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Assessing the Sudanese Standards and Guidelines of Edible Oils: A Case Study of Sunflower Oil

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Abstract: Two types of sunflower oil (SO) were stored in different packaging and periodically analyzed to assess the reliability of the local standards and guidelines of edible oils set by the Sudanese Standard and Metrology Organization (SSMO). Using standard procedures of the Association of Official Analytical Chemists (AOAC), thephysicochemical properties (color, refractive index, viscosity, acid value, peroxide value and iodine value) were determined. Results indicate that the maximum standard limit of 10 meq/kg set for peroxide value is not reliable since the entire oil samples exceeded this level even at 0.0 storagetimes. In spite of being not included among the SSMO standards, color intensity and viscosity of SO werefound to be affected remarkably over storage time. Considering regional climatic conditions when setting edible oil standards by the concern authorities deem necessary and by far paramount.

Key words: Sunflower · Deterioration · Oxidative Stability · Storage · Physicochemical

INTRODUCTION

Surrounding regional factors, such as temperature, atmospheric oxygen, light date of sowing and even irrigation regime type affect the oil composition of sunflower seeds and therefore, its oxidative stability. Robertson and Russell [1] studied the effect of climatic conditions on the composition of sunflower oil, finding that linoleic acid increased proportionally with increasing temperature difference.Lajara *et al*. [2] reported that an increase in temperature resulted in a decrease in the linoleic acid content and an increase in the oleic acid content. Ngassapa and Othman [3] studied the effect of atmospheric oxygen and light on the physicochemical characteristics of some vegetable oils manufactured in Tanzania and stated that the quality of the oils is greatly affected by atmospheric oxygen and light.

Several studies reported that there are many general factors affect the oxidative stability of SO as well as most vegetable oils during storage. One of which is the degree of unsaturation, i.e., the relative content of oleic and linoleic acids. Product shelf-life is affected by manufacturing conditions such as the type of extraction process (pressing, with solvent, with supercritical fluids), degree of purification (crude, refined, deodorized, etc.), addition of antioxidants and type of packaging (container material, incorporation of inert atmosphere, etc.) [4, 5] Other major factors influencing the oxidative stability are the particular storage conditions: time, temperature and light [4, 6]. Previous evidences reported that color of vegetable oils is attributed to minor oil components present in a very small concentration, such as tocopherols, carotenoids and other pigments. These components were formed to undergo oxidation during oil storage which ultimately caused oil decolorization [7, 8]. Previous study conducted by Ngassapa and Othman [3] found RI of refined SO grown in Tanzania ranged between 1.467 and 1.468. Aryo*et al*. [9] reported that RI of oils increased over storage time.It has been reported that oil of stored seeds is more exposure to hydrolysis factors [10]. Moreover, damage of seeds during harvesting and/or handling leads to astringent deterioration during prolonged storage [8]. Peroxide values ranged between 122 and 159 were obtained by Ngassapa and Othman [3]

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for some brands of SO collected off-shelf in Dar es Salaam (Tanzania) when exposed to atmospheric oxygen and light for 90 days. Light has been incriminated among factors breakdown pigments and vitamins present in small quantities in vegetable oils [11]. Relative degradation of oil sample stored in black container may be attributed to temperature absorbed by black color. Temperature plays a significant role of breakdown of oils and fats to fatty acids and glycerol [9]. In general, glass containers described previously by Jaimand and Rezaee[12] to be the best for edible oil storage.

Hence, the objective of the present study was to:

- Investigate the comparison between sunflower oils kept in different containers of different material and different color with the local standards set fir edible oils.
- Assessing the reliability of the current standards set by SSMO[13] for edible vegetable oils.

MATERIALS AND METHODS

The sunflower oil which has been used in the present study were two different samples, one of which was extracted from new harvested sunflower seeds that grown in the Gezira Agricultural Research Corporation farm. The other sample was commercial oil which had been already extracted, bleached and deodorized under industrial processing.

Oil Extraction: Sunflower seed of the variety PAN7411 was extracted by utilizing local made oil presser and Chinese presser. First oil samples were extracted prior harvesting and the second after end of storage period. The extracted crude oil was laboratory purified by using filter paper No. 140 under suction in order to accelerate oil filtration. The filtrated oil was then let to settle for about two days in room temperature and then filtered again. After complete sediment, all settlings and impurities were removed and the oil becomes markedly clear and suitable to subsequent analyses.

Oil Packaging and Storage Period: Commercial oil samples were stored in three types of containers' material: 1) galvanized tin; 2) polythene and 3) colorless glass container. Furthermore, the commercial oil samples also were stored in glass containers of different colors: 1) brown; 2) black and 3) colorless bottle. In respect of Pan-7411 variety, first extracted oil samples were stored in colorless glass bottle to be compared with that extracted at the end period of seed storage. Commercial oil samples were stored for 12 months at room temperature (35°C) and were sampled periodically every 4 months.

Proximate Analysis of Seed Composition: Determination of total oil content was carried out according to AOAC [14]. Crude protein was determined by semi micro Kjeldahi method as described by Pearson *et al*. [15]. Crude fiber was estimated by the method described by Pearson *et al*. [15]. Moisture content was determined by air oven as described by AOAC [14]. Total ash determined by the method that described by AOAC [14].

Oil Characteristics Analysis: Refractive index of all samples was determined at 35-40°C index by Abb-Refractometer according to AOAC [14]. Color intensity was recorded using alovibondtintometer, unites of red, yellow and blue according to AOCS [16]. Viscosity of the oil samples under investigation was recorded using Ostwald-U-tube viscometer according to Cocks and Van Rede [17]. Acid value, peroxide value and iodine value of all samples were determined according to Cocks and Van Rede [17].

RESULTS AND DISCUSSION

The standards and guidelines for major characteristics of sunflower oil as set by the Codex Aliment Arius Commission of the FAO/WHO [18] and SSMO [13] were summarized in Table (1). The analytical for all the determinations are presented in Tables (2-4). Table (2) presents the physicochemical characteristics of virgin sunflower oil PAN7411-variety after storing for one year. Table (3) presents the physicochemical characteristics of commercial refined sunflower oil stored in containers of different type-materials while Table (4) presented the physicochemical characteristics of the commercial refined sunflower oil stored in glass containers of different colors.

Color: In spite of the importance of color degradation test in oil characterization, color test has not set by the SSMO. Color intensity in the investigated SO was stable with respect to yellow and blue units of Alivibondtintometer instrument whereas the red unit was faded by different magnitude according to the storage time and container type. As presented in Table (2), oil samples extracted from the new harvested PAN7411-variety seeds exhibited more resistance to color degradation compared to those

Table 1: Local and foreign standards set for edible sunflower oil.

Standard and guidelines	Color Viscosity (at 35)	Refractive index (at 40°C)	Viscosity (at 35°C)	Acid value (mg KOH/ gm. oil)	Peroxide value (meq/kg)	Iodine value (Wijs method)***
FAO/WHO (1993)	Not limited	1.467-1.469	Not limited	≤0.6* ≤4.0**	≤10* ≤15**	110-143
SSMO (2003)	Not limited	1.461-1.469	Not limited	≤0.6* ≤4.0**	≤10* ≤15**	110-143

*= Upper limit set for refined oil, **= Upper limit set for virgin oil. ***=As indicated by AOAC (Official Methods of Analysis (1984) Chapter 28.023

Table 2: Comparison between physicochemical characteristics of virgin sunflower oil PAN4731-variety with SSMO standards after storing for one year

	Physical parameters					Chemical parameters		
	Color							
Type of sample	Yellow	Red	Blue	Refractive index (at 40° C)	Viscosity (at 35° C)	Acid value (mg KOH/gm. oil)	Peroxide value (meq/kg)	Iodine value (Wijs)
A	25	3.6	0.0	1.4720	54.1	0.447	7.98	127
B	25	3.4	0.0	1.4745	51.9	0.538	78.5	112.5
C	25	2.4	0.0	1.4750	60.3	2.112	69.5	112.5
SSMO standards	NL	NL	NL	1.461-1.469	NL	≤4*	≤15*	110-143

A= Fresh oil extracted from newly harvested seeds of the PAN4731-variety.

B= Stored oil extracted from the above mentioned variety seeds.

C= Fresh extracted oil from the stored seeds of the above mentioned variety.

NL = Not limited.

* = Upper limit set for virgin sunflower oil.

Table 3: Comparison between physicochemical characteristics of commercial refined sunflower oil with SSMO standards after storing in containers of different materials

			Type of container-material								
			Glass			Polythene			Galvanized tin		
			Period of storage time in month								
Oil parameter test		SSMO Standard and guidelines limits	0.0	4.0	8.0	0.0	4.0	8.0	0.0	4.0	8.0
Color	Yellow	NL	25	25	25	25	25	25	25	25	25
	Red	NL	2.9	2.6	2.3	2.9	2.5	2.1	2.9	2.1	1.7
	Blue	NL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Refractive index (at 40°C)		1.461-1.469	1.467	1.468	1.469	1.467	1.469	1.471	1.467	1.471	1.474
Viscosity (at 35°C)		NL	67.0	62.3	58.5	67.0	54.9	48.0	67.0	49.0	45.0
Acid value (mg KOH/gm. oil)		0.6*	0.059	0.100	0.338	0.059	0.192	0.458	0.050	0.220	0.518
Peroxide value (meq/kg)		10*	19.0	56.0	96.5	19.0	84.0	135.7	19.0	182.0	342.5
Iodine value (Wijs)		110-143	119.4	114.5	110.2	119.4	109.4	106.5	119.4	107.5	103.5

NL = Not limited.

*= Upper limit set for refined sunfloweroil.

Table 4: Comparison between physicochemical characteristics of commercial refined sunflower oil with SSMO standards after storing in containers of different colors

Oil parameter test		SSMO Standard and guidelines limits	Type of glass container-color / Period of storage time in month: Brown 0.0	Brown 4.0	Brown 8.0	Clear (colorless) 0.0	Clear (colorless) 4.0	Clear (colorless) 8.0	Black 0.0	Black 4.0	Black 8.0
Color	Yellow	NL	25	25	25	25	25	25	25	25	25
	Red	NL	2.9	2.8	2.7	2.9	2.6	2.3	2.9	2.5	2.2
	Blue	NL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Refractive index (at 40° C)		1.467-1.469	1.467	1.468	1.469	1.467	1.469	1.471	1.467	1.469	1.470
Viscosity (at 35° C)		NL	67.0	66.6	61.9	67.0	62.3	58.5	67.0	59.2	51.0
Acid value (mg KOH/gm.oil)		= 0.6*	0.059	0.100	0.328	0.059	0.100	0.338	0.050	0.150	0.392
Peroxide value (meq/kg)		= 10*	19.0	54.0	92.8	19.0	56.0	96.0	19.0	58.5	98.6
Iodine value (Wijs)		110-143	119.4	116.3	113.0	119.4	114.5	110.2	119.4	110.2	107.2

NL = Not limited.

*= Upper limit set for refined sunflower oil.

of stored ones. Therefore, oil samples of stored seed seemed to be the worst in term of oil deterioration. This means that it is better to extract oil immediately after harvesting and store it as crude oil than to store the seeds itself (storing oils inside the seeds) and extracted the oil thereafter. Color intensity of oil samples stored in containers of different type-materials (Table 3) have also showed no changes in records for each of yellow and blue units while red unit record was faded over storage time. At the end of storage period, glass container revealed acceptable resistance to color degradation (2.3), seconded by polythene container (2.1) and galvanized container was the lowest (1.7). Physicochemical parameters of commercial sunflower oil samples which stored in containers of different color were presented in Table (4). As well, yellow and blue colors were remained stable and did not affected by storage time while red color were faded in all types of the containers. Slight degradation has observed with respect to red color unit which faded from 2.9 (at 0.0 time) to 2.8, 2.6 and 2.5 at the end of the second period of storage time (4.0 months) and to 2.7, 2.3 and 2.2 at the end of the third period (8.0 months) for brown, clear and black glass containers, respectively. Alivibondtintometer red unit is seemed to be actively used in the determination of sunflower oil deterioration and therefore, should be included in sunflower oil standards and guidelines.

Refractive Index (RI): No standards and guidelines limits have been set for RI of virgin sunflower oil either by SSMO or by FAO/WHO. The RIs of all of the oil samples were increased progressively over storage time. In Table (2), the extracted oil of PAN4731-variety found to be having RIs of 1.4720, 1.4745 and 1.4750 for samples A, B and C, respectively. None of the stored three samples of virgin sunflower oil of PAN4731 was compliant to the general limits of 1.467-1.469 set for sunflower oil, even the oil sample of the newly harvested seeds. Therefore, standards and guidelines limits for virgin SO should be set separately from refined SO by the respective authorities.

Table (3) presented RIs of the oil samples stored in containers of different materials. At the end of storage period, class container has the lowest refractive index (1.469), followed by polythene (1.471) while galvanized tin was the highest (1.474). Only the oil sample of glass container has compliant to the limits set for refined SO at the end of storage period.

Table (4) presented RIs of the oil samples stored in containers of different colors. Refractive index was remained stable in brown colored container after the first period of storage time whereas in clear and black containers were found to has a slight increase from 1.467 (at 0.0 time) to 1.468 and 1.469 at 4.0 months, respectively. At the end of storage period (8.0 months), RIs were increased in all containers. Records were: 1.468, 1.469 and 1.470 for brown, clear and black color, respectively. Only the oil sample stored in black container was exceeded the upper limit of 1.469 set for SO.

Viscosity (V): No standards and guideline limits for viscosity have been set for virgin or refined SO either by SSMO or by FAO/WHO. As shown in Table (2), viscosity of stored oil samples extracted from PAN7411-variety was decreased during storage time from 54.1 (sample A) to 51.9 (sample B). On contrast, V was increased up to 60.3 in oil sample extracted from stored seeds (sample C). Presumably, this high viscosity could be attributed to glycerol formation generated by fatty acid hydrolysis caused by enzymatic reactions found substantially in the seeds. Increase of V by the formation of polymerized products, caused by the other deterioration factors, is not excluded and may by far contribute to magnify V in the stored seeds.

Slight decrease in V were observed in oil samples stored in the glass and polythene containers (Table 3), whereas oil sample stored in galvanized container showed a remarkable decrease in V which has fallen down to 49.0 after the first period and then decreased to 45.0 at the end of the storage period.

Table (4) showed V values of oil samples stored in containers of different color. Viscosity was decreased from 67.0 (at 0.0 time) to 66.6, 62.3 and 59.2 at 4.0 months and to 61.9, 58.5 and 51.0 at 8.0 months for brown, clear and black container, respectively. Viscosity is a reliable test indicating, to large extent, how much deterioration the oil has undergone during the storage. Therefore, including V test as a criterion in standards and guidelines for SO deem necessary and seemed to be inevitable.

Acid Value (AV): Acid values of 0.6 and 4.0 have been recommended by each of FAO/WHO and SSMO to be the upper limit for refined and virgin SO, respectively. Relatively, small changes were observed in AVs of stored PAN7411 variety oil samples which increases from 0.447 (sample A) to 0.538 (sample B) whereas the acid value in oil sample extracted from stored seeds was increased up to 2.112 (sample C) (Table 2). None of the investigated oil samples were exceeded the upper limit of 4.0 set for virgin SO. High acidity in oil samples extracted from stored seeds may attribute to decomposition of oil glycerides to their original fatty acids which caused by enzymatic reactions that remains kept inside the stored seeds. It could be noticed that (Table 3) the acidity increased with storage time for all oil samples. Primer acidity of the refined commercial sample was 0.059 which over storage increased slightly in all containers. Generally, glass and polythene containers seemed to be better than galvanized tin. None of the investigated oil samples were exceeded the upper limit of 0.6 set for refined sunflower oil.

Table (4) showed acid values of oil samples stored in different-colored containers. Acid values were increased from 0.059 (at 0.0 time) to 0.100, 0.100 and 0.150 (at 4.0 months) and to 0.328, 0.338 and 0.392 (at 8.0 months) for brown, clear and black container, respectively. None of the investigated oil samples were exceeded the upper limit of 0.6 set for refined sunflower oil acidity. Generally, the slight increase of acidity of the investigated samples may attribute to the complete inhibition of enzymes activity by heating during refining processing.

Peroxide Value (PV): Table (2) showed that there was obvious increase of PVs in each of samples B and C. However, fresh extracted oil from stored seeds seemed to be relatively, more resistant to peroxidation factors compared to the stored oil from the same variety of PAN7411. Probably, this resistance may attribute to the natural protection by the seed’s shell. Furthermore, stored oils may be more affected by light which promoted photo oxidation. The extracted oil from fresh harvested seed (sample A) exhibited PV of 7.98 which is quite below to the maximum recommended limit of 15 meq/kg set by each of FAO/WHO and SSMO for virgin sunflower oil. Whereas samples B and C were extremely exceeded this limit.

Peroxide value of commercial oil sample at 0.0 time was 19.0 (Table 3), indicating that the oil has already undergone to previous oxidation after industrial processing or while being stored in the industry site. Progressing increase in PVs was observed over storage time in all of the oil samples. Glass and polythene containers seemed to be better when compared to galvanized tin container. Peroxide value has increased up to 342.5 meq/kg at the end of storage period. Presumably, high peroxide formation in all of the investigated samples may attribute to climatic conditions that characterized arid and semi-arid region where the Sudan is located.According to Table (4), PV was increased from 19.0 (at 0.0 time) to 54.0, 56.0 and 58.5 (at 4.0 months) and to 92.8, 96.0 and 98.6 (at 8.0 months) for brown, clear and black container, respectively. Appreciably, all of the investigated oil samples have shown high degrees of PVs violating, to far extent, the limit of 10 meq/kg set by each of FAO/WHO and SSMO to be the maximum limit for refined SO. Therefore, optimal permissible limit of PV of vegetable oil, as general and sunflower oil, specifically, should be set independently of foreign published guidelines.

Iodine Value (IV): The IV of oil samples studied tended to decrease by the increase of storage time. A wide limit (110-143) has been set for IV for either virgin or refined SO. Each of the oil samples (B and C) showed IVs of 112.5 (Table 2) while sample A has showed the highest IV (127), demonstrating the similarity of oil resistance to double bond destruction factors whether being stored inside the seeds or as extracted oil. None of the three samples extracted from PAN7411-variety have found beyond the recommended limits.

Table (3) showed the different magnitudes of IVs of SO samples stored in different container type-materials. During the first period of storage, IV was decreased in the three samples. Primer analysis IV was 119.4. At the end of storage period IVs were decreased to 110.2, 106.5 and 103.5 for glass, polythene and galvanized containers, respectively. Each samples stored in polythene and galvanized containers were found below the minimum recommended limit of 110 during both of 4.0 and 8.0 months storage periods whereas the oil sample stored in glass container was found in compliance to the recommended limit.

Table (4) showed the different magnitudes of IVs of SO samples stored in different container kind-colors. Iodine value was decreased from 119.4 (at 0.0 time) to 116.3, 114.5 and 110.2 (at 4.0 months) and to 113.0, 110.2 and 107.2 (at 8.0 months) for brown, clear and black container, respectively. All of the investigated samples revealed IVs within the recommended limit of 110-143 over storage time with the exception of the sample stored in the black container which revealed IV of 107.2 at the end of storage time. From the above mentioned results, the brown container revealed more resistance to oil deterioration. Brown color may act as a protective shelter from light.

CONCLUSIONS

Based on the results of the present investigation, the following conclusions may be drawn:

- Prior to the storage, with the exception of PV, the physicochemical characteristics of SO samples were largely compliant to the SSMO standards.
- Depending on the mode of storage, the physicochemical characteristics changed significantly over storage time. The highest changing property was that of PV especially the SO sample stored in galvanized container.
- Due to high increase in PVs of stored oil even within the first period of storage time (4.0 months), the study recommended every country to set standards for food stuff, as general and for edible vegetable oils as specific, according to regional climatic conditions.
- Following the foreign published guidelines, literally, is not the best choice to set limits for sunflower oil. Considering the high temperature and other climatic elements is the key factor to set reliable safe guidelines.
- Including color, viscosity and peroxide value tests as criteria for SO edibility deem necessary and seemed to be, to large extent, inevitable when need to set its standards and guidelines.

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REFERENCES

1. Robertson, J.A. and R.B. Russell, 1972. Effect of Climatic Conditions on the Composition of Sunflower oil. J. Amer. Oil Chem. Soc., 49: 239-244.
2. Lajara J. R., U. Diaz and R. DiazQuidiello, 1990. Definite Influences of Location and Climatic Conditions on the Fatty Acids Composition of Sunflower Oil. J. Amer. Oil Chem. Soc., 67: 618-623.
3. Ngassapa F.N. and O.C. Othman, 2001. Physicochemical Characteristics of Some Locally Mnufactured Edible Vegetable Oils Marketed in Dares Salaam, Tanzania. Tanz. J. Sci., 27: 49-58.
4. Ramirez G., G. Hough and A. Contarini, 2001. Influence of Temperature and Light Exposure on Sensory Shelf-life of a Commercial Sunflower Oil. J. Food Qual., 24: 195-204.
5. Topallar, H., Y. Bayrak and M. Iscan, 1997. A Kinetic Study on the Autoxidation on Sunflowerseed Oil. J. Amer. Oil Chem. Soc., 74: 1323-1327.
6. Grompone, M.A., T. Pagano and Y. Pinchak, 2000. In Proceedings of the International Workshop on Fats, Oils and Oilseeds Analysis (IUPAC), pp: 46-61.
7. Nolen, G.A., J.C. Alexander and N.R. Artman, 1967. Long-term Rat Feeding Study with Use Frying Fats, J.Nut., 93: 337.
8. Daniel, S., 1979. Evaluating and Predicting n-fatty Acid Properties. Bailey's Industrial Oils and Fats Product, Volume (1), 4thedn. John Wiley & Sons, Inc., New York.

9. Grompone, M.A., T. Pagano and Y. Pinchak, 2000. In Proceedings of the International Workshop on Fats, Oils and Oilseeds Analysis (IUPAC), pp: 46-61.
10. Aryo, S.S., S. Ramaniyam and P.K. Vijayarapharan, 1969. Refractive Index as a Mounts of Gauging the Development of oxidative Rancidity in Fats and Oils, JAOCS, 46: 28-30.
11. Humeid, M.A. and H.A. Abu Blan, 1987. Effect of Molds Invading Olives Fruits During Storage on Oil Acidity and Aflatoxin (B1) Production. Dirasat, 14: 191-196.
12. Abdussattar, A. and J.M. De Man, 1974. Photo-oxidation of Milk and Milk Products.Crs Critical Review.Food Science Nutr., 7: 13-37.
13. Jaimand, K. and M.B. Rezaee, 1995. Studies on the Quality of Sunflower Oil. Agrochemica (Italy), 39: 177-183.
14. SSMO, 2003. (Sudanese Standard and Metrology Organization) Sunflower Oil, Standards No. 1008/2003
15. AOAC, 1970. Official Methods of Analysis of the Association of Official Agricultural Chemists, 12th ed. Washington D.C.A.
16. Pearson, D., Edn. Egon, H. Kirk and R.S. Sawyer, 1981. Pearson Chemical Analysis of Food, 8thedn. Churchill Livingstone, London, New York.
17. AOCS, 1973. American Oil Chemist's Society. Official and Tentative Methods of American Oil Chemist's Society, 2nded.
18. Cocks, L.V. and C. Van Rede, 1966. Laboratory Handbook for Oil and Fat Analysis, Acdemic Press inc. Ltd., London, New York.
19. Anon, 1993. Codex Alimentarius, Vol. 8. Codex Alimentarius Commission, FAO/WHO, Rme.