Physico-chemical changes in some Vegetable oils during frying

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Abstract: The aim of this study is to determine the physico - chemical properties of two oils: peanut oil and blend oil (peanut and palm olien oil 50:50) by utilizing them for frying Tamia (flafil) and fish. Two different types of frying continuous and discontinuous were executived in three hours. Free fatty acids of the two oils during continuous and discontinuous frying were within the range of Sudanese standard for edible oils (SSEO) 3 % as oleic acid. While peroxide value of the two oils during frying in case of flafil were within the range of SSEO (15 meq/kgoil|).Other quality properties were evaluated, i e. colour index, viscosity, specific gravity and refractive index, to assess the frying performance of the two oils. The blend oil was recorded high viscosity and high colour index 47 Centipoise and 5.7 R/ 50 Y respectively. The blend oil was found to be the least susceptible to oxidation.

Keys words: Frying, peanut oil, palm olein oil, blending.

Introduction:

Peanut oil is an important commodity in the daily diet of most people. Its advantage among vegetable oils is that it can be consumed in crude form. It has a major commercial role as frying oil in domestic applications. The necessity of using a good quality frying oil or fat and of maintaining it in that state as long as possible becomes obvious when one consider that some of that fat is absorbed by every piece of food fried in it.

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The most important characteristic of oil or fat used for frying is it's ability to withstand the high temperature used, without excessive chemical change (Burger, 1999).

Research has revealed a variety of chemical reactions during frying for example oxidation, polymerization and hydrolysis (Gertz and Klostermann, 2002). These reactions are causing deterioration of the frying oils; the degree of deterioration depends on many factors as the nature of the frying oil, a fryer design, the kind of food that is fried and the frying method (Gertz *et al*., 2000).

Oxidative stability is very important factor in oil quality especially for frying therefore the frying oil must have high oxidative stability during use (Tabee, *et al*., 2008).

Reasons for the rising consumption of fried foods are related to the improved sensory characteristics and their fast and easy preparation (Romero, Cuesta, and Sanchez- Muniz, 2001; Varela and Ruiz- Rosso, 2000).

From the consumer’s standpoint, fried food palatability is related to unique sensory characteristics, including flavour, texture and appearance (Saguy and Dana, 2003).

The type of oil or fat used during frying has a great influence on final product characteristics. The choice of the frying oil depends on many factors such as availability, price, frying performance, flavor and stability of the product during storage (Yusoff *et al*., 2001). Water loss from the fried food, as well as penetration of oil into the food, takes place. These interactions depend on initial characteristics of fat or oil, food and frying procedure (Guillaumin, 1988).

The aim of the present study was to investigate the high temperature performance of two vegetable oils as a function of heating duration at frying temperature 180°C.

MATERIALS AND METHODS

MATERIALS:

Commercially available sample of refined peanut oil (A) and blend formula (palm olein: peanut oil 50:50 (B)). The fried materials fish (F), Peagon pea for making Tamia (flafil) (T) and their ingredients were collected from the local market.

METHODS

Tamia and fish were prepared according to convenient popular recipes. The weight of oil used and the fried materials ratio were constant. Stainless steel fryers with heat regulator were used while frying time was kept manually. The process was divided into two experiments: discontinuous (Disc) and continuous (C) frying in three hours. Discontinuous frying typically 20 min. repeated five times consecutively .Continuous frying typically 30 min oil sample was taken. Two fryers were operated at the same time for each experiment. The fryers were filled with the two oils to recommended levels adjusted to 180°C and operated at the same time. After each batch the frying oil was sampled and analyzed.

Physiochemical characteristics including colour, specific gravity, refractive index, viscosity, peroxide value (PV) and free fatty acid (FFA) of the oils were determined according to AOAC (2009).

Organleptic tests on fried foods were carried out according to Ihekoronye and Ngoddy, (1985).

RESULTS AND DISCUSSION

Table (1): Characteristics of peanut oil (A) and new formula (B) used in frying experiments

Parameter	Oil (A)	Oil (B)
Peroxide value (meq/k oil)	2.000	1.020
Free fatty acid content (% as oleic acid)	0.150	0.100
Clour index	1.3 R/10Y	1.4R/20Y
Viscosity (Centipoise)	41.004	47.000
Specific gravity (gm/ml)	0.9146	0.9083
Refractive index	1.471	1.466

Each value is the mean of three analyses

Physico- chemical properties of the two oils:

Table (1) showed some physico- chemical properties of the two oils used in the study. The two oils were of good quality, as indicated by their low PV and percentages of FFA but concerning the viscosity, (B) had high value compared to (A) oil; this may be due to blending with palm olein oil.

Table (2): Changes in free fatty acid content and peroxide values of oil (A) during Tamia frying with the two experiments (Disc and C)

Frying No.	**A/T (Disc)**		**A/T (C)**	
	FFA(%)	PV(meq/k oil)	FFA(%)	PV(meq/k oil)
1	0.236	4.57	0.236	4.57
2	0.267	4.66	0.276	4.86
3	0.306	8.39	0.306	5.39
4	0.310	10.0	0.700	9.4
5	0.74	13.6	0.750	12.64

Each value is the mean of three analyses

Table (3): Changes in free fatty acid content and peroxide values of oil (B) during Tamia frying with the two experiments (Disc and C)

Frying No.	**B/T (Disc)**		**B/T (C)**	
	FFA (%)	PV(meq/k oil)	FFA(%)	PV(meq/k oil)
1	0.261	3.02	0.31	6.44
2	0.282	7.21	0.304	6.79
3	0.292	8.21	0.315	7.51
4	0.34	9.5	0.354	10.89
5	0.36	11.71	0.388	11.21

Each value is the mean of three analyses

Table (4): Changes in free fatty acid content and peroxide values of oil (A) during fish frying with the two experiments (Disc and C)

Frying No.	**A/F (Disc)**		**A/F (C)**	
	FFA (%)	PV(meq/k oil)	FFA(%)	PV(meq/k oil)
1	0.256	7.90	0.307	9.53
2	0.270	10.00	0.625	10.72
3	0.403	16.49	0.750	11.07
4	0.454	17.59	0.798	13.15
5	0.531	19.79	0.839	16.06

Each value is the mean of three analyses

Table (5): Changes in free fatty acid content and peroxide values of oil (B) during fish frying with the two experiments (Disc and C)

Frying No.	**B/F (Disc)**		**B/F (C)**	
	FFA(%)	**PV**(meq/k oil)	**FFA**(%)	**PV**(meq/k oil)
1	0.301	7.81	0.303	9.41
2	0.329	9.39	0.502	11.65
3	0.384	10.96	0.668	12.05

4	0.403	15.31	0.710	13.6
5	0.403	16.0	0.800	13.43

Each value is the mean of three analyses

Free Fatty Acid (FFA):

There was increase in free fatty acids in both discontinuous an continuous frying (B) oil and T as fried food showed the lowest increase, while T_2, T_4 and T_5 showed the highest increase. It reached 0.839% as oleic acid in case of A/F (L). The increase in FFA (%) could be attributed to oxidation and hydrolysis, which produces FFAs (Peeled *et al.*, 1975; Abdel- Aal and Karara (1986) and this increase indicating the oil degraded during successive frying. However, small changes in the FFA content did not affect the oil quality.

This phenomenon was the same as reported by other researchers Chu *et al.*, 2001; Warner and Gupta, 2005. It was reported that the FFA content is not a reliable measurement of oil deterioration (Fritch, 1981). Fritch's study concluded that the value of FFA content as a measurement of frying oil degradation level is controversial as FFA, are volatile and can be lost via steam distillation. The formation of FFA can be attributed by oil hydrolysis during frying and the presence of carboxylic groups in polymeric products of frying oil (Tyagi and Vasishtha, 1996).

In summary the FFA content of the two oil types after five numbers of frying were less than 2%. The upper limit of FFA, when oil must be discard is between 1- 2% (as oleic acid) as stated by Berger, (1984) therefore, all samples were suitable for further use.

Peroxide value (PV):

The primary products of lipid oxidation are hydroperoxides, generally referred to as peroxide value (PV) which is a good indicator of lipid oxidation, but it's used was limited to the initial stage of oxidation (Gray, 1978). Thus, PV may be not able to indicate the actual extent of oil deterioration (Fritch, 1981; Melton *et al*., 1994). Ansidine value (AV), which indicates secondary oxidations, is a more reliable quality measurement compared to PV. However, this test was not carried out in this study.

The two oils (A and B) where T and F were fried showed an increase in the PV in both type of frying, PVs of A and B oil samples where T were fried were in agreement with codex standard (except frying No. 5 Tables2 and 3). But for the same oil samples (A and B) where F fried were not in agreement with the maximum codex standard (Table 4 and 5), where PV reached high values (19.79 and 16.0 in Table 4). This could be due to the high moisture content in the fried food (fish) which promote the formation of peroxide product.

This revealed that oils should be replaced after the 4th frying for both short and long frying period in case of T, where as, the two oils should be replaced after the 2nd frying No for both frying period in case of F.

Table (6): Changes in colour, specific gravity, refractive index and viscosity of oil (A) during Tamia frying and (Disc) experiment

Frying No.	Colour	Specific gravity (gm/ml)	Refractive index	Viscosity (Centipoise)
1	1.3R/10Y	0.9147	1.471	41.004
2	1.4R	0.9154	1.471	41.005

3	1.4R	0.9155	1.471	41.011
4	1.4R	0.9157	1.471	41.022
5	1.4R	0.9157	1.471	41.020

Each value is the mean of three analyses

Table (7): Changes in colour, specific gravity, refractive index and viscosity of oil (A) during Tamia frying and (C) experiment

Frying No.	Colour	Specific gravity (gm/ml)	Refractive index	Viscosity (Centipoise)
1	1.3R/10Y	0.9151	1.472	35.055
2	1.3R/10Y	0.9153	1.472	35.035
3	1.2R/10Y	0.9152	1.471	35.070
4	1.3R/10Y	0.9151	1.470	41.002
5	1.4R/10Y	0.9151	1.471	41.009

Each value is the mean of three analyses

Table (8): Changes in colour, specific gravity, refractive index and viscosity of oil (A) during fish frying and (Disc) experiment

Frying No.	Colour	Specific gravity (gm/ml)	Refractive index	Viscosity(Centipoise)
1	2.2R/20Y	0.9163	1.471	35.0240
2	2.2R/20Y	0.9166	1.471	35.0024
3	2.5R/20Y	0.9165	1.472	35.006

4	2.6R/30Y	0.9166	1.474	41.006
5	3.4R/30Y	0.9167	1.474	41.008

Each value is the mean of three analyses

Table (9): Changes in colour, specific gravity, refractive index and viscosity of oil (A) during fish frying and (C) experiment

Frying No.	Colour	Specific gravity (gm/ml)	Refractive index	Viscosity(Centipoise)
1	1.4R/10Y	0.9212	1.471	41.031
2	1.8R/20Y	0.9206	1.471	35.057
3	2.5R/20Y	0.9229	1.470	35.045
4	3.6R/30Y	0.9242	1.470	35.058
5	4.4R/40Y	0.9232	1.470	41.001

Each value is the mean of three analyses

Table (10): Changes in colour, specific gravity, refractive index and viscosity of oil (B) during Tamia frying and (Disc) experiment

Frying No.	Colour	Specific gravity (gm/ml)	Refractive index	Viscosity(Centipoise)

1	1.4R/10Y	0.9084	1.466	47.009
2	1.5R/10Y	0.9086	1.466	47.041
3	2R/10Y	0.9091	1.466	47.043
4	2.3R/20Y	0.9087	1.466	47.045
5	2.3R/20Y	0.9086	1.466	47.045

Each value is the mean of three analyses

Table (11): Changes in colour, specific gravity, refractive index and viscosity of oil (B) during Tamia frying and (C) experiment

Frying No.	Colour	Specific gravity (gm/ml)	Refractive index	Viscosity(Centipoise)
1	1.4R/10Y	0.9086	1.464	47.030
2	1.4R/10Y	0.9085	1.465	47.050
3	2R/20Y	0.9087	1.466	47.050
4	2R/20Y	0.9088	1.466	47.052
5	2.1R/20Y	0.90886	1.467	47.053

Each value is the mean of three analyses

Table (12): Changes in colour, specific gravity, refractive index and viscosity of oil (B) during fish frying and (Disc) experiment

Frying	Colour	Specific gravity	Refractive index	Viscosity

No.		(gm/ml)		(Centipoise)
1	2.5R/30Y	0.9102	1.4655	47.016
2	3.2R/30Y	0.9103	1.4645	47.004
3	4R/40Y	0.9099	1.4645	47.002
4	5.5R/50Y	0.9112	1.4646	47.018
5	5.7R/50Y	0.9113	1.4648	47.810

Each value is the mean of three analyses

Table (13): Changes in colour, specific gravity, refractive index and viscosity of oil (B) during fish frying and(C) experiment

Frying No.	Colour	Specific gravity (gm/ml)	Refractive index	Viscosity (Centipoise)
1	2R/20Y	0.9192	1.466	41.039
2	2.5R/20Y	0.9173	1.466	41.042
3	3.3R/30Y	0.9163	1.465	41.048
4	4R/40Y	0.9169	1.464	41.051
5	5R/50Y	0.9181	1.462	41.052

Each value is the mean of three analyses.

Viscosity:

The changes in viscosity of the two oil types were presented in tables 6, 7, 8, 9, 10, 11, 12 and 13, as the oxidation process accelerated by heat, the viscosity increased (Koh *et al*., 2011). There was a marked increased in viscosity value (Table 7 and 8). But fluctuations in viscosity results happened in table 9 and this may be due to addition of ingredients like flour to the fried food (fish). The oil viscosity is directly related to degradation products (polymers) formed during frying. However, this test was not carried in this study.

Colour:

Colour is an important physical characteristic of oil. It is reported that cooking and frying oils become darker as heating proceeded (Kim *et al*., 1983). The change from the light yellow of fresh oil through amber and reddish brown is the result of oxidation.

The results showed that except tables6 and 7, there was an increase in colour. In tables 8, 9, 10, 12 and 13 the red colour increase from 2R to 5R while the yellow colour increase from 20Y to 50Y. The increase in colour content was attributed to the alpha, beta- unsaturated carbonyl compounds, which are intermediated to give nonvolatile decomposition products containing carbonyl group and have the ability to absorb energy of the magnitude of visible light (Gutierrez *et al*., 1988).

Specific Gravity (SG):

In all tables from 6 to 13, the SG of both oils increased with the progress of frying. Sometimes there were fluctuations in SG results, but the increase was observed. This increase may be attributed to the formation of polymeric fractions of higher molecular weight compounds due to oxidation reactions during frying (Ahon and Min, 1998). Table 5 showed that SG value of oil A increased linearly opposite to oil B which may be due to presence of natural anti- oxidatants of palm -olein which suppress the oxidation of oil and further the oxidative polymerization of the fatty acid chain (Johnson and Kumerows, 1957).

Refractive Index (R I):

RI is characteristic of oil type. In table 6 and 10 the results of RI for both oils used the Tamia food material and short frying period were constant, while increase was observed in table 8 and 11. The increases in molecular weight and degree of un saturation causes increases in refractive index. On the other hand a fluctuation was observed in table 7 and 12.

Viscosity:

The changes in viscosity of the two oil types were presented in tables 6, 7, 8, 9, 10, 11, 12 and 13, as the oxidation process accelerated by heat, the viscosity increased (Koh *et al.*, 2011). There was a marked increased in viscosity value (Table 7 and 8). But fluctuations in viscosity results happened in table 9 and this may be due to addition of ingredients like flour to the fried food (fish). The oil viscosity is directly related to degradation products (polymers) formed during frying. However, this test was not carried in this study.

Sensory Analysis (S. A.):

S. A on fried products has been carried out according to the Ihekoronye and Ngoddy (1985).

The sensory quality of the fried food was evaluated based on their appearance, colour, flavour, crispness, greasiness and preference. The results of S. A. were analyzed to determine preference and significant difference among sets of fried samples.

Marinova *et al.*, 2012, stated that with prolonged heating time the accumulation of deterioration products leads to orangoleptic failure and decrease of the nutritive value of the fried food.

According to the results of the sensory evaluation we observed that all the fried food either with A or B oil showed no significant differences in terms of flavour and crispiness. However, there was a significant difference between samples in terms of colour.

Conclusion:

The type of food being fried affects the frying life of the oil, the higher the moisture content of the food is, the higher the moisture transfer, and hence hydrolysis. Other factors such as oil quality used, the frying equipment, temperature and heating time also affect the frying process.

Our investigation approved that ground nut oil (A) must be replenished with fresh oil after the second fry while the new formula oil (B) after the fourth fry.

The increase in the peroxide levels in (A) oil compared to (B) oil could be attributed to the higher poly unsaturated fatty acids which undergo oxidation resulting in the formation of peroxides, aldehydes and ketones. Palm olein is commonly used as frying oil in food industry as this oil match most of the important criteria of frying oil. It has a very balanced fatty acid composition, with a safe level of polyunsaturated fatty acid, linoleic acid. This attribute couple with a high content of vitamin E, confer stability to palm olein at high temperatures. Which make it ideal for frying operations (Yusoff *et al.*, 2001). Moreover, it has been reported that palm oil has a high proportion of the saturated palmatic acid, it also contain a high quantity of unsaturated fats, principally those derived from oleic (Hartley, 1977).

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