Effect of Temperature, UV, Sun and White Lights on the Stability of Olive Oil

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Summary: The effects of temperature, UV, sun and white lights on the carotene value, stability and subsequent oxidation of olive oil have been investigated. Five different brands of olive oils were purchased from the local market. The oils were preserved in Pyrex test tubes in ultra low temperature refrigerator (4 °C), oven (72 °C), UV, sun, and white lights for one hour daily up to 14 days. The samples were analyzed using UV-visible spectroscopy and standard AOCS methods. The results suggested that carotene value showed a considerable variation in all the oils samples and treated conditions. The significant decreasing trend was observed in white light and oven treated samples, while UV and sunlight treatments were also effective and showed oxidation of different olive oils. Oxidation parameters like free acidity, peroxide and anisidine values represented similar trend in the deterioration of olive oils. Low temperature storage was found beneficial to olive oil; however, UV and sunlight are effective for depletion of carotenoids and consequent photo-oxidation.

Introduction

Oxidative stability is an important parameter in evaluating the quality of oils and fats, as it gives a good estimation of their susceptibility to oxidative degeneration, which is the main cause of their alteration [1]. There are some factors such as aging, deep fat frying, irradiation, light etc, which influence the quality of oils and fats and become rancid. Rancid off-flavors are concerned with the changes that result from the reaction with atmospheric oxygen or by hydrolytic reaction catalyzed by an enzyme called *lipase*, from food or microorganisms [2, 3]. The quality of oil or fat depends on its approaches toward rancidity [4].

At the same time, any reaction preventing the propagation of per-oxidation, or removing free radicals, plays an important role in the oxidation mechanism. Chain breaking antioxidants, such as phenolic compounds, react with lipid radicals to form non-reactive radicals and stopping the propagation chain [5]. In fact, these compounds are able to donate a hydrogen atom to the lipid radical formed during the propagation phase of lipid oxidation [6]. Carotenoids are also pigments possessing conjugated hydrocarbons and have been found to be potent protectors against photosensitized oxidation, acting as singlet oxygen quenchers [7, 8]. The physical quenching mechanism of carotenes is based on their low singlet energy state, which facilitates the acceptance of energy from the singlet oxygen. The result of the effects of chlorophyll & β-carotene on the oxidation stability of purified olive oil suggested that singlet oxygen was mainly responsible for the photo-oxidation of the oil containing chlorophyll [9, 10].

The oxidative stability of olive oil is greatly affected by the presence of chlorophylls and their derivatives, especially in the presence of light, as they have the ability to transfer energy from light into chemical molecules [11]. In Pakistan olive oil is available in commercial markets, which are used for medicinal purposes, but the quality and stability of these different brands are not known nor is its oxidative stability studied. This study is therefore, aimed to investigate the effect of different conditions on the carotene value stability of different brands of olive oils.

Results and Discussion

Carotene Value

The lowest carotene values are shown in Marhaba olive oil was in white light treated samples, which was 183.84± 0.020 μg/g, while the highest carotene value was shown in refrigerator condition which was 221.56±0.025μg/g as shown in Table-1. Similarly the lowest value of 145.54±0.043 was recorded at sunlight and the highest value, which was obtained for refrigerator (309.65±0.041 μg/g) in Top Treatment oil. In Pure olive oil the lowest carotene

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Table-1: Effect of Temperature, UV, Sun and White Lights on the carotene values of Marhaba, Top Treatment, Pure, Italian and Rivera Olive Oils.

Conditions	Oil Samples					
	Marhaba	Top Treatment	Pure	Italian	Rivera	
UV light	199.73 ± 0.041	271.35 ± 0.015	203.56 ± 0.037	220.79 ± 0.032	315.97±0.040	Carotene value(μg/g)*
Oven (72 °C)	196.67 ± 0.015	242.63 ± 0.015	222.14 ± 0.010	203.56 ± 0.037	308.88±0.015	
White light	183.84 ± 0.020	195.33 ± 0.010	125.62 ± 0.030	222.14 ± 0.010	293.56±0.030	
Sunlight	214.48 ± 0.010	145.54 ± 0.043	202.41 ± 0.032	280.93 ± 0.005	263.69±0.032	
Refrigerator (4 °C)	221.56 ± 0.025	309.65 ± 0.041	262.35 ± 0.020	310.23 ± 0.010	353.70±0.040	

*Carotene value is mean ± standard deviation (n=3).

value, 125.62±0.030 was recorded at white light, and refrigerator with a value of 262.35 ± 0.020 μg/g. Similar trend was observed in Rivera olive oil, with lowest value of 263.69 ± 0.032 μg/g for sunlight treatment. However, in Italian olive oil, oven was found to be the potent condition for lowering of carotenoids from room (429.53±0.03) to oven (203.56 ± 0.037 μg/g).

In the present study carotene value shows a considerable variation, in all the oils sample and treated conditions. In Italian olive oil, the lower value was observed in oven. Similarly, Marhaba oil give lower value at white light, while in Spanish oil depletion of carotene was observed at UV light treatment. The highest carotene level was observed in refrigerator condition. The present results are supported by those of Caponio *et al.*, [3] who observed that the oils stored in the light had significantly lower tocopherol, carotenoids and chlorophyll contents compared to storage in dark. The present results are in correlation with those of Alyas *et al.*, [12] who heated RPO (Red palm oil) at very high temperature (200 ^{0}C for 30 min) resulted in only 15% loss of the β-carotene. However, increasing the exposure time at the same temperature causes 59% reduction in the β-carotene contents. Bangash, *et al.*, [2] found that the gamma radiation splits up the molecule of β-carotene thereby decreasing the level of carotene, which results in the lowering of the antioxidant activity and thus the stability of oil and fat decreases. These findings are in agreement with Lin and Chen [13] who observed that β-carotene exhibit a declining tendency with increase in temperature, in carrot and tomato juice stored at different temperatures. It was found that in photo-oxidation of olive oil the carotenes and tocopherols were apparently destroyed more rapidly in the presence of chlorophyll [11].

Analytical Parameters

Free acidity of different olive oils is given in Fig. 1. It is clear from the figure that more effective condition for increase level of free acidity

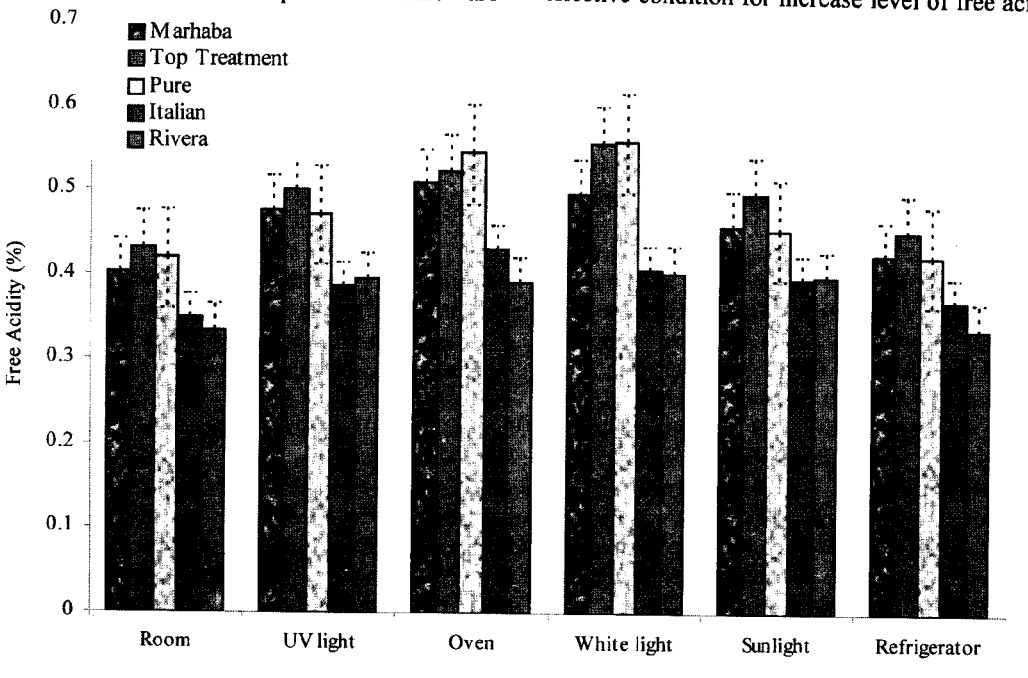

Fig. 1: Effect of Temperature, UV, Sun light and White light on the Free Acidity (%) of Marhaba, Top Treatment, Pure, Italian and Rivera Olive oils

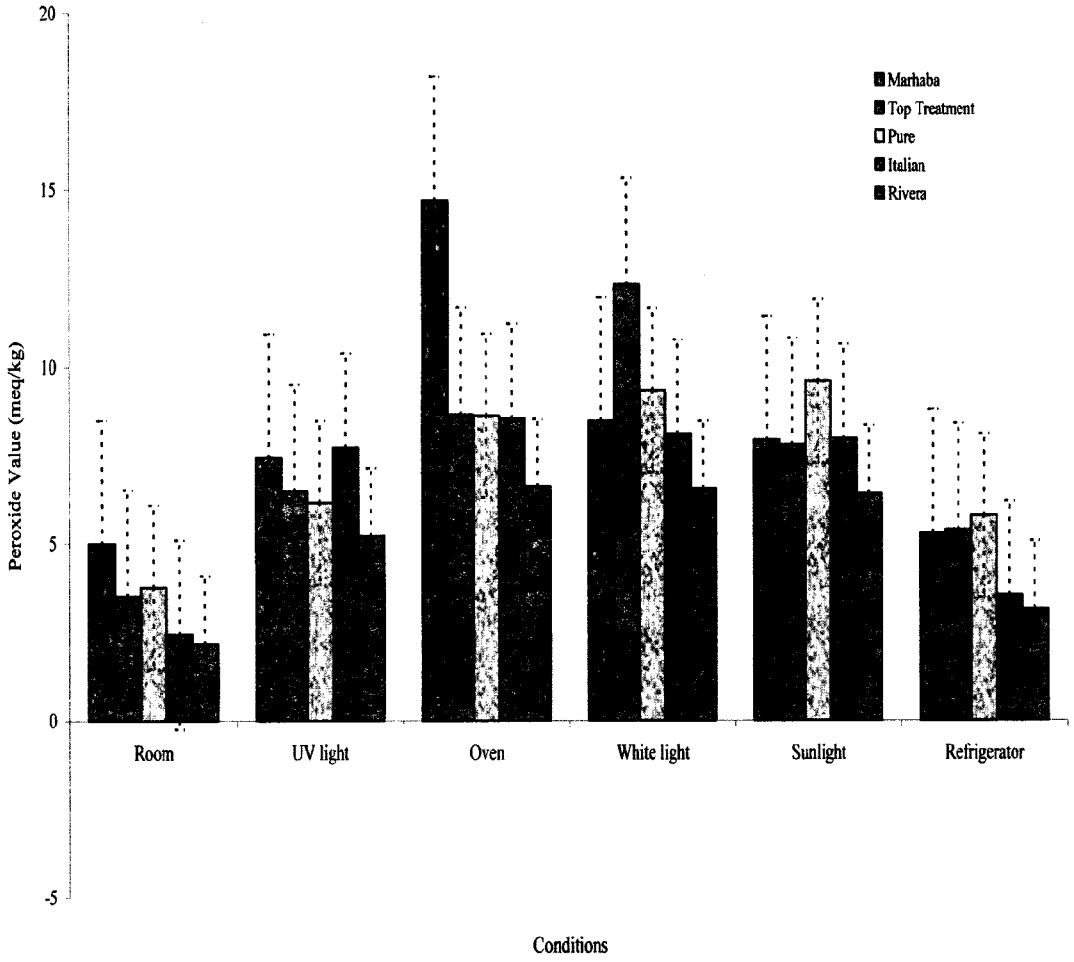

Fig. 2: Effect of Temperature, UV, Sun light and White light on the Peroxide value (meq/kg) of Marhaba, Top Treatment, Pure, Italian and Rivera Olive oils

are oven and white light. The highest acidity value of 0.510 % and 0.432 % are observed in Marhaba and Italian olive oils in oven. While white light was found to be effective in Top Treatment, Pure and Rivera olive oils with 0.556 %, 0.558 %, and 0.403%, respectively. The maximum values of free fatty acid were observed in the presence of white light & oven, while the minimum value was recorded at refrigerator. The effect shown by the UV & sun light were moderate. Kiritsakis & Dugan [14] mentioned the departure of free fatty acid level from normal value under the storage conditions of light and ambient temperature in olive oil.

Peroxide value is a measure of the concentration of peroxides and hydro-peroxides formed in the initial stages of lipid oxidation. Milli-equivalents of peroxide per kg of fat are measured by titration with iodide ion. Peroxide values are not static and care must be taken in handling and testing samples. High peroxide values are a definite indication of a rancid fat, but moderate values may be the result of depletion of peroxides after reaching high concentrations. Results regarding peroxide values are given in Fig. 2. Oven was found effective condition for the elevation of PV values of Marhaba, Rivera and Italian olive oil, while in Top Treatment and Pure olive oil white light and sunlight are effective condition in producing more peroxide in olive oils. Results suggest that PV increases from control to every condition. This increase in PV is less than reported by Okogeri & Margari [15] who stated

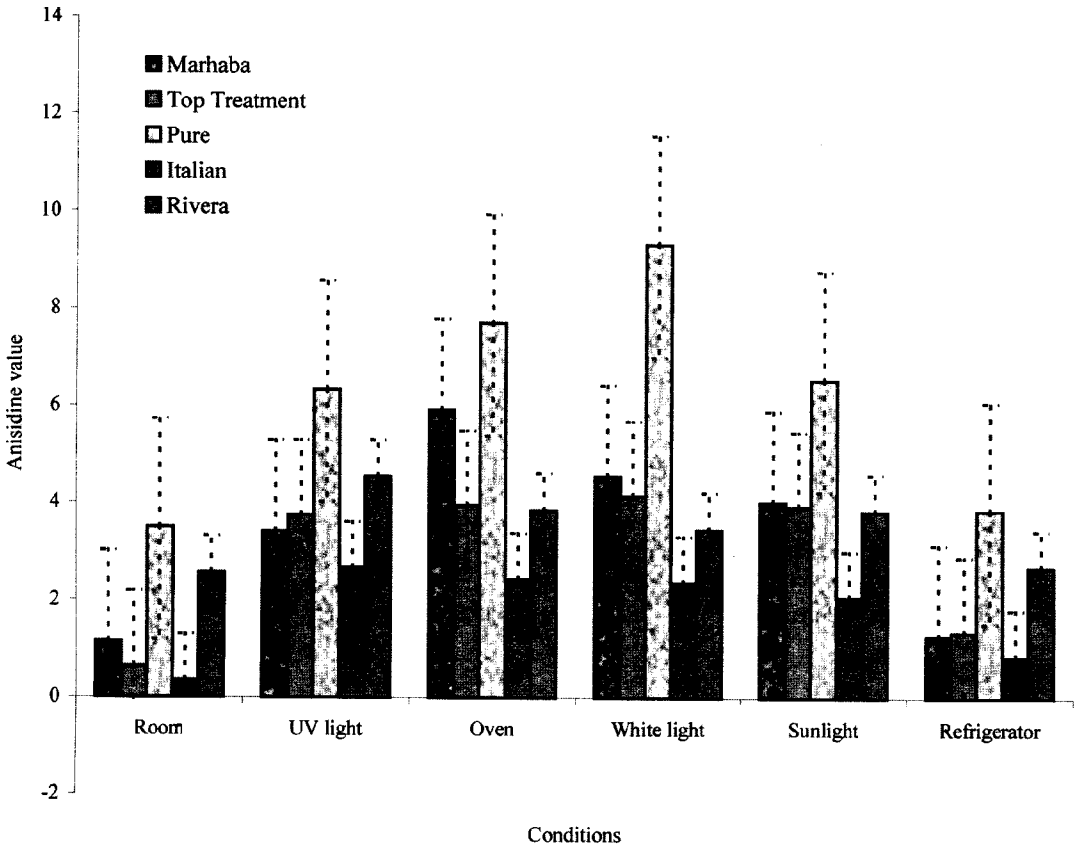

Fig. 3: Effect of Temperature, UV, Sun light and White light on the Anisidine value of Marhaba, Top Treatment, Pure, Italian and Rivera Olive oils.

that during storage of virgin olive oil under diffused light at temperature between 6 and 18 °C, the PV rose from 7.2 to 34 meq/kg.

Anisidine value is the measure of non-volatile reaction product in oxidized oil. The anisidine values of different olive oils are shown in Fig. 3. It is clear from the figure that the most effective condition in Rivera and Italian oil is UV light, while in Top Treatment and Pure oils white light is causing the production of more hydroperoxides. However, oven is the effective condition in Marhaba olive oil. The present results correlate with Muik *et al.*, [16] who found that anisidine value increases for all oils during heating.

Experimental

Samples Collection

Five different medicinally important olive oils available with the following names were purchased from the local markets at Chakdara, Batkhela & Mingora, Pakistan. The oils are either local or important from different countries (Italy & Spain). All the oils were of same season or year as given on its seal. The oils are "Marhaba olive oil, Top Treatment olive oil, Pure olive oil, Italy olive oil and Rivera olive oil". Each these different oils were taken into Pyrex test tubes and then subjected to different conditions each day for one hour for fourteen days.

Storage Conditions

The following different treatment conditions were applied; while the room condition was taken as a control. *Refrigerator*: The oil samples were kept in Pyrex test tub having tight plastic cap in Ultra low temperature refrigerator at 4 °C each day for one hour during the entire experiment. *Oven*: The same Pyrex test tubes having equal amount of oil were kept at 72 °C at oven. *Ultra Violet radiation*: The oil samples having similar conditions of storage were exposed to

ultraviolet radiation in the dark at room temperature (15 °C) for one hour each day. *Sunlight*: The oil samples in Pyrex test tube were exposed to sunlight for one hour every day where temperature range varies from 10 to 15 °C at noontime. *White light*: All the seven oil samples in Pyrex test tubes were exposed to white tube light having the intensity of 1000-lux in a closed controlled room (temperature 25 °C & humidity 55 %).

Carotenoids Contents

The oil samples were accurately weighed through a semi-accurate balance into 25 mL volumetric flasks as describe in our previous work [4, 5]. Test portion in each flask was dissolved with a few mL of solvent and diluted up to the mark. The solutions were transferred to 1 cm cuvette and absorbance was measured at 446 nm against the solvent using Shimadzu UV-Visible 1700 spectrophotometer (Shimadzu Japan).

Analytical Parameters

Free acidity (FA) given as % of oleic acid and peroxide value (PV) expressed as milli-equivalents of active oxygen per kilogram of oil (meq O_2/kg) were measured following the analytical methods described in European Regulation EEC 2568/91 and later amendments [17]. Anisidine value (AV) was determined according to the AOCS official method (Cd 18-90), using Shimadzu UV-Visible 1700 spectrophotometer (Shimadzu, Japan) as described earlier [18].

Conclusions

From the present study it is concluded that with the exception of freezer, oxidation was observed in all other conditions at different rates. The most affected condition was observed in white light followed by oven, which represents a high rate of oxidation. The UV and sunlight treatments are also effective and show oxidation of olive oils, however, the intensity of oxidation was recorded lower than oven and white light. The most affected oils were Marhaba, Top Treatment, and Pure, While Italian and Rivera shows more stability toward treated conditions. The reason was the presence of high level of carotenoids in these oils. In all treated conditions, the best result recorded was at Refrigerator condition and showed high stability for each of different oil. The oil samples in Refrigerator became cloudy and condensed but their antioxidant level was almost remained constant and show minimal oxidation rate. It is therefore, recommended that olive oil should be stored at dark condition to avoid photo-oxidation; low temperature favors best quality of oil and avoid exposure to intense radiations because it depleted the level of antioxidant and caused rancidity in oils.

References

1. R. Aparicio, T. M. Morales and V. Alonso, *J. Agric. Food Chem.*, **45**, 1076 (1997)
2. F. K. Bangash, T. Ahmad, S. Atta and A. Zeb, *J Chin. Chem. Soc.*, **51**, 991 (2004).
3. F. Caponio, M. T. Bilancia, P. Antonella, E. Sikorska and T. Gomes, *Euro. Food Res. Tech.*, **221**, 92 (2005).
4. I. Khan, H. Ullah and Ihsanullah, *J. Chem. Soc. Pak.*, **29**, 213 (2007)
5. A. Zeb and G. Lutfullah, *J. Chem. Soc. Pak.*, **27**, 205 (2005)
6. F. Shahidi and P. D. Wanasundra, *Crit. Rev. Food Sci. Nutr.*, **32**, 67 (1992).
7. D. G. Bradley and D. B. Min, *Crit. Rev. Food Sci. Nutr.*, **31**, 211 (1992).
8. A. Zeb and S. Mehmood, *Pak. J. Nutr.*, **3**, 197 (2004)
9. N. Fakourelis, E. C. Lee and D. B. Min, *J. Food Sci.*, **52**, 234 (1987).
10. M. T. Morales, J. J. Rios and R. Aparicio, *J. Agric. Food Chem.*, **45**, 2666 (1997).
11. M. A. Khan and F. Shahidi, *J. Food Lipids.*, **6**, 331 (1999)
12. S. A. Alyas, A. Abdulah and N.A. Idris, *J. Oil Palm Res.*, **April**, 99 (2006)
13. C. H. Lin and B. H. Chen, *Food Chem.*, **90**, 837 (2005)
14. A. Kiritsakis and L.R. Dugan, *J. Am. Oil Chem. Soc.*, **62**, 892 (1985).
15. O. Okogeri and M. T. Margari, *J. Agric. Food Chem.*, **50**, 1077 (2002).
16. B. Muik, B. Lendl, A. D. Molina and M. J. C. Ayora, *Anal. Chim. Acta.*, **487**, 211 (2003).
17. S. Gomez-Alonso, V. Mancebo-Campos, M. D. Salvador and G. Fregapane, *Food Chem.*, **100**, 36 (2007)
18. G. Lutfullah, A. Zeb, T. Ahmad, S. Atta and F. Khan, *J. Chem. Soc. Pak.*, **25**, 269 (2003).