Pak. J. Biochem. Mol. Biol. 2011; 44(3): 92-94

Effect of packing materials on storage stability of sunflower oil

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Abstract: This study was undertaken to determine storage stability of sunflower oil in different packing materials such as Glass (GS), Polyethylenterephthalate (PET), Polyethylene (PE) and Tin (TN) filled with sunflower oil were stored under florescent light (room condition) and were either fully filled (without headspace) or partially filled (with headspace) to determine the effects of packaging materials and storage time on the stability of sunflower oil. Peroxide values (PV), free fatty acids (FFA), saponification value (SV) and iodine value (IV) were measured to determine stability of sunflower oil every 2 month until 6 months. Glass (GS) bottles recorded lower oxidation values than oils packaged in polyethylenterephthalate (PET), polyethylene (PE) and tin (TN). The oxidation not exceeded in oil packed in glass without headspace and preceded faster in packages stored in those with headspace in PE bag. So glass gives the best protection against oxidation under florescent light then the other bottles under florescent light (at room condition). This study showed that for long storage life sunflower oil should be stored under florescent light at room condition in glass bottle fully filled (without headspace) and air, packaging and storage time all have an effect on the stability of sunflower oil.

Keywords: Sunflower oil, storage, packaging materials, rancidity.
Received: April 21, 2011 **Accepted:** July 7, 2011
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INTRODUCTION

One of the best and widely availability of sunflower oil in Pakistan has proven to be an excellent vegetable oil both in terms of its healthy characteristics and applicability for a wide variety of uses. This increase has brought with it a number of storage problems and given rise to an urgent need to maintain sunflower oil quality during storage[1]. Sunflower oil is a rich source of vitamin E and contains alpha-tocopherol. It has a high level of linoleic acid[2]. High reactivity of this unsaturated fatty acid is associated with oxidation (rancidity), loss of nutritional value and quality[3]. Light, oxygen, moisture, metal contamination and heat cause deterioration of the oil's quality. Of particular interest in the sunflower oil field is that the process of oxidation occurs only to a limited extent. Peroxides are the main initial products formed by autoxidation during storage[1]. The combination of oxygen and light can create the conditions for some decomposition of the oil's triacylglycerols and production of oxidization products that alters the oil quality [4]. Therefore, peroxide concentration gives a measure of degree of oxidative rancidity and serves as an indicator of quality change[5,6]. Vegetable oils are rich in polyunsaturated fatty acids which are prone to oxidation resulting in peroxides and other compounds that give the oil an objectionable odor[7,8].

The packaging of sunflower oil is of decisive importance. Physical characteristics of the packaging material (permeability and light transmittance) may directly affect the quality of oil. Glass tins and different kinds of polyethylene (bags) are all used for packaging of oil in Pakistan. Glass has many advantages such as inertness and rigidity. However, it is costly and brittle. Plastic bottles are used extensively for packing due to their outstanding function. But they offer limited protection concerning the barrier properties compared to glass and tinplate. Therefore, they are not always suitable for this purpose. Polyethylene (PE), polyvinyl chloride (PVC) and polyethylenterephthalate (PET) are used as packaging materials. PET is becoming a popular plastic because of its excellent barrier, appearance, mechanical properties, low weight and price.

On the other hand, one of the most important limitations of plastic packaging is that polymers allow for mass transport[9,10]. Storage stability and shelf life of packaged oils are now receiving much attention. The few studies published about the effect of packaging on oil quality have concluded that stability can be enhanced by suitable selection of packaging. Glass bottles provide better protection against oxidation than PE plastic bottles[11]. Changes in peroxide value (PV) and thiobarbituric acid value in refined sunflower oil and ground nut oil at 37^{o}C were significantly less in the presence of plastic films[12] that incorporated butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) than in control samples[13].

The increased use of plastic bottles for oil in Pakistan motivated the present study to compare the effect of packaging containers to retain the quality of sunflower oil. In this study sunflower oil was packaged in both PET, PE, TN and GS bottles, All are with and without air (with and without headspace) and stored in conditions for only at room condition 6 months.

After a period of 2 months, oil induplicate samples were analyzed for peroxide value (PV), free fatty acids (FFA), saponification value (SV) and iodine value (IV).

MATERIALS AND METHODS

Collection of samples

The sunflower oil samples were procured from commercial industrial manufacturer (Kisan Sunflower oil and Faisalabad oil refinery Pvt. Ltd). One liter each sample of refined sunflower oil was packed in different containers such as PET bottles, PE bag, tin pack and glass bottles. All containers were stored at room conditions (fluorescent light), with or without headspace and at room temperature for 6 months. These samples were stored in open wooden cabinet during this study and were analyzed after every 2 months up to 6 month storage period (0, 2, 4 and 6 months).

Chemical analyses

Peroxide value in all the samples was determined by standard method[14]. In which all the substances in terms of milliequivalents of peroxide per 1000g of sample (meq O_2/Kg), oxidize potassium iodide. Free fatty acids were determined by titration according to the standard method[14] and expressed as percentage of oleic acid. The Wijs method was used for determining the iodine value (IV) of sunflower oil[14]. The oil was weighed and dissolved in a suitable organic solvent, to which a known amount of iodine chloride was added. The saponification value (soap content) was determined by standard methods as sodium oleate, representing the remaining amount of soap[14].

RESULTS AND DISCUSSION

The effects of packaging material, storage at room condition and storage time on measured properties were determined. Because edible oils are subject to oxidative rancidity, packaging in plastics poses some problems. Interactions between oxygen permeate and unsaturated fatty acids cause quality deterioration in vegetable oils during storage. The amount of PVs showed significant increases in oil stored in different packaging material from starting point to 2, 4 and 6 months are summarized (Table 1).

During the first 6 months of storage a significantly higher content of peroxides was produced in oil that was with the addition of headspace than in oil stored without headspace. It is clear that the sunflower oil packaged in glass containers gave the least in PV, while oil packaged in PE bag gave the highest in PV. The highest average PV of 3.4 (meqO_2/Kg) was recorded for the oil sample packaged in PE bag with air. This is due to the combined effects of the relatively higher permeability of PE to oxygen and of transmittance of light. Oil that was filled in glass bottles without headspace and stored at room condition under florescent light showed the lowest deterioration average PV of 2.83 (meqO_2/Kg). Sunflower oil samples packaged without air (without headspace) had significantly lower PV than oil packed in the air (Table 1). It should be noted that the quality of sunflower oil is highly affected by the ability of the container to exclude light and oxygen, which further retards oxidative changes. PET proved to be quite adequate in preserving the quality of the sunflower oil and to avoid oxidation up to 1 year.

Table 1: Effect of Packaging materials (with or without head space at room conditions) and storage time on mean peroxide values (meqO_2/Kg).

Package	Head space	Storage time (Months)				Mean differential
		Initial	2M	4M	6M	
PE Bags	With	2.50	3.20	3.70	4.20	3.40
	Without	2.50	3.00	3.50	4.00	3.25
PET Pack	With	2.50	2.95	3.50	3.90	3.21
	Without	2.50	2.93	3.45	3.70	3.14
Tin Pack	With	2.50	3.00	3.60	3.80	3.22
	Without	2.50	2.95	3.50	3.60	3.13
Glass Pack	With	2.50	2.75	3.00	3.30	2.88
	Without	2.50	2.65	2.90	3.30	2.83

It was noticed that the PVs of sunflower oil were significantly dependent on the container type and conditions of storage. The values under the mean column indicate that there are significant differences in storage conditions and the packaging materials that prevent the formation of free fatty acids in sunflower oil (Table 2).

Table 2: Effect of Packaging materials (with or without head space at room conditions) and storage time on mean free fatty acid values (%).

Package	Head space	Storage time (Months)				Mean differential
		Initial	2M	4M	6M	
PE Bags	With	0.20	0.30	0.45	0.51	0.36
	Without	0.20	0.30	0.38	0.40	0.32
PET Pack	With	0.20	0.36	0.40	0.45	0.35
	Without	0.20	0.32	0.38	0.42	0.33
Tin Pack	With	0.20	0.34	0.40	0.45	0.34
	Without	0.20	0.30	0.38	0.45	0.33
Glass Pack	With	0.20	0.30	0.35	0.40	0.31
	Without	0.20	0.30	0.32	0.40	0.30

Variance analyses of free fatty acid values (FFA%) showed significant increases in their content, similar to PVs, in different packaging from starting point to 2, 4 and 6 months of storage. During storage, FFA % of all samples exhibited similarly increasing trends (Table 2). This result showed that the free fatty acids of samples increased during storage. Samples stored under florescent light in glass containers at room condition experienced the least hydrolysis during storage.

The IVs increased during the storage period as shown (Table 3). IVs of oil packed in PE bags stored under florescent light significantly increased until 6 months of storage. IVs exhibited similar increasing

trends during first 6 months of storage (with/without headspace) in all containers stored under light. Glass containers have the lowest IVs, the mean average iodine value of sample PE bag with headspace under florescent light in the first 6 months of this research work recorded the highest value of 119.62g/100g of oil is recorded. While the lowest IV value which is 116.25g/100g of oil is recorded for the sample packed in glass without headspace under florescent light at room condition.

Table 3: Effect of Packaging materials (with or without head space at room conditions) and storage time on mean iodine value (g/100g).

Package	Head space	Storage time (Months)				Mean differential
		Initial	2M	4M	6M	
PE Bags	With	112.5	118.0	122.0	126.0	119.62
	Without	112.5	118.0	121.0	123.0	118.62
PET Pack	With	112.5	118.0	121.5	123.5	118.87
	Without	112.5	114.5	119.0	122.5	117.12
Tin Pack	With	112.5	116.0	121.0	125.0	118.62
	Without	112.5	116.0	120.0	122.5	117.75
Glass Pack	With	112.5	114.5	118.0	122.0	116.75
	Without	112.5	114.5	116.0	122.0	116.25

The sample packed in PE bag with headspace has the highest saponification value 184.75mg/KOH/g which increased in the 6 month storage time. The SV of sample packed in glass bottle represented the lowest value of 181.6 mg/KOH/g are shown (Table 4).

Table 4: Effect of Packaging materials (with or without head space at room conditions) and storage time on mean saponification value (mg/KOH/g).

Package	Head space	Storage time (Months)				Mean differential
		Initial	2M	4M	6M	
PE Bags	With	180	186	185	188	184.75
	Without	180	185	185	186	184.00
PET Pack	With	180	185	187	188	185.00
	Without	180	185	185	187	184.25
Tin Pack	With	180	183	185	187	183.75
	Without	180	183	185	185	183.25
Glass Pack	With	180	183	183	185	182.75
	Without	180	183	183	183	182.25

The soap content of packaged Glass, polyethylenterephthalate (PET), polyethylene (PE) and tin sunflower oil stored at room condition under fluorescent light were have significant change. Glass, tin and PET stored without headspace produced significantly lower soap content as compare with packed along headspace.

CONCLUSION

The increasing the storage time had an adverse effect on PV and FFA (%), iodine and soap values. The increase of peroxide and FFA (%) was more notable than that of soap content in all packages within the first few months of storage. The difference in increase of those values in different packaging materials could be explained by the absorption of light into packaging materials, and the degradation of oil compounds due to initial oxygen concentration and permeability of oxygen through the package. Sunflower oil stored in glass in florescent light at room condition showed very low oxidation and maintained its original profile for a long period. It has shown that sunflower oil is affected by light and oxygen in much the same way as other vegetable fats and oils are affected. It also reaffirmed that glass provides better protection from oxidation than other packing materials.

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