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Physicochemical Properties of Processed Peanut (*Arachis hypogaea* L.) Oil in Relation to Sudanese Standards: A Case Study in Nyala; South Darfur State; Sudan

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Abstract: This study was oriented to valuate physical and chemical properties of the native peanut oil processed in Nyala; South Darfur state; in order to investigate the impact of local processing and storage on quality with respect to Sudanese standard measurements. Peanut oil (season, 2005) from three different processing regimes; industrially produced oil; traditionally produced oil by imported a small mill and traditionally produced oil by locally made a small mill; were analyzed for their physicochemical attributes. Changes in these attributes on storage (room temperature 35±2°C) over a period of 3 months were also investigated. Refractive index, iodine value and saponification value of all three oil samples are in coincidence with Sudanese standards. The red and yellow colors, free fatty acids, acid value and moisture contents for all peanut oil samples are significantly higher than the recommended values. But the density, the relative viscosity is slightly lower. Results of the storage experiment showed significant increases in the free fatty acids, acid values and peroxide values; and decreases in the moisture contents and iodine values for all peanut oil samples. The peanut oil sample processed industrially by a large mill was found more stable during storage. So, this oil could be valid for use for a period not less than three months. The peanut oil sample processed traditionally by a small imported mill was found less stable during storage than the industrially produced peanut oil. Thus emphasizes its consumption within a period of 3 months from production date. The sample processed traditionally by locally made a small mill was observed to be the least stable during storage. It reached the rancid zone within two months of storage.

Key words: Peanut oil, processing regimes, storage, physical and chemical properties, Nyala, South Darfur State, Sudan

INTRODUCTION

Peanut (*Arachis hypogaea* L.) also recognized by groundnut or earthnut, belongs to the family paplionaceae. It is one of the most important five edible oil seed crops in the world that grown widely in Africa, India and China (Bailey, 1979). In the Sudan peanut is well known by the colloquial name "Foul Sudani ". It is mostly grown as a rain-fed crop mainly for its oil. The peanut seed contains 35.8-54.2% oil. About 20% of the oil is saturated fatty acids, mainly palmitic, stearic and arachidic.The remaining 80% is unsaturated fatty acids; oleic acid represents the major fraction (55%), followed by linoleic acid which comprises 25%. Unsaponifiable materials and pigments are also found in peanut oil (Elhindawy, 1963; Bailey, 1979). Peanut is one of the main cash crops to the traditional farmers of south-Darfur state (13°-30', 8°-30' N and 28°-00', 22°-30' E). It also represents the principal source of edible oil in the state. In the year 2003, the total cultivated area in the traditional sector is estimated to be 7.2 million hectares. About 129382 hectares occupied be peanut farms that produced 278232 tons of peanut seed (MFAS, 2003). The crude peanut oil beside its composition of triacylglycerols contains many non-oil substances. Some of these are desirable constituents and others are not. Oil refining is carried out to remove non-acylglycerol impurities consisting mainly of free fatty acids, with a major objective of accomplishing this with minimum refining loss (Sherwin,1978). Therefore, oil refining is an inevitable process so as to help in keeping quality of the product. Due to its high percentage of unsaturated fatty acids, crude peanut oil is easily prone to deterioration results from oxidative substances, high moisture level and storage temperature. Therefore, oxidative stability is considered an important quality control parameter both for the manufacturers and the consumers (Hassel, 1976). Moreover, non-processed or partially processed crude oil from peanut seed may increase the risk of instability that may adversely affect nutrition and functional characteristics of the oil.

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Most of the peanut oils supplied to Nyala, chief market in south Darfur state, are those produced locally through two channels:

- Traditional production using both imported or locally-made small mills and
- Industrialized production using large mills. Almost all of the commercial peanut oils produced suffer, with varied degrees, from low storage ability.

Thus, a satisfactory and systematic determination of physical and chemical properties is required to evaluate and possibly predict how these locally produced peanut oils interact with market conditions. In regard with this view, the present research aims to:

- Standardize the commercial peanut oil produced in Nyala town with the Sudanese specifications for quality control.
- Present the local processing effects on stability characteristics from a fundamental physicochemical approach.

MATERIALS AND METHODS

Materials: Commercial peanut oil samples from three diferrent processing regimes were used in this study.

Methods

Processing of peanut oil in Nyala: Most of the peanut oil found in Nyala is a native produce of either of a traditional processing or of industrial processing. In the traditional processing the raw peanut oilseed is pressed using a small mechanical mill; locally made or imported. The extracted oil is subjected to hot water treatment and let to settle to separate from impurities. Occasionally, the separated oil is heated further in order to reduce its moisture and then packed to the market for domestic use. In the industrial processing the oil is extracted by mechanical pressing from cooked peanut seeds. The oil produced is then transferred to the settling container and then through a mechanical pump to the filter and lastly to the packing tank.

Sample collection and preparation for study: Peanut oils of season 2005, were collected from three different mills' produce; from industrial oil mill, a small imported oil mill and a locally made oil mill; designated as M1, M2 and M3, respectively. Three different production runs; from the morning, mid-noon and evening productions; were collected from each type of oil mill and kept in plastic containers. Part of the collected oil samples was stored in a deep freezer till analysis. The rest of oil samples was stored at room temperature for 3 months. Samples are withdrawn a month each and kept in cold. Accordingly, 12 treated oil samples were developed. The samples were analysed for their physical and chemical attributes.

Analysis of oil samples

Color: Color was measured using Lovibond Tintometer (Model E) using 5¼ inches cell fitted with units of red and yellow color. Oil samples were filtered using filter paper just before measuring (red and yellow colors).

Refractive index: Refractive index was determined by Abbe Refractometer according to the method of AOAC (1990). The refractive indices of all samples were determined at 34 C°.

Relative viscosity and relative density: An Ostwald U-shaped tube viscometer was used in determining the viscosity of oil samples according to Cocks and Van Rede (1966). Relative density was determined by pycnometer method according to AOAC (1990).

Moisture content: Moisture Content (MC) was detemined by the method of AOAC (1990).

Free fatty acids, acid value and peroxide value: Free Fatty Acids (FFA) and Acid Value (AV) were determined as described by AOCS (1976). The FFA was expressed as percent oleic acid while the AV as milligrams of KOH per gram oil sample. Peroxide value was determined according to AOCS (1976). It was expressed as meq peroxides per Kg oil.

Iodine value and saponification value: Hanus method was applied to determine Iodine Value (IV) according to AOAC (1990). The IV was expressed as grams of iodine absorbrd by unsaturated bonds in 100 grams oil. Saponification value was determined according to the method applied by AOAC (1990) and expressed as milligrams of KOH required to saponify one gram oil.

Statistical analysis: Data repesent means and they were assessed by analysis of variance (ANOVA) in a factorial experiment 3×4 designed in a randomized complete block design (Snedecor and Cochran, 1987). Means were separated by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Characteristics of peanut oil produced in Nyala

Color, refractive index, relative viscosity and relative density: Results showed that the peanut oil samples; M1, M2 and M3 had red and yellow colors (Table 1) higher than the specified color limits of 1-2 for red and 16-25 for

Table 1: Characteristics of peanut oil from different processing regimes*

Sample# characteristic		M1	M2	M3	Average
Color (Lovibond)	Red	2.550[a]	2.557[a]	2.033[b]	2.383
		(0.132)	(0.058)	(0.153)	
	Yellow	35.000	35.000	35.000	35.000
		(0.000)	(0.000)	(0.000)	
Refractive index (34° C°)		1.462[a]	1.462[a]	1.462[a]	1.462
		(0.00)	(0.001)	(0.001)	
Relative viscosity (30° C°)		27.667[a]	28.167[a]	26.533[b]	27.417
		(0.520)	(0.144)	(0.878)	
Relative density (25° C°)		0.855[a]	0.864[a]	0.862[a]	0.861
		(0.028)	(0.019)	(0.024)	
MC%**		2.833[a]	2.970[b]	3.133[a]	2.979
		(0.058)	(0.058)	(0.058)	
FFA, g 100 g^{-1}		0.343[a]	0.375[a]	0.347[a]	0.355
		(0.006)	(0.012)	(0.006)	
AV, mg g^{-1}		0.680[a]	0.703[a]	0.693[a]	0.692
		(0.010)	(0.035)	(0.021)	
PV**, meq K^{-1}		6.333[c]	7.000[b]	15.967[a]	9.767
		(0.577)	(0.346)	(1.350)	
IV, g 100 g^{-1}		93.733[a]	91.267[b]	90.767[b]	91.922
		(1.258)	(1.002)	(0.710)	
SV, mg KOH g^{-1}		188.733[a]	190.233[a]	189.067[a]	189.344
		(0.929)	(1.006)	(1.422)	

*Means of thee determinations and three replicates. Values in parentheses are standard deviations. Means followed by different letters in a row are significantly different according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$. ** Significant at ($p \leq 0.01$). #M1, industrially produced peanut oil by a large mechanical mill; M2, traditionally produced peanut oil by an imported small mechanical mill; M3, traditionally produced peanut oil by a locally made mechanical mill. MC, moisture content; FFA, free fatty acids; AV, acid value; PV, peroxide value; IV, iodine value; SV, saponification value

yellow of refined peanut oil (Weiss, 1983). In general crude oils have denser colors than refined oils (Mariam, 1999). Refractive indices of M1, M2 and M3 (Table 1) are in conformity with that recommended by the Sudanese standards measurements (SSMO, 1995). Relative viscosities of all samples (Table 1) are lower than that of 33.3 found for refined peanut oil (Awad Elgied, 2000). Viscosity has an importance in evaluating the quality of edible oils, since it can have a significant effect on frying performance and on fried food quality (Alim and Morlan, 1974). Also results reveal insignificant ($p \geq 0.05$) variation in relative density between the three peanut oil samples; M1, M2 and M3 (Table 1), which are slightly lower than the recommended range of 0.912-0.920 (SSMO, 1995). Relative density of oil is used in establishing quality or purity of the oil and also used in assessing the weight of oil in bulk shipment or oils stored in large tanks (Mariam, 1999).

Moisture content: Table 1, gives Moisture Contents (MC) of peanut oil samples studied. Results reveal values of 2.833, 2.970 and 3.133% for M1, M2 and M3, respectively, which are significantly ($p \leq 0.05$) different from each other. Also they are far higher than the standard value of 0.2% recommended by SSMO (1995). Water treatments during processing of samples may be responsible for the higher level of moisture observed. Moisture content has an impact on o il stability. The higher the MC the higher the rate of hydrolysis and the rate of oxidation of oil (Ball *et al*., 1973).

Free fatty acids and acid value: Figures of Free Fatty Acids (FFA) and Acid Value (AV) given by the peanut oil samples; M1, M2 and M3; are insignificantly ($p \geq 0.05$) different from each other (Table 1). All these values are higher than the values of 0.200% and 0.600 mg KOH g^{-1} recommended for FFA and AV, respectively (SSMO, 1995). The high moisture levels in the peanut oil samples (Table 2) may motivates hydrolysis of triacylglycerols. As a result the FFAs increase and hence the AV.

Peroxide, iodine and saponification values: Results in Table 1, indicate significant ($p \leq 0.01$) differences in Peroxide Values (PV) of peanut oil samples. The peroxide value for M3 is higher than the value of 10 meq H_2O_2/kg recommended for the refined peanut oil (SSMO, 1955). Weiss (1983) reported that the PV of oil should not exceed 10 meq H_2O_2 kg^{-1} to be valid for international trading. The differences in peroxide values may be result from combined effects of factors such as prolonged contact of hot oil with atmospheric oxygen, presence of high level of moisture and presence of considerable amounts of prooxidants (Nawar, 1996). Iodine and saponification values of all samples are comparable with the ranges specified for peanut by SSMO (1995).

Changes in characteristics of peanut oil produced by processing regimes and storage

Color, refractive index, relative viscosity and relative density: Results in Table 2, showed that storage of peanut oil samples for three months did not reveal significant

Table 2: Physical characteristics of stored peanut oils from different processing regimes*

Treated oil sample#	Color (lovibond) red	Color (lovibond) yellow	Refractive index (34°C)	Relative viscosity (30°C)	Relative density (25°C)
M1:Zero month storage	2.550^{a}	35.000^{a}	1.462^{a}	27.667^{ab}	0.855^{a}
	(0.130)	(0.000)	(0.000)	(0.520)	(0,028)
One month storage	2.567^{a}	35.000^{a}	1.462^{a}	30.370^{a}	0.857^{a}
	(0.153)	(0.000)	(0.000)	(2.250)	(0.019)
Two months storage	2.560^{a}	35.000^{a}	1.462^{a}	29.167^{ab}	0.866^{a}
	(0.070)	(0.000)	(0.001)	(0.629)	(0.012)
Three months storage	2.657^{a}	35.000^{a}	1.462^{a}	30.583^{a}	0.866^{a}
	(0.153)	(0.000)	(0.000)	(0.764)	(0.012)
M2: Zero month storage	2.567^{a}	35.000^{a}	1.462^{a}	28.167^{ab}	0.864^{a}
	(0.058)	(0.000)	(0.001)	(0.144)	(0.019)
One month storage	2.567^{a}	35.000^{a}	1.461^{a}	28.167^{ab}	0.876^{a}
	(0.058)	(0.000)	(0.000)	(1.693)	(0.013)
Two months storage	2.567^{a}	35.000^{a}	1.461^{a}	28.833^{ab}	0.876^{a}
	(0.058)	(0.000)	(0.001)	(1.464)	(0.021)
Three months storage	2.567^{a}	35.000^{a}	1.461^{a}	30.250^{a}	0.860^{a}
	(0.058)	(0.000)	(0.001)	(0.661)	(0.007)
M3: Zero month storage	2.033^{b}	35.000^{a}	1.462^{a}	26.533^{b}	0.862^{a}
	(0.153)	(0.000)	(0.001)	(0.878)	(0.024)
One month storage	2.100^{b}	35.000^{a}	1.462^{a}	30.533^{a}	0.875^{a}
	(0.173)	(0.000)	(0.001)	(1.365)	(0.008)
Two months storage	2.133^{b}	35.000^{a}	1.462^{a}	28.176^{ab}	0.876^{a}
	(0.153)	(0.000)	(0.001)	(0.629)	(0.012)
Three months storage	2.100^{b}	35.000^{a}	1.462^{a}	29.500^{ab}	0.876^{a}
	(0.173)	(0.000)	(0.001)	(0.661)	(0.012)

*Means of three determinations and three replicates. Values in parentheses are standard deviations. Means followed by different litters within a column are significantly different according to D M RT (p≤0.01). #M1, industrial peanut oil produced by a large mechanical mill; M2, peanut oil produced traditionally by an imported small mechanical mill ; M3, peanut oil produced traditionally by a locally made small mechanical mill

Table 3: Chemical characteristics of stored peanut oils from different processing regimes*

Treated oil samples #	MC %	FFA %	AV mg g^{-1}	PV meq Kg^{-1}	IV g 100 g^{-1}	SV mg KOH g^{-1}
M1 : Zero storage	2.833^{c}	0.343^{i}	0.680^{j}	6.333^{l}	93.733^{a}	188.733^{a}
	(0.058)	(0.006)	(0.010)	(0.577)	(1.258)	(0.930)
One month storage	1.063^{k}	0.500^{h}	1.076^{i}	8.333^{j}	89.833^{c}	188.733^{a}
	(0.110)	(0.000)	(0.058)	(0.577)	(0.551)	(0.321)
Two months storage	1.110^{j}	0.710^{g}	1.567^{h}	11.000^{i}	85.476^{fg}	190.600^{a}
	(0.085)	(0.017)	(0.208)	(1.000)	(1.041)	(0.866)
Three months storage	1.800^{e}	0.850^{f}	1.767^{g}	12.000^{h}	80.700^{h}	190.700^{a}
	(0.100)	(0.050)	(0.115)	(0.300)	(0.500)	(0.872)
M2: Zero storage	2.970^{b}	0.357^{i}	0.703^{j}	7.000^{k}	91.267^{b}	190.233^{a}
	(0.058)	(0.012)	(0.072)	(0.346)	(1.002)	(1.006)
One month storage	1.233^{i}	1.000^{e}	1.967^{f}	14.667^{g}	87.267^{ef}	190.833^{a}
	(0.058)	(0.100	(0.252)	(1.155)	(1.050)	(1.115)
Two months storage	1.333^{g}	1.500^{d}	1.133^{e}	15.667^{f}	81.533^{h}	189.233^{a}
	(0.115)	(0.100)	(0.153)	(1.530)	(0.764)	(0.802)
Three months storage	1.857^{d}	1.700^{c}	3.533^{c}	25.167^{c}	84.100^{gh}	189.200^{a}
	(0.067)	(0.200)	(0.115)	(1.595)	(0.819)	(0.655)
M3 : Zero storage	3.133^{a}	0.347^{i}	0.693^{j}	15.967^{e}	90.433^{bc}	189.067^{a}
	(0.058)	(0.006)	(0.021)	(1.350)	(0.710)	(1.422)
One month storage	1.267^{h}	1.667^{c}	3.367^{d}	43.333^{a}	82.200^{h}	188.867^{a}
	(0.058)	(0.058)	(0.252)	(1.155)	(0.500)	(0.833)
Two months storage	1.560^{f}	4.067^{a}	8.233^{a}	28.333^{b}	87.467^{de}	190.133^{a}
	(0.060)	(0.513)	(0.862)	(1.221)	(0.764)	(0.737)
Three months storage	1.870^{d}	3.433^{b}	6.833^{b}	18.900^{d}	89.300^{cd}	190.833^{a}
	(0.046)	(0.058)	(0.290)	(0.964)	(0.500)	(1.365)

*Means of 3 determinations and 3 replicates. Values in parentheses are standard deviations. Means followed by different letters within a column are significantly different according to DMRT (p≤0.01). #M1, industrially produced peanut oil by a large mechanical mill; M2, traditionally produced peanut oil by an imported small mechanical mill; M3, traditionally produced peanut oil by a locally made mechanical mill. MC, moisture content; FFA, free fatty acids; AV, acid value; PV, peroxide value; IV, iodine value; SV, saponification value

changes in color (red; yellow), refractive index, relative viscosity and relative density. Some vegetable oils, such as sunflower oil, have been found to have no significant changes in color during storage (Hunag *et al*., 1981).

Moisture content: Moisture Contents (MC) of peanut oil stored samples have significant (p≤0.01) variations (Table 3). However, similar patterns of changes in MCs were found during the whole course of storage. A significant (p≤0.01) decrease in MC after one month of storage was observed. Thereafter the moisture levels increased gradually as the storage prolonged to second and third month. The fluctuation in MC during storage of samples may be due to occurrence of water-dependent reactions at beginning and water-release reactions as the storage prolonged (Elwarraky, 1977). Irrespective to storage period, differences in processing regimes may be a factor responsible for the differences in MC (Table 4).

Table 4: Moisture content (percent) of peanut oil as affected by processing regime and storage period

Sample# storage (month)	M1	M2	M3	Average*
Zero	2.833	2.970	3.133	2.979[a] (0.150)
One	1.063	1.233	1.267	1.188[c] (0.110)
Two	1.110	1.333	1.560	1.334[d] (0.225)
Three	1.800	1.857	1.870	1.842[b] (0.037)
Average*	1.702[c] (0.826)	1.848[b] (0.800)	1.958[a] (0.821)	

*In a column average of 3 replicates and soil products; in a row average of 3 replicates and 4 storage periods. Values in parentheses are standard deviations. Averages having different letters in a column and in a row are significantly different according to DMRT ($p \leq 0.05$). #M1, industrially produced peanut oil by a large mechanical mill; M2, traditionally produced peanut oil by an imported small mechanical mill; M3, traditionally produced peanut oil by a locally made mechanical mill

Table 5: Free fatty acids (g 100 g^{-1}) of peanut oil as affected by processing regimes and storage periods

Sample# storage (month)	M1	M2	M3	Average*
Zero	0.343	0.357	0.347	0.350[d] (0.007)
One	0.500	1.000	1.667	1.056[c] (0.585)
Two	0.710	1.500	4.067	2.092 (1.755)
Three	0.850	1.700	3.433	1.994[b] (1.316)
Average*	0.601[c] (0.224)	1.139[b] (0.599)	2.379[a] (1.692)	

*In a row average of 3 replicates and 3 oil products; in a column average of 3 replicates and 4 storage periods. Values in parentheses are standard deviations. Averages having different letters in a column and in a row are significantly different according to DMRT ($p \leq 0.01$). #M1, industrially produced peanut oil by a large mechanical mill; M2, traditionally produced peanut oil by an imported small mechanical mill; M3, traditionally produced peanut oil by a locally made mechanical mill

Table 6: Acid value (mg g^{-1}) of peanut oil as affected by processing regime and storage period

Sample# storage (month)	M1	M2	M3	Average*
Zero	0.68	0.703	0.693	0.692[d] (0.012)
One	1.067	1.967	3.367	2.134[c] (1.160)
Two	1.567	3.133	8.233	4.311[a] (3.486)
Three	1.767	3.533	6.833	4.044[b] (2.571)
Average*	1.270[c] (0.491)	2.334[b] (1.274)	4.782[a] (3.408)	

* In a row average of 3 replicates and 3 oil products; in a column average of 3 replicates and 4 storage periods. Values in parentheses are standard deviations. Averages having different letters in a column and in a row are significantly different according to DMRT ($p \leq 0.01$). #M1, industrially produced peanut oil by a large mechanical mill; M2, traditionally produced peanut oil by an imported small mechanical mill; M3, traditionally produced peanut oil by a locally made mechanical mill

Free fatty acids and acid value: Results showed that the Free Fatty Acids (FFA) and Acid Values (AV) of peanut oil samples have increased significantly ($p \leq 0.01$) with varied magnitudes as the storage proceeds (Table 3). For M1 and M2 the FFA is increased steadily on progress of storage. For M3 the original FFA is significantly ($p \leq 0.01$) increased in a gradual manner up to the end of the second month of storage and then falls off. This means that some reactions may occur in peanut oil during the storage; leading to liberation of free fatty acids (Woolley and Petersen, 1994) and hence the AV increased. A similar finding was reported by Awad Elgied (2000). The same author concluded that the development of free fatty acids in oil is usually considered to be one of the main parameters to use in evaluating the quality of oil, especially under the conditions of storage and heat. The increase in FFA level is an indication to the beginning of spoilage of the oil (Elwarraky, 1977). Results in Table 5 and 6 proved that processing has a significant impact on extend of liberation of FFA on storage.

Peroxide value: Peroxide values (PV) of M1 and M2 (6.333 and 7.000 meq Kg^{-1}, respectively) are increased steadily significantly as storage progressed. While that of M3 increased significantly ($p \leq 0.01$) to a maximum by the end of the first month of storage, then it falls off (Table 3 and 7). Despite that the changes in PV can be used to monitor the potential shelf-life (Awad Elgied, 2000). It is not always a reliable indication of the degree of oxidation, since highly oxidized oil has low PV. This could be result from the decomposition of formed peroxides into hydrocarbons, ketones, aldehydes and alcohols (Elwarraky, 1977). Accordingly, oils are described rancid at various peroxide levels (Schultz *et al.*, 1962; Elwarraky, 1977). Results also indicated that differences in processing regimes result in significant differences in liability of oils to spoilage factors (Table 7).

Iodine value: Storage of peanut oil samples resulted in significant ($p \leq 0.01$) decrease in iodine values (Table 3 and 8); suggesting oxidation of unsaturated bonds in the oil. The increase in PV may explain this decrease (Table 7). Similar finding was reported by Awad Elgied (2000). Oxidation or polymerization reactions tend to lower the iodine value of vegetable oil (Eckey, 1954).

Saponification value: Results indicated that 3 months of storage of peanut oil samples have no significant ($p \geq 0.01$) effect on saponification value (Table 3). This finding a greed with the remarks of Mostafa (1974) who reported that prolonged storage of vegetable oils does not show significant change in saponification values.

Table 7: Peroxide value (meq Kg^{-1}) of peanut oil as affected by processing regime and storage period

Sample storage (month)	M1	M2	M3	Average*
Zero	6.333	7	15.967	9.767[d] (5.380)
One	8.333	14.667	43.333	22.111[a] (18.650)
Two	11	15.667	28.333	18.333[c] (8.970)
Three	12	25.167	18.9	18.689[b] (6.586)
Average*	9.417[c] (12.320)	15.625[b] (7.447)	26.633[a] (2.530)	

* In a row average of 3 replicates and 3 oil products; in a column average of 3 replicates and 4 storage periods. Values in parentheses are standard deviations. Averages having different letters in a column and in a row are significantly different according to DMRT ($p \le 0.01$). #M1, industrially produced peanut oil by a large mechanical mill; M2, traditionally produced peanut oil by an imported small mechanical mill; M3, traditionally produced peanut oil by a locally made mechanical mill

Table 8: Iodine value (g 100 g^{-1}) of peanut oil as affected by processing regime and storage period

Sample storage (month)	M1	M2	M3	Average*
Zero time	93.733	91.276	90.433	91.811[a] (1.716)
One	89.833	87.267	82.200	86.433[b] (3.884)
Two	85.467	81.533	87.467	84.822[c] (3.020)
Three	80.700	84.100	89.300	84.700[c] (4.331)
Average*	87.433[a] (5.617)	86.042[b] (4.200)	87.350[a] (3.644)	

* In a row average of 3 replicates and 3 oil products; in a column average of 3 replicates and 4 storage periods. Values in parentheses are standard deviations. Averages having different letters in a column and in a row are significantly different according to DMRT ($p \le 0.01$). # M1, industrially produced peanut oil by a large mechanical mill; M2, traditionally produced peanut oil by an imported small mechanical mill; M3, traditionally produced peanut oil by a locally made mechanical mill

CONCLUSION

It can be concluded that the processed peanut oil samples studied have characteristics almost differ from those specified by the Sudanese standards. Results also showed that storage have varied effect on stability characteristics (peroxide, free fatty acids and acid values) of samples; indicating that processing regime is an effective factor from viewpoint of liability of peanut oil to spoilage.

REFERENCES

Alim, H. and I.D. Morlon, 1974. Deep Fat Frying oil and absorption by a fried product. J. Sci. Food Agric., pp: 25-1041.

AOAC, 1990. Association of Official Analytical Chemists (1990). Official methods of analysis. 15th (Edn), vol, 2 AOAC, INC, virginia, USA.

AOCS, 1976. American Oil Chemists' Society. Official and Tentative Methods of Analysis, Champaign-IL.

Awad Elgied, T.E.E., 2000. Effect of frequent frying and storage on quality of Sudanese edible oils. M.ScThesis (Agric.), University of Khartoum, Sudan.

Bailey, 1979. Industrial oil and fat products, D. Swern (Ed.), John Wiley and Sons, New York.

Balls, A.K., M.B. Matlach and I.W. Trucher, 1973 . J. Biol. Chem., 122: 125-137.

Cocks, L.V. and C. Van Rede, 1966. Laboratory Hanbook for Oil and Fat Analysis. Academic Press, London.

Duncan, D.B., 1955. Multiple range and multiple F-test. Biometrics, 11: 1-42.

Eckey, E.W., 1954. Effect of polyethylene and polypropylene films on the stability of vegetable oils. Vegetable fats and oils, E.W Eckey (Ed.), Reinhold Publishing Corp., New York.

Elhindawy, S.M., 1963. Studies on peanut oil. M.Sc. Thesis. Ain shams University, Cairo.

Elwarraky, 1977. Oil and fats technology. Ain shams university Press, Cairo.

Hassel, R.L., 1976. Thermal analysis: An alternative method of measuring oil stability. J. Am. Oil Chem. Soc., 53: 179-181.

Huang, A.S., O.A.L. Hsich, C.L. Huang and S.S. Change, 1981. A composition of the stability of sunflower seed oil and corn oil. J. Am. Oil Chem. Soc., 58: 997-1001.

Mariam, Y.E., 1999. Potential industrial utliztion of Tartar seed oil. PhD Thesis (Agric.), University of Khartoum, Sudan.

MFAS, 2003. Minstry of Fainance and Agricultural Sheets, Nyala, South Darfur State, Sudan.

Mostafa, M., 1974. Oil characteristics of Iranian Walnuts. J. Am. Oil Chem. Soc., 51: 477-478.

Nawar, W.W., 1996. Lipids. Food chemistry, Owen, R., Fennema (Ed.). 3rd (Edn). Marcel Dekker, Inc. New York, USA, pp: 225-320.

Schultz, H.W., E.A. Day and R.O. Sinn Huber, 1962. Symposium of foods: Lipids and their oxidation. H.W. Schultz *et al*. (Ed.), Avi publishing Co., West port, Connecticut, pp: 279-195.

Sherwin, E.R., 1978. Oxidation and antioxidants in fats and oil processing. J. Am. Oil Chem. Soc., 55: 809-814.

Snedecor, G.W. and W.G. Cochran, 1987. Statistical methods, 17th (Edn). I.A.: The Iowa State University.

SSMO, 1995. Sudanese Standards and Meterology Organization. Sudanese standards specified for peanut oil for use, No. 6.

Weiss, E.A., 1983. Oilseed Crops. Longman Group ltd. London, New York.

Wolley, P. and S. Petersen, 1981. Lipases: Their structure, biochemistry and application. P. Wolley and S. Petersen (Eds.). Cambridge University Press. Cambridge, UK.