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Stability of Some Edible Oil Blends Based on Palm Olein

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Abstract

Palm olein was blended with three Sudanese edible oils namely cottonseed, groundnut, and sunflower oils, at two levels (3:1; 1:1, respectively), to evaluate the effect of these oils on palm olein stability during storage and as influenced by the frying process. The viscosity, color, refractive index (R.I), free fatty acids (FFA), peroxide value (PV), polymer content (PC) and iodine value (IV) of the blends were monitored during both storage intervals of 0, 3, 6 and 12 months, and exposure to frying temperature at 180 ± 2^0C for 5, 10 and 15hrs. During storage of the palm olein blends for 12 months, it was found that the degradation of the triglycerides of palm olein blends 1:1 mixing level into FFA particularly of groundnut oil blends was significantly (P≤0.05) higher than the pure palm olein (6.51 and 4.30%, respectively). However, the FFA of palm olein blends of cottonseed oil and sunflower oil at high olein level (3:1) showed no significant (P≤0.05) changes compared to the pure palm olein. The stability of palm olein containing conventional oils has significantly (P≤0.05) decreased with all blends, as shown by high level of peroxides (PV above 15 meq.O_2), compared to the pure palm olein (9.17 meq.O_2). The polymer formation in all palm olein blends of 1:1 ratios has significantly (P≤0.05) increased (PC ranged between 6.13 and 8.00%) compared to the pure palm olein (3.8%). After 15 hrs of exposure to frying temperature, palm olein blends containing low level of Sudanese oils were more stable as shown by less split in FFA (2.59%) compared to higher ones in high level of these oils in olein (3.34%).Similarly, the formation of peroxides was lower during frying of olein of low blending level (PV ranged between 8.06 and 8.80 meq.O_2) compared to the one containing high level of Sudanese oils (10.44 to 14.19 meq.O_2). Equally, the formation of polymers was faster and higher in high blending levels (PC ranged between 5.84 and 7.44%) compared to lower levels (3.84 to 5.42%).

Key words: Stability, Blend, Oil, Frying, Sudanese.

Introduction

Customers always choose their foods according to their palatability and not to their nutritional values. Fats and oils play an important part in creating enjoyable foods. They usually impart excellent flavors which are initially existing or formed during the cooking process.

Sudanese consumers do have sequence of preference for frying oils e.g. palm olein is the first choice for frying of potato chips, followed by sunflower oil, cottonseed oil and then groundnut oil (Farah, 2004). Such

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habit would definitely encourage the technology of blending oils such as palm olein with domestically processed oils such as sunflower, cottonseed and groundnut oils. Such step is expected to fulfill objectives such as encouraging local production of the more expensive groundnut oil for export market against the cheaper imported palm olein and making available oil blends with better characteristics compared to their respective individual oil.

Blending technology of vegetable oils is a well known practice for different purposes such as nutrition, medicine, pharmacy, cosmetic, and for energy as fuel blends (Flora, 2006; Luna and Michelena, 1986). It had been demonstrated that stability of polyunsaturated vegetable oils were improved by blending oils with different portion of high oleic sunflower oil (Frankel and Huang 1994).

Palm oil and its product have excellent oxidative and frying stability owing to their inherent composition and to the presence of tocopherols and tocotrienols which are natural antioxidant (Slover 1971 and Wong *et al.*, 1988).

Materials and Methods

Four different Vegetable oils of cottonseed oil, sunflower seed oil, palm olein, and groundnut refined oil were collected from Khartoum North Industrial Area.

Samples of potato tubers (Alpha variety) used in frying experiments were purchased from the local market of Khartoum North.

Palm olein (commercial quality) analyzed for quality was carefully blended with cottonseed oil, groundnut oil and sunflower seed oil at two blending levels of 1:1 and 3:1 of palm olein to latter oils. The palm olein blends together with the pure palm olein, were kept for different uses and analysis.

Potato tubers were peeled, sliced to thickness of 2 mm by using a mechanical slicer and dipped in water to reduce browning before frying.

Three hundred grams of potato slices were fried intermittently at half an hour interval, for 8 to 10 minutes at frying temperature of 180^0 C ± 2 in four liters of oil using a frying pot (Seb-France). The yield of fried potato chips was 90 to 100 grams. In the next day, 250 ml oil sample was withdrawn and kept in cleaned plastic container for analysis. The frying of potato was carried out using palm olein containing sunflower oil, groundnut oil, and cottonseed oil of both blending levels (1:1; 3:1 respectively), and with pure palm olein; for three consecutive days under the same conditions. At the end of the frying, the excess oil from the chips was allowed to drain off and the chips were allowed to cool on absorbent tissue.

Samples of palm olein blends and the pure palm olein , were packaged in dark brown bottles of 100 ml size, tightly closed and stored at ambient temperature (37^0 C ± 4^0) for intervals of 0,3,6 and 12 months. Samples of oils were withdrawn after each storage period for monitoring changes in physiochemical characteristics.

The viscosity, color, refractive index (R.I), free fatty acids (FFA), peroxide value (PV), polymer content (PC) and iodine value (IV) of the blends were carried out using A.O.C.S. (1982) methods.

Results and Discussion

Physiochemical characteristics of palm olein as affected by blending.

The physical changes

Viscosity

Table 1 shows changes in viscosity of palm olein containing two levels (1:1; 3:1) of cottonseed, groundnut and sunflower oils. Addition of such oils at both blending levels has significantly ($P \leq 0.05$) reduced viscosity of palm olein. During storage of the palm olein blends for 12 months, presence of cottonseed oil (1:1) and

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groundnut oil (1:1; 1:3) in palm olein has no significant ($P \leq 0.05$) effect on palm olein viscosity, while presence of sunflower oil at both blending levels, together with cottonseed oil (1:3) has significantly ($P \leq 0.05$) decreased (30.17) viscosity, compared to the pure palm olein (31.58). Generally the viscosity of palm olein blend was reported to increase with increasing storage periods (Berry *et al.* 1983, Smith, 1986; Elkabashi, 2000). Table 1 as well shows changes in viscosity of palm olein containing cottonseed, groundnut and sunflower oils at two blending levels (1:1; 3:1) as affected by frying time. After five hours exposure to frying temperature (180^0 C) the viscosity of palm olein containing sunflower oil at both ratios of (1:1 and 1:3) has significantly decreased (25.5), while the viscosity of palm olein containing groundnut oil at both ratios has significantly ($P \leq 0.05$) increased and surprisingly the viscosity of palm olein cottonseed oil remained unchanged by frying. However, after 15hrs of exposure to frying temperature, the viscosity of all palm olein blends of conventional vegetable oils was significantly ($P \leq 0.05$) decreased compared to the pure palm olein, while palm olein / groundnut oil (1:1) blend remained unchanged (Mostafa *et al.*, 1996; Ibrahim, 2000; Omer, 2002).

Table 1: Changes in viscosity of palm olein and its blends as affected by storage and frying temperature

Oil type	Viscosity (centipoises)						
	Storage period (month)				Frying time (hrs)		
	0	3	6	12	5	10	15
Palm olien	26.50^{d}	26.50^{d}	30.70^{abcd}	31.58^{abc}	27.0^{d}	28.7^{ef}	30.2^{f}
Palm olein / cottonseed oil (1:1)	25.25^{a}	26.50^{d}	30.08^{abcd}	31.92^{abc}	27.0^{d}	27.8^{c}	29.3^{e}
Palm olein / Groundnut oil (1:1)	25.50^{b}	27.33^{g}	30.25^{abcd}	32.58^{c}	27.7^{e}	29.0^{f}	30.0^{f}
Palm olein / Sunflower oil (1:1)	25.25^{a}	25.33^{a}	27.17^{a}	30.33^{a}	25.5^{b}	27.0^{b}	27.3^{a}
Palm olein / Cottonseed oil (3:1)	25.88^{c}	25.88^{c}	28.17^{abc}	30.17^{a}	25.5^{b}	26.7^{ab}	28.1^{c}
Palm olein / Groundnut oil (3:1)	26.00^{c}	26.00^{c}	28.92^{abcd}	30.58^{b}	25.5^{b}	28.0^{cd}	28.5^{d}
Palm olein / Sunflower oil (3:1)	25.88^{c}	25.67^{b}	27.75^{ab}	30.17^{a}	24.5^{a}	26.5^{a}	27.5^{b}
S. E.	0.14	0.11	0.21	0.03	0.00-0.29	0.12	0.05

Mean values having different superscript letter(s) in columns and rows differ significantly ($P \leq 0.05$).

Refractive index

Table 2 shows changes in refractive index (R.I.) of palm olein containing two blending levels (1:1; 3:1) of cottonseed oil, groundnut oil and sunflower oil. Presence of all these oils at both levels in palm olein has no significant effect on R.I. of the latter. Similarly, there was no significant ($P \leq 0.05$) change in R.I. of all these blends during storage for 12 months.

Table 2 shows changes in R.I. of palm olein blends as affected by frying at 180^0 C for different exposure time. The R.I. of palm olein blends was significantly ($P \leq 0.05$) reduced (ranged between 1.461 and 1.471) for palm olein / sunflower oil at (1:1) and (3:1) ratios respectively, after 15 hrs of frying time compared to palm olein (1.474), while R.I. of palm olein / cottonseed oil (1:1) has significantly ($P \leq 0.05$) increased more than the pure palm olein (from 1.474 to 1.529) for the same frying time. Earlier work on blends of palm olein containing groundnut oil, cottonseed oil and sunflower oil reported changes in R.I.of these oils (Mostafa *et al.*, 1996; Omer, 2002).

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Table 2: Changes in refractive index of palm olein and its blends as affected by storage and frying temperature

Oil type	Refractive index						
	Storage period (month)				Frying time (hrs)		
	0	3	6	12	5	10	15
Palm olein	1.454[a]	1.454[a]	1.462[a]	1.472[a]	1.459[c]	1.466[c]	1.474[f]
Palm olein / cottonseed oil (1:1)	1.459[d]	1.459[d]	1.473[a]	1.475[a]	1.459[c]	1.459[b]	1.529[g]
Palm olein / Groundnut oil (1:1)	1.458[c]	1.458[c]	1.461[a]	1.462[a]	1.459[b]	1.459[b]	1.461[a]
Palm olein / Sunflower oil (1:1)	1.458[c]	1.458[c]	1.460[a]	1.462[a]	1.459[b]	1.459[b]	1.462[b]
Palm olein / Cottonseed oil (3:1)	1.458[c]	1.458[c]	1.462[a]	1.464[a]	1.459[b]	1.459[b]	1.466[d]
Palm olein / Groundnut oil (3:1)	1.456[b]	1.457[b]	1.461[a]	1.463[a]	1.457[a]	1.459[a]	1.464[c]
Palm olein / Sunflower oil (3:1)	1.459[d]	1.459[d]	1.466[a]	1.467[a]	1.459[c]	1.466[c]	1.471[e]
S. E.	0.00	0.00	0.01	0.02	0.00	0.00	0.00

Mean values having different superscript letter(s) in columns and rows differ significantly (P≤0.05).

Colour

Table 3 shows changes in color of palm olein containing two levels (1:1; 3:1) of cottonseed oil, groundnut oil and sunflower oil during different storage period. The initial color of palm olein / cottonseed oil (1:1) blend was significantly (P ≤0.05) increased (1.42 to 2.00 degrees in red) compared to the pure palm olein. The effect of the color of blend containing high level of cottonseed oil (1:1) was more compared to color of sunflower and groundnut oils. The color of the palm olein / cottonseed blend has significantly (P≤0.05) increased during storage for 12 months to 6.55 compared to 3.63 recorded for pure palm olein. There was less change in color of palm olein containing sunflower and groundnut oils. Ibrahim, (1996) reported that the desirable yellow color oils (e.g. groundnut oil) did not show any changes during a storage period for one and a half year.

Table 3 also shows changes in color of palm olein blends as affected by exposure to frying temperature of 180^0 C for different times. The color of palm olein blends was significantly (P≤ 0.05) increased in red compared to the pure palm olein. The findings agree with Das and Pereira (1990) and Elkabashi (2000).

Table 3: Changes in colour of palm olein and its blends as affected by storage and frying temperature

Oil type	Colour (red)						
	Storage period (month)				Frying time (hrs)		
	0	3	6	12	5	10	15
Palm olein	1.42[ef]	1.60[d]	2.95[a]	3.63[a]	1.62[a]	2.35[a]	2.71[a]
Palm olein / cottonseed oil (1:1)	2.00[g]	2.43[f]	4.03[ab]	6.55[bcd]	2.77[f]	3.63[h]	4.18[g]
Palm olein / Groundnut oil (1:1)	1.13[bc]	1.43[b]	3.20[a]	4.31[ab]	2.17[e]	3.30[f]	3.91[f]
Palm olein / Sunflower oil (1:1)	1.25[cd]	1.58[d]	3.33[a]	5.21[abc]	2.00[d]	2.80[de]	3.32[d]
Palm olein / Cottonseed oil(3:1)	1.23[cd]	1.50[c]	4.45[abc]	5.45[abc]	1.80[bc]	2.45[c]	3.60[e]
Palm olein / Groundnut oil (3:1)	1.10[ab]	1.25[a]	2.66[a]	3.99[ab]	1.55[a]	2.77[d]	3.05[c]
Palm olein / Sunflower oil (3:1)	1.47[f]	1.82[e]	3.92[ab]	5.10[abc]	1.75[b]	2.40[b]	2.95[b]
S. E.	0.04	0.02	0.03	0.01	0.00-0.02	0.02	0.02

Mean values having different superscript letter(s) in columns and rows differ significantly (P≤0.0)

Chemical changes in oil blends

Free fatty acids

Table 4 shows changes in free fatty acids (F.F.A.) of palm olein blends (1:1; 3:1) of cottonseed oil, groundnut oil and sunflower oil as affected by storage period. Initially there were no significant (P≤ 0.05) changes in F.F.A. of palm olein blends compared to pure palm olein. The F.F.A. of palm olein blends of 1:1 mixing level has significantly

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(P≤ 0.05) increased compared to pure palm olein (4.30 to 6.51%) after 12 months storage. On the other hand, the F.F.A. of palm olein / groundnut oil low blend (3:1) has significantly (P≤ 0.05) decreased (from 4.30 to 3.50%) compared to the pure palm olein after the same storage period. However, the F.F.A. of palm olein / cottonseed oil and palm olein / sunflower oil blends (3:1) showed no significant (P≤ 0.05) changes compared to pure palm olein after 12 months storage. Robertson *et al*. (1988) reported that the FFA of sunflower oil increased significantly (p ≤ 0.1) during 16 weeks storage at 27^0 C.

Table (4) shows changes in F.F.A. of palm olein containing cottonseed oil, groundnut oil and sunflower oil (1:1 ; 3:1)as affected by exposure to frying temperature of 180^0 C for 15 hrs. The F.F.A. of all palm olein blends has significantly (P ≤ 0.05) increased (from 2.03 in pure palm olein to 3.34% in high palm olein / groundnut oil (1:1) blend). Hassan (1992) reported the same results.

Table 4: Changes in free fatty acids of palm olein and its blends as affected by storage and frying temperature

Oil type	Free fatty acids (%)						
	Storage period (month)				Frying time (hrs)		
	0	3	6	12	5	10	15
Palm olein	0.14^{a}	0.370^{b}	4.02^{d}	4.30^{b}	0.20^{b}	0.20^{a}	2.03^{a}
Palm olein /Cottonseed oil(1:1)	0.14^{a}	0.357^{a}	3.37^{b}	5.10^{ab}	0.25^{d}	0.29^{c}	2.78^{c}
Palm olein /Groundnut oil(1:1)	0.56^{f}	0.650^{e}	3.92^{c}	6.51^{abc}	0.86^{g}	1.01^{h}	3.34^{f}
Palm olein /Sunflower oil(1:1)	0.28^{d}	0.823^{g}	3.04^{a}	5.65^{abc}	0.49^{e}	0.89^{g}	2.89^{d}
Palm olein /Cottonseed oil(3:1)	0.14^{a}	0.670^{f}	3.61^{abc}	4.57^{ab}	0.17^{a}	0.25^{b}	2.59^{b}
Palm olein /Groundnut oil(3:1)	0.17^{b}	0.410^{c}	2.57^{a}	3.50^{a}	0.23^{c}	0.52^{d}	3.52^{g}
Palm olein /Sunflower oil(3:1)	0.14^{a}	0.450^{d}	3.51^{ab}	4.75^{ab}	0.17^{a}	0.67^{e}	3.00^{e}
S.E.	0.00	0.00	0.05	0.01	0.00	0.01	0.01

Mean values having different superscript letter(s) in each columns and rows differ significantly (P≤0.05).

Peroxide value

Table 5 shows changes in peroxide value (PV) of palm olein and blends containing cottonseeds, groundnut and sunflower oils at two different mixing levels (1:1 and 3:1) as affected by different storage periods. Initially the PV of all palm olein blends has significantly (P ≤ 0.05) increased compared to pure palm olein. The PV of high level of conventional oils in palm olein (1:1 blends) after six months storage showed significant (P ≤ 0.05) increase (› 11.5 meq O_2) compared to low level of blends (3:1) and to the pure palm olein (6.61 meq O_2). After 12 months storage, palm olein containing conventional oils has significantly (P≤0.05) increased in PV with all blends showing PV above 15 meq O_2 compared to pure palm olein (9.17 meq O_2), which remained below the recommended level of Codex (1993) in edible oils which is 10 meq O_2. Gaing (1968) suggested that peroxide formation has been directly related to storage time and temperature and susceptibility to atmospheric oxygen

The PV is a measure of the peroxides that accumulate in the oil during storage where formation is slow, at first, during induction period which may vary from few weeks to several months according to the particular oil or fat, temperature, …etc. Fresh oils usually have PV well below 5 ml 0.0002 *N* sodium thiosulphate gram (Person, 1981). Allam (2001) studied nine untraditional oils, distinguished by their high oleic acid content, for their stability. The results revealed a good correlation between the C 18:1 and the oxidative stability of oils.

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Furthermore, the oxidative stability of sunflower oil was improved through the blending procedure with high oleic acid oils like apricot and peach kernel oils. Results clearly indicated that the stability of sunflower oil increased with the increase of its C 18:1 content. Such poor stability in Sudanese edible oils is attributed to the poor manufacturing practices adopted by the Sudanese edible oils industry (Rahama, 2000). The oxidative stability of palm olein was negatively affected by blending with such Sudanese vegetable oils.

Table 5 also shows changes in PV of palm olein blends (1:1 ; 3:1) containing cottonseed, groundnut and sunflower oils as affected by exposure to frying temperature of 180 C^0 for different times. After 15 hrs of frying exposure time, the PV of palm olein blend 1:1 ratio has significantly ($P \leq 0.05$) increased (›10.44 meq O_2) compared to the pure palm olein which was 7.48 meq O_2. The PV of palm olein containing low level of conventional oils (3:1) showed little difference (PV ranged between 8.0 and 8.5 meq O_2) compared to the pure palm olein. The latter palm olein blends (3:1) together with the pure palm olein remained well stable even after 15 hrs frying time. Nourooz, *et al*., (1995) reported that there was strong negative correlation between initial hydroperoxide levels and total tocopherols content in the oil. Berry *et al.* (1983) and Neff *et al*., (1994) studied the improvement of oxidative stability of soybean oil by blending with more stable oil which was palm oil. They concluded that the oxidative stability of soybean oil was improved by blending with olein.

Table 5: Changes in peroxide value of palm olein and its blends as affected by storage and frying temperature

Oil type	Peroxide value (meq O_2)						
	Storage period (month)				Frying time (hrs)		
	0	3	6	12	5	10	15
Palm olein	0.18[a]	1.37[d]	6.61[a]	9.17[a]	0.84[a]	1.00[a]	7.48[a]
Palm olein / Cottonseed oil (1:1)	1.40[f]	1.60[e]	11.53[e]	26.00[f]	2.73[f]	4.00[e]	12.08[f]
Palm olein / Groundnut oil (1:1)	1.00[e]	1.40[d]	12.07[f]	18.63[d]	2.80[g]	4.40[g]	10.44[e]
Palm olein / Sunflower oil (1:1)	2.00[h]	2.83[f]	15.92[g]	28.13[g]	4.20[h]	4.60[h]	14.19[g]
Palm olein / Cottonseed oil (3:1)	0.54[c]	0.87[b]	7.26[d]	17.76[c]	2.00[e]	2.80[c]	8.06[b]
Palm olein / Groundnut oil (3:1}	0.40[b]	0.67[a]	6.68[b]	15.78[b]	1.00[b]	4.00[e]	8.14[c]
Palm olein/ Sunflower oil(3:1)	0.60[d]	0.97[c]	8.88[c]	18.74[e]	2.00[e]	4.20[f]	8.80[d]
S.E.	0.00	0.02	0.02	0.02	0.01	0.00	0.01

Mean values having different superscript letter(s) in each columns and rows differ significantly ($P \leq 0.05$).

Polymer content

Table 6 shows change in polymer content (PC) of palm olein and its blends of cottonseed, groundnut, and sunflower oils at two mixing levels 1:1 and 3:1 during different storage periods. The PC of palm olein blends of 1:1 ratio has significantly ($P \leq 0.05$) higher values (ranged between 6.13% and 8.00%) compared to the pure palm olein, which recorded 3.80% after 12 months storage period. The PC of palm olein blends of 3:1 ratio also has significantly ($P \leq 0.05$) changed compared to the pure palm olein, after the same storage period. However, the palm olein blends of 3:1 ratio together with the pure palm olein proved to be more stable during 12 months storage. Pokorny *et al.*, (1975) stated that the PC of edible oils increased regularly with increasing storage period.

Table 6 also shows changes in PC of palm olein and its blends after exposure to frying

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temperature of 180 C^0 for different frying times. The presence of cottonseed, groundnut and sunflower oils in palm olein at two mixing levels after exposure to 15 hrs frying time has significantly ($P \leq 0.05$) increased their PC compared to the pure palm olein . Palm olein blends of 1:1 ratio recorded higher PC for the same frying times compared to PC of palm olein blends of 3:1 level. However, the pure palm olein showed the highest stability with polymer formation of 3.12% only. The polymer formation is always associated with peroxide decomposition in vegetable oils and fats which are exposed to adverse conditions such as storage at high temperature for long period of time, heat treatment, deep-fat frying etc. (Kawada *et al.*, 1972, Gertz and kochhar, 2001). Wai (2001) concluded that a number of factors affect the stability of the oil during frying, including the frying temperature, time of heating and replenishment of oil. With all these factors being equal, the stability of the frying oils is decreased with increasing degree of unsaturation the constituent fatty acids.

Yussoff *et al.,* (2001) reported that, research carried out at Malaysian Palm Oil Board (MPOB), has shown that further improvement and mutual benefit from blending of palm olein with other liquid vegetable oils. By blending palm olein with liquid vegetable oils, the positive effect of palm olein is conferred to the liquid vegetable oils during frying. The best example was demonstrated by blending palm olein with groundnut and cottonseed oils by simple blending, these oils generally improved their frying qualities in terms of polymers, polar components, primary and secondary oxidation and oxidized fatty acids.

Table: 6 Changes in polymer content (PC) of palm olein and its blends during storage and frying temperature

Oil type	Polymer content (%)						
	Storage period (month)				Frying time (hrs)		
	0	3	6	12	5	10	15
Palm olein	0.01^{b}	0.05^{a}	0.50^{a}	3.80^{a}	0.00^{a}	1.11^{a}	3.12^{a}
Palm olein / Cottonseed oil (1:1)	0.01^{c}	0.09^{c}	0.90^{c}	6.76^{e}	1.47^{g}	2.24^{d}	6.73^{f}
Palm olein / Groundnut oil (1:1)	0.05^{f}	1.23^{e}	2.46^{e}	6.13^{c}	1.15^{e}	2.37^{d}	5.84^{e}
Palm olein / Sunflower oil (1:1)	0.01^{e}	0.06^{b}	0.63^{b}	8.00^{f}	0.83^{d}	1.58^{c}	7.44^{g}
Palm olein / Cottonseed oil (3:1)	0.00^{a}	0.08^{c}	0.87^{c}	4.72^{b}	0.46^{c}	1.54^{c}	3.36^{b}
Palm olein / Groundnut oil (3:1)	0.00^{a}	0.22^{d}	1.00^{d}	6.66^{d}	0.36^{b}	1.26^{b}	5.42^{d}
Palm olein / Sunflower oil (3:1)	0.01^{c}	0.09^{c}	0.85^{c}	4.73^{b}	0.49^{c}	0.88^{a}	4.02^{c}
S. E.	0.00	0.00	0.04	0.04	0.01	0.03	0.00

Mean values having different superscript letter(s) in each columns and rows differ significantly ($P \leq 0.05$)

Iodine value

Table 7 shows changes in iodine value (I.V.) of palm olein containing cottonseed oil, groundnut oil and sunflower oil respectively, of two blending ratios (1:1 ; 3:1) as affected by storage period. Initially the I.V. of all palm olein blends has significantly ($P \leq 0.05$) increased compared to the pure palm olein. Moreover, the I.V. of palm olein blends,(cottonseeds, groundnut and sunflower oils) of 1:1 mixing level has significantly ($P \leq 0.05$) higher (79.50, 74.80 and 91.37) than the palm olein blends of the same oils of 3:1 ratio, which recorded I.V. of (67.02, 63.84 and 71.60) respectively. However, the

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pure palm olein showed the lowest I.V. of 51.51. Similarly the I.V. of all palm olein blends after 12 months of storage has significantly (P≤0.05) decreased compared to the pure palm olein. The I.V. of high level of conventional oils in palm olein (1:1) ratio after the same storage period, showed higher significance (P≤0.05) compared to the low level of blends 3:1 and to the pure palm olein (46.88 value).

Table: 7 Changes in iodine value of palm olein and its blends as affected by storage and frying temperature

Oil type	Iodine value						
	Storage period (month)				Frying time (hrs)		
	0	3	6	12	5	10	15
Palm olein	54.51^{a}	54.51^{a}	48.24^{a}	46.88^{a}	52.67^{a}	50.89^{a}	49.30^{a}
Palm olein / Cottonseed oil (1:1)	79.50^{f}	77.95^{f}	74.61^{d}	71.36^{cd}	75.90^{f}	74.36^{f}	71.88^{f}
Palm olein / Groundnut oil (1:1)	74.25^{e}	73.01^{e}	70.15^{cd}	67.27^{c}	70.95^{e}	69.92^{e}	67.97^{e}
Palm olein / Sunflower oil (1:1)	91.37^{g}	90.14^{h}	86.31^{e}	81.05^{e}	88.59^{g}	87.23^{g}	86.19^{h}
Palm olein / Cottonseed oil (3:1)	67.02^{c}	66.87^{c}	61.27^{b}	58.88^{b}	65.87^{c}	63.39^{c}	61.69^{c}
Palm olein / Groundnut oil (3:1)	63.84^{b}	62.22^{b}	56.37^{b}	53.11^{ab}	61.87^{b}	59.18^{b}	57.02^{b}
Palm olein / Sunflower oil (3:1)	71.6^{d}	70.22^{d}	63.35^{bc}	59.79^{b}	69.98^{d}	65.69^{d}	63.97^{d}
S.E.	0.01	0.01	0.00	0.02	0.01	0.01	0.00

Mean values having different superscript letter(s) in each columns and rows differ significantly (P≤0.05)

Hassan (1992) stated that I.V. could be used as a measure of oxidation and stability of sunflower oil during storage period.

Table 7 also shows changes in I.V. of palm olein blends containing cottonseed oil, groundnut oil and sunflower oil respectively, at two mixing levels (1:1; 3:1)as affected by exposure to frying temperature at 180^{0} C for different frying hours. The I.V. of all palm olein blends after 15 hrs of exposure to frying temperature has significantly (P≤0.05) increased compared to the pure palm olein.The I.V. of high level of conventional oils in palm olein (1:1) blends, after 15 hrs of exposure to frying temperature, showed higher significant (P≤0.05) value (71.88, 67.97 and 86.19 of palm olein containing cottonseed, groundnut and sunflower oils, respectively, compared to low level of blends (3:1), which recorded I.V. of 61.69, 57.62 and 93.97; respectively. However, the I.V. of the pure palm olein showed the least significance (P≤0.05) decrease of 49.30 after the same frying time.A study carried out by Khattab *et al.* (1974) on cottonseeds, sesame and groundnut oils, showed that the initial iodine values were 106.7; 103; 97.5 (mg / iodine / 100 g fat) respectively. When these oils were subjected to a temperature of 195^{0} C the iodine value decreased gradually in case of cottonseeds and groundnut oils but rather sharply in case of sesame oil. Robertson and Russel (1972) concluded that IV of cottonseed and sunflower seed oils decreased when these oils were subjected to heat.

Conclusions and Recommendations

During the storage of 12 months, the degree of split of triglcerides (formation of free fatty acids) in palm olein blends of 1:1 level was greater compared to that of the pure palm olein or palm olein / sunflower oil (3:1) and palm olein / cottonseed oil (3:1) blends.

Palm olein containing low levels of Sudanese edible oils (3:1 ratios) together with the pure palm olein showed better stability than that of blends containing high level of Sudanese oils (1:1).

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Polymer formation in palm olein blends of 1:1 was faster than that of both, the pure palm olein and palm olein blends of the low levels (3:1).

After 15 hrs of exposure to frying temperature, palm olein blends of 3:1 ratios and the pure palm olein showed more stability than that of high level of Sudanese edible oils (1:1). Similarly, the polymer formation of palm olein with low level of these oils together with the pure palm olein was slower than the palm olein of high blended ratios.

From these findings, the following points are recommended:

Palm olein can be used as a base to be blended with sunflower oil at 3:1 ratio of the former to the latter for all food uses particularly frying.

For any other commercial purposes, palm olein can be blended with cottonseed oil at high level of olein to cottonseed oil (3:1) only.

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ثباتية بعض زيوت الطعام المخلوطة مع زيت النخيل

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المستخلص

تم خلط زيت الأولين مع ثلاثة من زيوت الطعام السودانية، زيت بذرة القطن زيت الفول السوداني وزيت بذرة زهرة الشمس على مستويين (1:3 1:1) على الترتيب. لاختبار اثر هذه الزيوت السودانية على درجة ثباتية زيت الأولين و ذلك إثناء فترة التخزين و قياس الأثر الناتج من التعرض لدرجة حرارة التحمير . تم قياس درجة اللزوجة، اللون، معامل الانكسار، الأحماض الدهنية الحرة، قيمة البيروكسيد، محتوى البوليمر و الرقم اليودي للخليط إثناء فترات التخزين المختلفة (0، 3، 6 و 12 شهر) و إثناء التعرض لدرجة حرارة التحمير (180± 2 ° م) و ذلك لمدة 5 ، 10 ، 15 ساعة .

لقد وجد أثناء فترة تخزين خليط زيت الأولين مع الزيوت المذكورة بنسبة 1:1 إن عملية تفكيك الجلسريدات الثلاثية إلى أحماض دهنية حرة خاصة الخليط الذي يحتوي على زيت الفو ل السوداني ذو تأثير عالي المعنوية مقارنة بزيت الأولين الصافي (6.51 4.30 % على الترتيب) . على الرغم من إن قيمة الأحماض الدهنية الحرة لخليط زيت الأولين مع زيت بذرة القطن و زيت بذرة زهرة الشمس بنسبة 1:3 لم تظهرا أي فروقات معنوية مقارنة مع زيت الاولين الغير مخلوط .درجة ثباتية زيت الاولين المحتوي على نسبة عالية من الزيوت المعنية أظهرت انخفاض معنوي كبير و ذلك بتسجيلها مستوى عال من البيروكسيدات حيث إن قيمة البروكسيد كانت أعلى من 15 ملي مكافئ أوكسجين مقارنة مع زيت الأولين غير المخلوط (9.17 ملي مكافئ أوكسجين) . تكوين البوليمرات في الزيوت المخلوطة بنسبة 1:1 ازدادت معنويا (6.13 إلى 8.00 %) مقارنة بزيت الأولين الصافي (3.8 %) .

بعد التعرض لمدة 15 ساعة على درجة حرارة التحمير (180 ± 2 ° م) لوحظ إن خليط زيت الأولين الذي يحتوي على نسبة اقل من الزيوت الأخرى (1:3) أكثر ثباتا بقيمة أحماض دهنية حرة منخفضة (2.59%) مقارنة بالخليط الذي يحتوي على نسبة أعلى من هذه الزيوت بزيت الأولين (3.34 %) كذلك وجد إن عملية تكسير البيروكسيدات تتم بصورة اقل بالنسبة لخليط زيت الأولين المحتوي على نسبة اقل من الزيوت السودانية حيث تراوحت قيمة البيروكسيد بين 8.06 و 8.08 ملي مكافئ اوكسجين مقارنة بالذي يحتوي على نسبة عالية من الزيوت المعنية حيث تراوحت القيمة بين 10.44 و 14.19 ملي مكافئ أوكسجين، ونفس الأمر ينطبق على تكوين البوليمرات حيث نجدها أسرع و أعلى من الخليط العالي من الزيوت الأخرى حيث تراوحت قيمة محتوى البوليمرات بين 5.84 و 7.44 % مقارنة بالخليط ذو المستوى المنخفض (بين 3.84 و 5.42 %) .

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