxide value (primary oxidation products) showing the onset of oxidation and the TBA-value (secondary oxidation products), which is a marker for the volatile oxidation products.

Figure 2a shows the effect of time of exposure to elevated temperature on the peroxide value of groundnut oil. The peroxide value is a measurement of the extent to which rancidity reactions have occurred in oils. The peroxide value of the groundnut oil increases to 23.93 on 7th day, 63.22 on 14th day, 108.56 on 21st day and finally to 177.3 on 28th day. The addition of TRF is able to lower the extent of lipid peroxidation occurring under the accelerated oxidation condition. This is evident from the peroxide value when TRF is present-19.6 on 7th day, 56.28 on 14th day, 92.6 on 21st day and 145.6 on 28th day.

Figure 2b shows the effect of time of exposure to elevated temperature on the TBARS value of groundnut oil. The TBARS value is particularly useful for measuring oxidative changes in oils. Secondary oxidation products react with TBA forming condensation products, absorption of which can be measured at 530nm. The TBARS value of groundnut oil increase with increase in lipid peroxidation. The TBARS values are 0.88, 1.38, 1.96 and 2.67 on day 7, 14, 21 and 28 respectively. TRF addition lowers the TBARS value to 0.552, 0.99, 1.2 and 1.78 on day 7, 14, 21 and 28 respectively. The rate at which lipid peroxidation occurs is dependent on time of exposure and temperature.

Effect of air exposure on lipid peroxidation of groundnut oil

As the oil comes in contact with aerial oxygen, oxidation takes place depending on the oxygen partial pressure in the headspace of the oil. A higher amount of oxygen is dissolved in the oil when the oxygen partial pressure in the headspace is high. Figure 3a shows the effect of time of exposure to air on the acid value of groundnut oil. The acid values of groundnut oil are 6, 11, 16 and 18 after 7,14,21,28 days of aerial exposure and that of groundnut oil with TRF are 5, 9, 12 and 15 after 7, 14, 21,28 days of aerial exposure. The effect of time of exposure to air on the iodine value of groundnut oil has been shown in Figure 3b. Upon exposure to air, the iodine value of groundnut oil is 93 on 7th day, 83 on 14th day, 75 on 21st day and 69 on 28th day. But addition of TRF is able to lower the rate of the process. In presence of TRF however, the iodine value becomes 95 on 7th

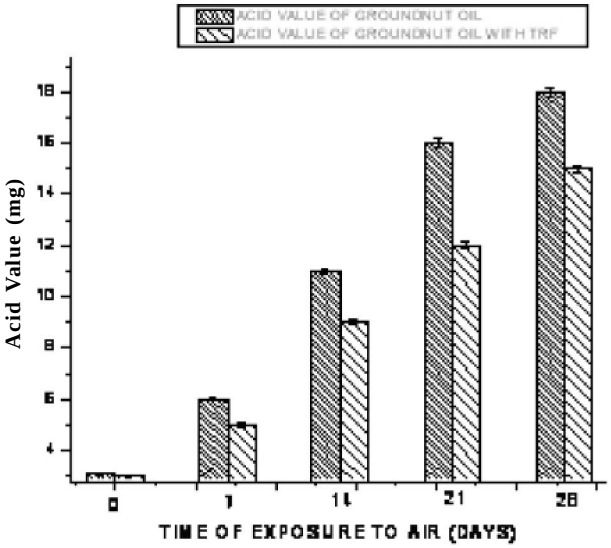

Figure 3a : Effect of time of exposure to air on the acid value of groundnut oil

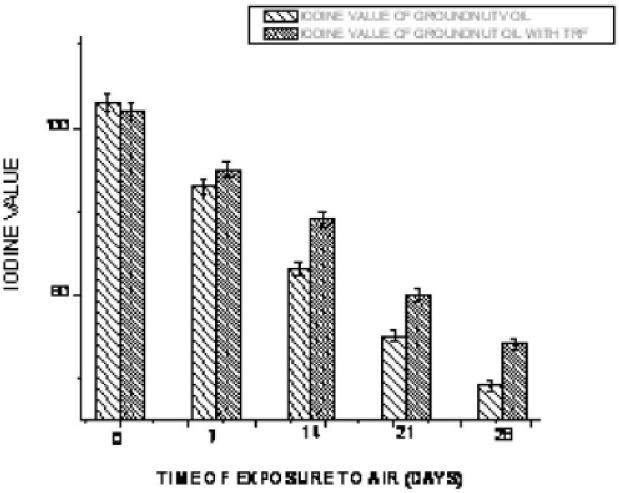

Figure 3b: Effect of time of exposure to air on iodine value of groundnut oil

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day, 89 on 14th day, 80 on 21st day and 74 on 28th day.

Figure 4a depicts the effect of time of exposure to air on the peroxide value of groundnut oil. The peroxide value of groundnut oil on 7th day is 30, on 14th day 58, on 21st day 100 and on 28th day 140. TRF addition to the groundnut oil makes the peroxide value 22 on 7th day, 39 on 14th day, 78 on 21st day, 120 on 28th day. Thus, TRF acts as good additive that has the potential to slower the peroxidation process. The effect of time of exposure to air on the TBARS value of groundnut oil has been depicted in Figure 4b. TBARS value of groundnut oil when exposed to air are 0.9 on 7th day, 1.5 on 14th day, 1.8 on 21st day and 2.22 on 28th day. TRF addition to the groundnut oil however lowers the TBARS value to 0.7 on 7th day,1.2 on 14th day, 1.35 on 21st day and 1.54 on 28th day. The acid value, peroxide value and TBARS value of groundnut oil are increasing with time of exposure to air but in presence of TRF the values are lower than the corresponding values in absence of TRF. The iodine values decrease with time but TRF when present, the rate of decrease is lowered. It has been found that lipid peroxidation in groundnut is higher than that of oil containing TRF, when exposed to aerial oxygen for 28 days.

Effect of time of exposure to UV on lipid peroxidation of groundnut oil

The free fatty acid content went on increasing with

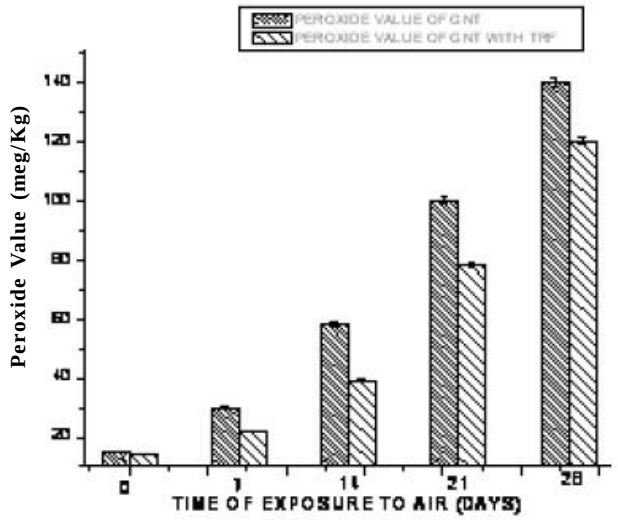

Figure 4a : Effect of time of exposure to air on peroxidation value of groundnut oil

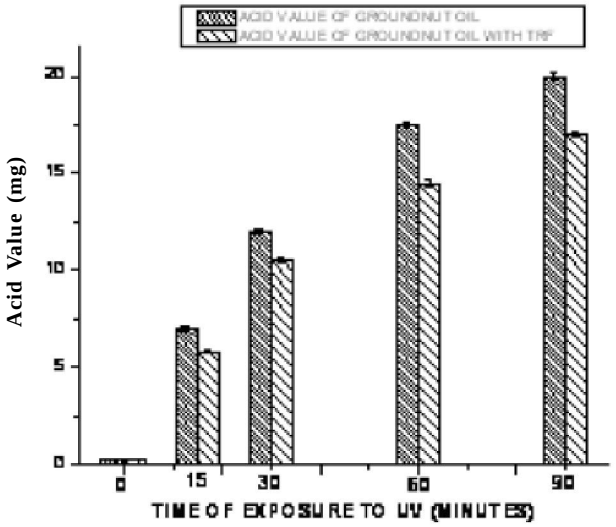

Figure 5a : Effect of time of exposure to UV on the acid value of groundnut oil

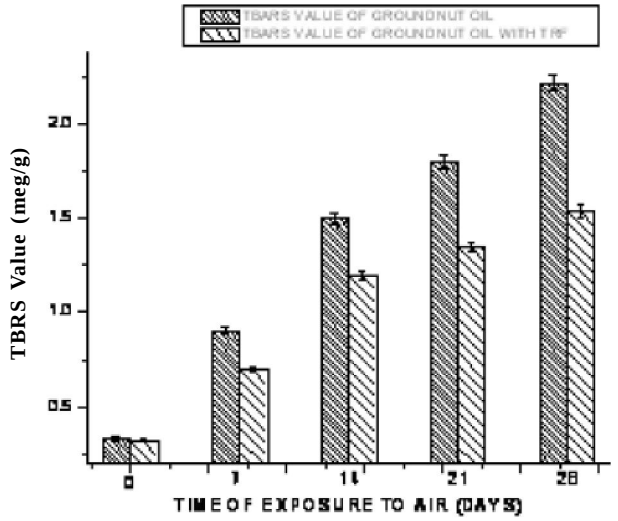

Figure 4b : Effect of time of exposure to air on the TBARS value of the groundnut oil

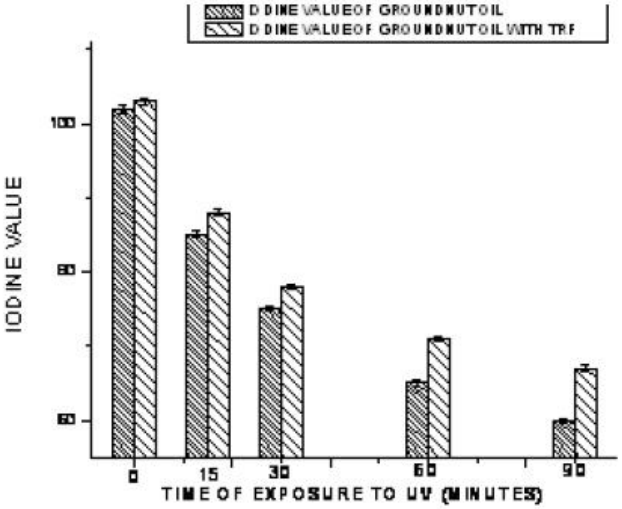

Figure 5b : Effect of time of exposure to UV on the iodine value of groundnut oil

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the increase in exposure period for all the samples, as shown in Figure 5a. The control exhibited the higher acid value. Exposure to UV generates free radicals which are responsible for the enhanced lipid peroxidation. TRF quenches the free radicals and thereby lowers the extent of lipid peroxidation and acid value. After 15, 30, 60 90 minutes of exposure to UV, the acid value reaches 7, 12, 17.5 and 20 respectively. TRF when present in the oil can however control the values to 5.8, 10.5, 14.5 and 17 respectively. Iodine value of groundnut oil lowers upon UV exposure. TRF when present lowers the extent of lipid peroxidation by reacting with free radicals itself. Figure 5b shows the effect of exposure to UV on the iodine value of the groundnut oil. The iodine value gradually decreases to 85, 75,65 to 60 after 15, 30,60 and 90 minutes of exposure to UV radiation. Upon addition of TRF, the iodine value becomes 88, 78, 71 and 67 after 15, 30, 60 and 90 minutes of UV exposure.

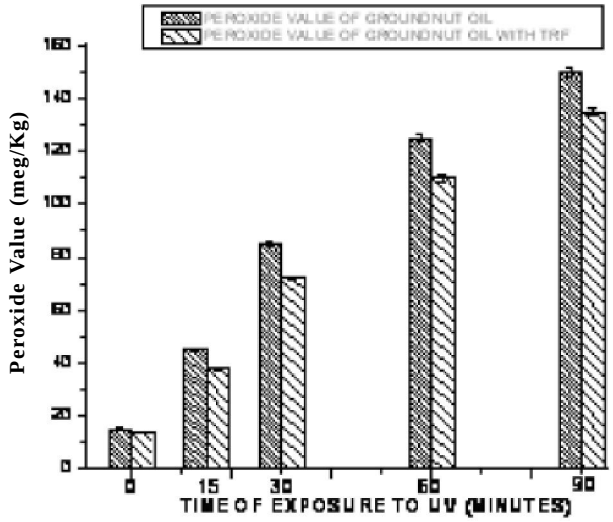

Figure 6a : Effect of time of exposure to UV on the peroxidation value of groundnut oil

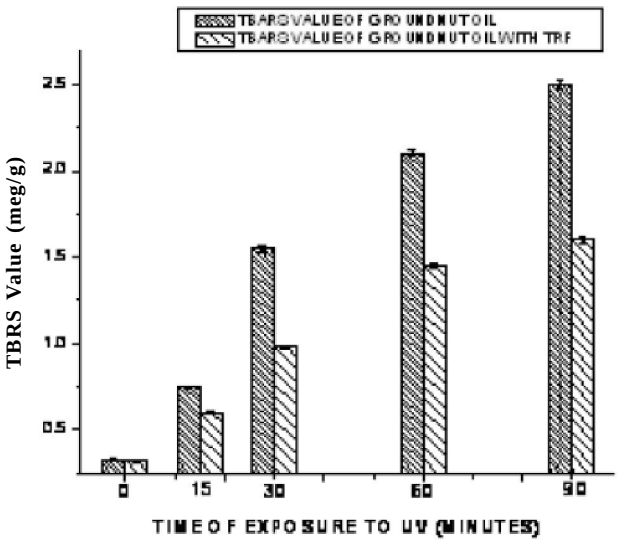

Figure 6b : Effect of time of exposure to UV on the TBARS value of groundnut oil

As shown in Figure 6a, the peroxide value of the control groundnut oil after 90 minutes of UV exposure becomes as high as 150. As acid value, peroxide value also reduces upon TRF addition under accelerated oxidation condition of UV exposure. The effect of adding TRF to groundnut oil exposed to UV on the TBARS value is shown in Figure 6b. The TBARS value gradually increases with prolonged time of exposure. But TRF when present in the exposed groundnut oil lowers the TBARS value . It shows that with more time of exposure to UV the TRF shows more efficiency in lowering the TBARS value. UV radiation-induced lipid oxidation and TBARS values increased with UV radiation exposure time. With UV light, used to mimic sunlight, lipid peroxidation increases steadily with increase in time of exposure as UV light accelerates free radical formation. Here also, TRF can exert its antioxidant activity and retard peroxidation.

CONCLUSION

It can be concluded that TRF possesses the antioxidant potential required to decelerate lipid peroxidation in groundnut oil even under such accelerated oxidation conditions. The results show that the antioxidant ability of TRF was efficient not only under heating and air exposure but also under UV irradiation. This study proves the antioxidant effectiveness of TRF Thus TRF can be used to retard lipid peroxidation thereby extending shelf life and retaining the quality of the groundnut oil.

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