EFFECT OF FRYING AND STORAGE ON OXIDATIVE STABILITY OF OIL BLENDS AND QUALITY ATTRIBUTES OF BISCUITS PREPARED WITH THE BLENDS

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Abstract
The changes occurring in groundnut (GO), sunflower (SO) and palm olein (PO) oil and their blends containing GO: PO: SO at ratios 40:30:30, 50:30:20 and 60:30:10 for blend 1, 2 and 3, respectively, during storage (6 months, room temperature) and repeated frying (200 °C for 30 s) of biscuits were monitored. The parameters assessed were: free fatty acid (FFA) and peroxide value (PV). Also the chemical composition, total energy, in vitro protein digestibility, PV and FFA of the biscuits prepared with the blended oils were also determined. The FFA of PO were lower than that of GO and SO during storage and frying period. However, blending of oils further decreased the FFA with blend 3 oil having the lowest value during storage and frying with biscuits. The PV of SO was lower than that of the oils tested during storage. However, at the end of the frying period, blended oils had lowest PV with blend 2 having the lowest value. No significant differences were observed in the chemical composition, total energy and in-vitro protein digestibility of the biscuits prepared with the blends but with the storage period the values decreased. Similar observation occurred in the PV and FFA of biscuits but the values increased with increase in storage period. Biscuits prepared with blend 2 had lowest PV and FFA during storage. Oxidative stability of oils during repeated frying and storage can be improved by blending groundnut, palm olein and sunflower oils at a ratio of 60:30:10.

Keywords: oil blends, biscuits, deep fat frying, storage, free-fatty acids, peroxide value, chemical composition

Received: 03.08.2017 Received in revised form: 14.11.2017 Accepted: 07.12.2017

1. INTRODUCTION

During frying and storage, vegetable oils undergo different reactions such as hydrolysis, oxidation and polymerization and this causes quality deterioration in the oils. Even though, different fats have almost the same process mechanisms, the kinetics of deteriorative reactions may vary (Reyes-Hernández *et al.,* 2007). Greater functionality of large number of product formulations can be achieved by altering the natural physical and chemical properties of a fat or oil. For many years, modification of original fats by means of direct blending with other fats, fractionation, hydrogenation and inter-esterification has been attempted to improve the fat functionalities and thus optimize their application in food products. Of the modification techniques, direct blending of fats is the method of choice as it has been considered to be a cheap and nondestructive technique. The technique has been used to modify the suitability of several underutilized fats and oils (Nor Hayati *et al.,* 2002). The oils can be blended even to derive the protective advantage due to the presence of specific ingredients that offer protection against oxidation to improve frying recyclability (Toliwal *et al.,* 2005). Groundnut oil is rich in oleic and linoleic acids, which represent approximately 75% of the oil. The storage and nutritional quality (and flavor) of groundnut can be affected by the fatty acid composition of its oil. The oleic to linoleic acid ratio is considered to be an indicator of groundnut oil stability, and it is a shelf-life index for industrial applications (Bolton and Sanders, 2002).
Palm olein’ (PO) the liquid fraction of palm oil has been shown as highly monounsaturated oil, which is rich in oleic acids, is currently touted to be oxidatively stable.

PO, besides being marketed as liquid oil, can be promoted for blending with other edible oils (Lin, 2002).

Sunflower oil which consists of a combination of monounsaturated and polyunsaturated fats with low saturated fat levels is valued for its light taste, frying performance and health benefits. Ideal edible oil is one in which the ratio of saturated, monounsaturated and polyunsaturated fatty acids is close to 1: 1: 1 and this could be utilized for frying of foods (Grundy, 1988). Frying is used extensively both at home and on a commercial scale to enhance the organoleptic quality of foods (Jaswir *et al.,* 2000).

During frying, vegetable oils will undergo a series of chemical reactions, such as hydrolysis, oxidation and polymerization, resulting in quality deterioration with respect to their nutritive value (Anwar *et al.,* 2007). Since oils such as sunflower, groundnut and palm olein have different fatty acid composition that may affect their stability during storage and frying, therefore an inexpensive modification of the oils by blending at different ratios could provide information on improving the stability of the oils and possible use of the blended oils to improve quality of fried foods.

Therefore, the aim of the study is to evaluate the oxidative stability of oils (groundnut, sunflower and palm olein) and their blends during storage and repeated frying process. Furthermore, the chemical composition, total energy and *in vitro* protein digestibility of biscuits prepared with the blends were evaluated.

2. MATERIALS AND METHODS

2.1. Materials procurement

Refined groundnut oil (GO), palm olein (PO) and sunflower oil (SO) were obtained from Arab Sudanese of Vegetable Oils Co. Ltd., Khartoum North. Commercially refined wheat flour, sugar, eggs and sodium bicarbonate for preparation of biscuits were brought from local market.

Unless otherwise stated all chemicals used in this study were of reagent grade.

2.2. Preparation of oil blends

Oil blends were prepared by mixing groundnut oil, palm olein and sunflower oil as follows: Blend 1 (40% GO: 30% PO: 30% SO), Blend 2 (50% GO: 30% PO: 20% SO) and Blend 3 (60% GO: 30% PO: 10% SO). The oils in the specific proportions were blended using high shear mixer. The blending was done at speed of 150 rpm, temperature of 50°C for 20 min. Some parts of the oils were used for preparation of biscuits and analyzed while the second parts were stored in polyethylene terephthalate (PET) bottles and kept at room temperature for 6 months.

2.3. Preparation of biscuits

Biscuits were prepared with some modification in the method given in AACC (2000). The ingredients needed for the preparation of biscuits were weighed accurately. Then creaming of vegetable ghee and sugar was done, followed by the addition of eggs. Creaming was continued till foaming occurred. The flour and baking powder were added to the creamy mass and mixed to a homogenous mass. The batter was then rolled out into sheet of 8 mm thickness and was cut with the help of a biscuit cutter into circular shape using 42 mm diameter cutter. The biscuit sheets were then fried under the designed conditions.

2.4. Fat frying of biscuits

The modified method of Sharma *et al.* (2006) was used for fat frying process. The process was carried out by frying the biscuit sheets with 500 mL of each single oil sample as well as blended oils separately in a frying domestic fryer (diameter 25 cm, depth 5 cm) at a temperature of 200 °C for 30 s. The frying temperature and time selected were based on preliminary experiments carried out in the laboratory. Another frying operation was carried out in 500 mL of oil under the same frying conditions. After frying, the oil samples from single and blended oils were cooled to room temperature and stored separately in PET bottles for analysis and further frying process. About 80 mL of oil sample was taken from single and blended oils for analysis. The frying process was done in four successive days. After every frying cycle, the volume of all oil samples was again made up to 500 mL by adding oil from another operation carried out under similar conditions, cooled and 80 mL oil withdrawn again for each frying cycle. Also storage stability of these biscuits for analysis was determined after 0, 1, 2, 3, 4 and 5 month intervals.

2.5. Analytical procedures

The free fatty acids (FFA) of the oils during storage period and different frying cycles as well as the biscuits were determined by titrating the free fatty acids with alkali in presence of ethyl alcohol as solvent [Ca 5a-40]. The peroxide value (PV) was estimated by using sodium thiosulfate solution as titrating agent against the evolved iodine in the sample, after reacting the peroxides present in the sample with salt of iodine (KI) [Cd 8-53] as reported in AOCS (2004).

2.6. Chemical analysis of biscuits

The chips were analyzed for moisture, ash, crude fiber, fat, protein, carbohydrate, total energy and pepsin *in vitro* protein digestibility by their respective procedures as described in AACC (2000).

2.7. Statistical analysis

All analysis was carried out in triplicate and statistical analysis of data were done by applying one-way analysis of variance (ANOVA) performed using SPSS. The differences between two means were determined by using Duncan multiple range test and were considered significant when $p<0.05$.

3. RESULTS AND DISCUSSION

3.1. Changes in free fatty acids (FFA) and peroxide value (PV) of oils during repeated frying and storage

Changes in free fatty acids of groundnut, sunflower and palm oil and their blends during 6-month storage is presented in Fig. 1. Free fatty acids occurred in fats as a result of enzymatic hydrolysis by lipases, metal ions acting as free radicals or at high temperature. The results showed that the FFA values of GO and SO were similar and this remained stable during storage till the 4th month and this may be due to the low amount of saturated fatty acids in the two oils. However, the FFA of PO reduced by 15.6% from beginning of storage to the 4th month.

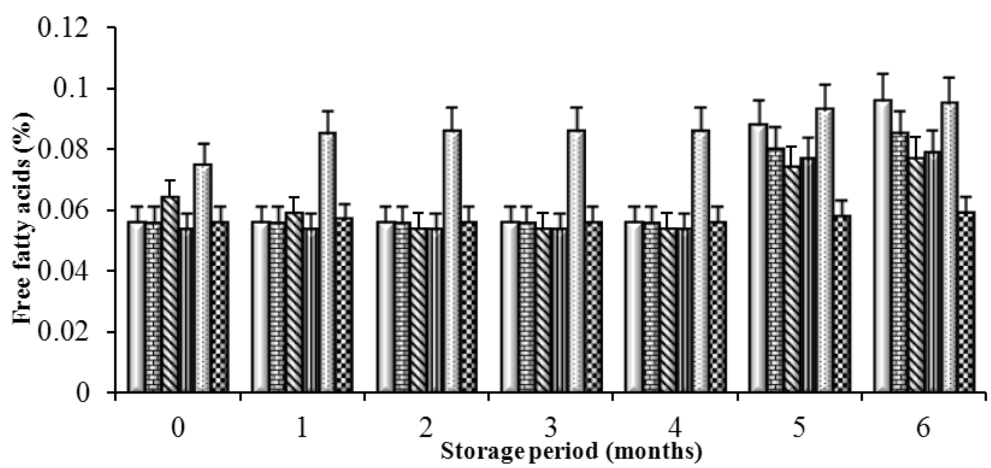

Figure 1: Changes in free fatty acids (% oleic or palmitic) of three oils and their blends during storage
For each storage period, bar 1, groundnut oil (GO); bar 2, sunflower oil (SO); bar 3, palm olein (PO); bar 4, blend 1 (40% GO: 30% PO: 30% SO); bar 5, blend 2 (50% GO: 30% PO: 20% SO), bar 6; blend 3 (60% GO: 30% PO: 10% SO).

A sharp rise in FFA content (0.077-0.096%) was noticed in the three oils as the storage period increased with PO and GO having the lowest and highest value, respectively, at the end of the storage period ($p \leq 0.05$).
This may be due to activation of lipase enzyme later and begins to hydrolyze all the triglycerides into free fatty acids, di-glycerides and mono glycerides over a period of several months.
Also during the first 4 months of storage, the oils blends exhibited stable FFA values with blend 2 having significantly ($p \leq 0.05$) higher FFA than blend 1 and 3. A significant ($p \leq 0.05$) increase in FFA value during 5th and 6th month of storage of the oils blends was observed with blend 2 which observed to have the highest. This could be due to high FFA of sunflower and groundnut oil present in blend 2 (50% GO: 30% PO: 20% SO). However, it has been observed that blending palm olein with vegetable oils with higher degrees of unsaturation, resulted in blends that are more stable at low temperatures. The blends stay clear for a longer period of time (Nor Aini *et al.,* 1992).
Figure 2 shows the changes in FFA of the oils and their blends during repeated frying period. It could be depicted from the graph that FFA of PO and blend 2 significantly ($p \leq 0.05$) increased after the first frying period to 0.084% and 0.104%, respectively. Rise in FFA of other oils was observed after 2nd frying period and this increment continued till the end of frying period. Increase in FFA could be attributed to moisture content of the fried product that accelerates the hydrolysis of oil. It is known that water can promote the hydrolysis of triacylglycerols to form a combination of mono and diacylglycerols, glycerol and free fatty acids (Velasco *et al.,* 2008). Moreover, the FFA content is a dynamic value because at the same time that the acids are being produced, they have sufficient vapor pressure at frying temperatures to evaporate from the surface (Abd El-Rahman *et al.,* 2006).
At the end of the frying period, blend 3 had the least FFA while highest value was recorded for SO. This may result from the fact that blend 3 which contains largest percentage of GO has high hydrolyzed saturated fatty acids that are more resistant to further degradation and remained in the oil during frying. This phenomenon was also reported by Hau *et al.,* (1986). However, no sample can be declared inferior in terms of thermal stability on the basis of this parameter even after the fourth frying cycle because all the oil samples had FFA content lower than 0.5 as reported in Prevention of Food adulteration Act (PFA, 1954).
Lipid oxidation results in peroxides which are responsible for primary oxidation. During oxidation process, oil initially formed hydroperoxide compounds, which are good indicators of lipid oxidation under normal conditions.

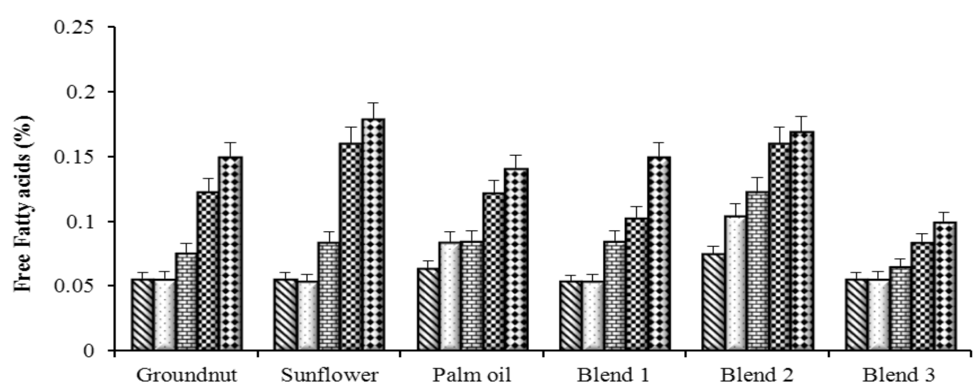

Fig. 2:Changes in free fatty acids (% oleic or palmitic) of three oils and their blends during repeated frying times
For each oil type and blend, bar 1, control; bar 2, 1st time frying; bar 3, 2ndtime frying; bar 4, 3rdtime frying; bar 5, 4th time frying.

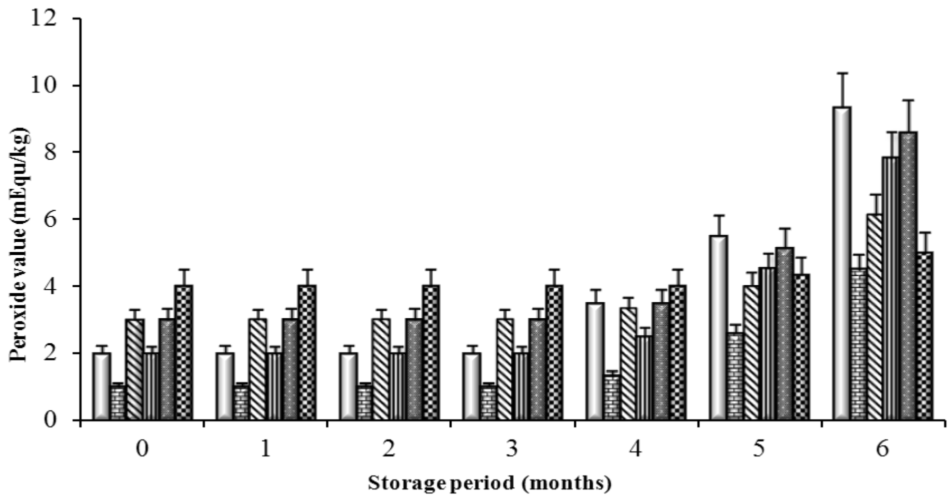

Figure 3: Changes in peroxide value (mEqu/kg) of three oils and their blends during storage.
For each storage period, bar 1, groundnut oil (GO); bar 2, sunflower oil (SO); bar 3, palm olein (PO); bar 4, blend 1 (40% GO: 30% PO: 30% SO); bar 5, blend 2 (50% GO: 30% PO: 20% SO), bar 6; blend 3 (60% GO: 30% PO: 10% SO).

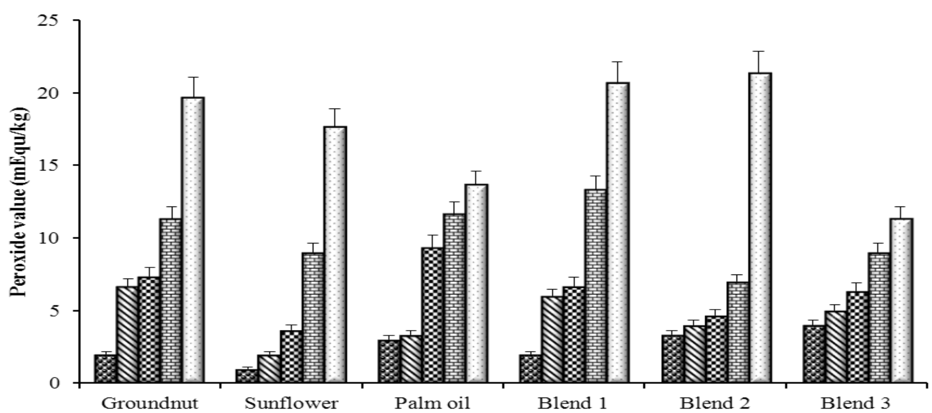

Figure 4: Changes in peroxide value (mEqu/kg) of three oils and their blends during repeated frying times
For each oil type and blend, bar 1, control; bar 2, 1st time frying; bar 3, 2nd time frying; bar 4, 3rd time frying; bar 5, 4th time frying.

The peroxide value of individual oils ranged from 1-3 meqO_2/kg with PO having the highest value while that of oils blends ranged from 2-4 meqO_2/kg with blend 3 having the highest value (Fig. 3). These values obtained for peroxide are still lower than that of codex maximum level (10 meqO_2/kg) (Codex Alimentarius, 2003). Changes in PV of the oils and the blends during storage follow a trend similar to that of the FFA by being stable till the 3rd month of storage. However, the PV increased significantly ($p \leq 0.05$) in all oils and blends except blend 3 at the end of 4th month and this continued with the storage period. This may be due to improper packaging and storage that induce degradation via photo-oxidation. Self-oxidation of unsaturated fats may also appear during storage due to air or oxygen (Susheelamma *et al.,* 2002). Blend 1 and 2 have significantly ($p \leq 0.05$) higher values than that of blend 3 at the end of the storage period. Sunflower oil had high amount of polyunsaturated fatty acids that are susceptible to oxidation and its higher percentage in blend 1 and 2 oils compared to blend 3 could be responsible for its high PV during storage.

Changes in PV of the oils and their blends during repeated frying is shown in Figure 4.

At the end of the first frying period, a sharp increase in PV of groundnut and blend 1 was observed and this could be due to presence of high temperature and moisture from the fried foods. As the frying continues, the PV of the oils and blends increased significantly ($p \leq 0.05$). Other authors also reported an increase in peroxide value of oil upon heating (Serjouie *et al.,* 2010). At the end of the 4th frying time, blend 1 and 2 had higher amount of SO therefore, they exhibited the highest PV while the lowest value was noticed in blend 3. Poly-unsaturated oils such as sunflower oil have reduced stability at elevated temperatures; unsaturated fatty acids easily react with oxygen to form peroxides (Che-Man and Wan-Hussin, 1998). This indicates the better frying stability of blend 3 oil as compared to other oils.

3.2. Chemical composition of biscuits fried with oils blends

No significant ($p \leq 0.05$) difference was observed in the moisture content, ash and crude fiber of the biscuits during the storage periods (Table 1).

The moisture content of the biscuits fried with the oils increased as the storage period increased but the crude fiber and ash content reduced. Similar observations were reported by Waheed *et al.* (2010) on chemical composition of cookies fried with blends of cottonseed and palm oil.

Table 1. Changes in chemical composition (%) during storage of biscuits prepared using oils blends

Blends	Storage period (months)					
	0	1	2	3	4	5
Moisture						
B1	2.89±0.03^{d}	2.91±0.04^{d}	3.00±0.06^{cd}	3.30±0.07^{bc}	3.42±0.08^{ab}	3.60±0.09^{a}
B2	2.89±0.03^{d}	2.90±0.04^{d}	2.98±0.05^{cd}	3.22±0.06^{c}	3.31±0.07^{bc}	3.49±0.08^{ab}
B3	2.89±0.03^{d}	2.90±0.04^{d}	3.00±0.06^{cd}	3.25±0.07^{c}	3.38±0.08^{b}	3.58±0.09^{a}
Ash						
B1	0.82±0.03^{a}	0.82±0.03^{a}	0.80±0.02^{a}	0.77±0.01^{ab}	0.70±0.01^{b}	0.64±0.01^{bc}
B2	0.81±0.02^{a}	0.81±0.02^{a}	0.81±0.02^{a}	0.79±0.01^{a}	0.77±0.01^{ab}	0.70±0.01^{b}
B3	0.82±0.03^{a}	0.82±0.03	0.80±0.02^{a}	0.75±0.01^{b}	0.72±0.01^{b}	0.59±0.01^{bc}
Crude fiber						
B1	1.14±0.05^{a}	1.14±0.05^{a}	1.10±0.02^{ab}	1.00±0.01^{b}	0.85±0.00^{bc}	0.80±0.00^{c}
B2	1.13±0.04^{a}	1.13±0.04^{a}	1.12±0.04^{ab}	1.05±0.02^{b}	1.00±0.01^{b}	1.00±0.01^{b}
B3	1.15±0.05^{a}	1.15±0.05^{a}	1.13±0.04^{a}	1.02±0.02	0.92±0.01^{bc}	0.84±0.00
Crude protein						
B1	11.25±0.05^{ab}	11.25±0.05^{ab}	11.15±0.04^{b}	11.00±0.04^{bc}	10.94±0.02^{cd}	10.90±0.02^{cd}
B2	11.35±0.06^{a}	11.35±0.06^{a}	11.30±0.04^{a}	11.25±0.05^{ab}	11.03±0.03^{c}	11.00±0.01^{c}
B3	11.23±0.05^{ab}	11.25±0.05	11.18±0.04^{b}	11.09±0.04^{b}	10.92±0.02^{cd}	10.82±0.01^{d}
oil						
B1	19.78±1.13^{ab}	19.79±1.12^{ab}	19.751.13^{ab}	19.66±1.13^{b}	19.45±1.09	19.40±1.08^{bc}
B2	20.03±1.15^{a}	20.00±1.16^{a}	20.00±1.16^{a}	19.88±1.13^{a}	19.68±1.10	19.62±1.10^{b}
B3	19.68±1.13^{b}	19.70±1.11^{ab}	19.60±1.13^{b}	19.42±1.09	19.35±1.09^{bc}	19.30±1.07^{c}
Carbohydrate						
B1	64.46±0.44^{ab}	64.10±0.01^{bc}	64.20±0.04^{b}	64.27±0.03^{b}	64.64±0.02^{a}	64.66±0.01^{a}
B2	63.80±0.06^{c}	63.81±0.05^{c}	63.75±0.02^{c}	63.81±0.02^{c}	64.21±0.01^{b}	64.19±0.03^{b}
B3	64.24±0.06^{bc}	64.18±0.05^{b}	64.29±0.02^{b}	64.47±0.03^{ab}	63.79±0.03^{c}	64.87±0.02^{a}

Values are mean ±SD of triplicate samples. Values having the same superscripts in a row are not significantly different at $P \leq 0.05$. B1, blend 1 (40% GO: 30% PO: 30% SO); B2, blend 2 (50% GO: 30% PO: 20% SO), B3; blend 3 (60% GO: 30% PO: 10% SO)

Table 2. Effect of storage on total energy (kcal) and *in vitro* protein digestibility during storage of biscuits prepared using oils blends

Sample	Storage period (months)					
	0	1	2	3	4	5
Total energy (kcal)						
B1	480.58±1.10^{a}	479.56±1.08^{a}	479.15±1.06^{a}	478.02±1.03^{a}	477.37±1.02^{a}	476.84±0.78^{a}
B2	480.83±0.92^{a}	479.51±0.08^{a}	480.58±0.18^{a}	479.16±1.03^{a}	478.10±0.02^{a}	477.34±0.65^{a}
B3	478.96±0.21^{a}	479.02±1.07^{a}	478.28±1.05^{a}	477.00±1.02^{a}	472.99±0.98^{ab}	476.49±0.03^{a}
In vitro protein digestibility (%)						
B1	57.00±0.03^{a}	57.00±0.03^{a}	57.00±0.03^{a}	52.00±0.02^{b}	52.00±0.02^{b}	51.00±0.01^{b}
B2	57.00±0.03^{a}	57.00±0.03^{a}	57.00±0.03^{a}	52.00±0.02^{b}	52.00±0.02^{b}	51.00±0.01^{b}
B3	57.00±0.03^{a}	57.00±0.03^{a}	57.00±0.03^{a}	52.00±0.02^{b}	52.00±0.02^{b}	51.00±0.01^{b}

Values are mean ±SD of triplicate samples. Values having the same superscripts in a row are not significantly different at $P \leq 0.05$. B1, blend 1 (40% GO: 30% PO: 30% SO); B2, blend 2 (50% GO: 30% PO: 20% SO); B3, blend 3 (60% GO: 30% PO: 10% SO)

Table 3. Changes in peroxide value and free fatty acids during storage of biscuits prepared using oil blends

Blends	Storage period (months)					
	0	1	2	3	4	5
Peroxide value (mEqu/kg)						
B1	0.75±0.04^{e}	0.88±0.09^{e}	2.23±0.03^{d}	6.91±0.01^{c}	8.63±0.02^{ab}	9.85±0.02^{a}
B2	0.63±0.02^{e}	0.75±0.04^{e}	1.75±0.05^{de}	6.20±0.02^{cd}	7.92±0.01^{b}	8.91±0.01^{ab}
B3	0.72±0.03^{e}	0.91±0.01^{e}	2.11±0.01^{d}	7.12±0.01^{bc}	8.88±0.03^{ab}	9.65±0.02^{a}
Free fatty acids (% oleic acid)						
B1	0.0920±0.01^{d}	0.1260±0.02^{c}	0.3540±0.03^{bc}	0.955±0.04^{b}	1.252±0.01^{a}	1.635±0.01^{a}
B2	0.1256±0.01^{cd}	0.1250±0.02^{c}	0.289±0.02^{bc}	0.831±0.01^{b}	1.051±0.02^{ab}	1.079±0.03^{ab}
B3	0.1254±0.01^{cd}	0.1320±0.02^{c}	0.443±0.03^{bc}	0.973±0.01^{b}	1.307±0.04^{a}	1.871±0.01^{a}

Values are mean ±SD of triplicate samples. Values having the same superscripts in a row are not significantly different at $P \leq 0.05$. B1, blend 1 (40% GO: 30% PO: 30% SO); B2, blend 2 (50% GO: 30% PO: 20% SO); B3, blend 3 (60% GO: 30% PO: 10% SO)

The crude protein content of the biscuits fried with oils 1, 2 and 3 ranging from 11.23-11.35% also showed no significant ($p \leq 0.05$) differences and the values decreased with the storage period. The reduction in protein content of biscuits during storage might be due to increasing level of moisture which enhances proteolytic activity. Masih *et al.* (2014) reported a decreasing trend in protein content of cookies during storage. Biscuits fried with blend 2 had significantly ($p \leq 0.05$) higher protein content than that fried with blend 3 at the end of storage period. Frying of the biscuits with blend 1 and 2 showed significantly ($p \leq 0.05$) higher oil content than that fried with blend 3 as noticed for the control sample and that stored for 6th month. This difference might be due to the difference in moisture uptake by cookies from the surrounding air. The values were comparable with that reported by Sharif *et al.* (2003) for oil content of cookies fried with rice bran oil. A significantly ($p \leq 0.05$) higher carbohydrate content was observed in biscuits fried with blend 1 than that of blend 3.

The effect of storage on total energy and *in vitro* protein digestibility of biscuits fried with the oils blends is presented in Table 2. The total energy content ranged from 478.96-480.83 kcal with biscuits fried with blend 2 exhibited the highest value. A non-significant difference in the total energy content of the biscuits fried with the oil was observed and the values reduced as storage period increases. Similar observation as that of total energy was recorded for pepsin *in vitro* protein digestibility of the biscuits and the values reduced from 57.0% to 51.0% at the end of the storage period in all biscuits prepared using oil blends.

3.3. Changes in PV and FFA of biscuits fried with oil blends during storage

It can be depicted from Table 3 that biscuits prepared with blend 1 oil had the least PV (0.63 $meqO_2/kg$) and that with blend 1 had the highest (0.75 $meqO_2/kg$) but the values are not significant ($p \leq 0.05$). The low PV value recorded in biscuits fried with blend 1 could be due to the low PV of the oil at the beginning of the storage period. These values were higher than that reported by Waheed *et al.* (2010) for PV of cookies prepared with blend of inter-esterified palm and cottonseed oil blends. As the storage period increased there is a sharp rise in the PV of the biscuits prepared with blend 1, 2 and 3 at the 5^{th} month of storage. Peroxide value results can be supported through the studies of Arogba (2002) that use processed mango (*Mangifera indica*) kernel flour in cookie preparation and observed increase in peroxide value during 90 days of storage intervals.

The FFA of the biscuit prepared using oil blends ranged from 0.092-0.1256% with the biscuit prepared with blend 1 and 3 having the highest and lowest values, respectively. Blend 3 oil has low FFA at the beginning of the storage period and this could be responsible for the low FFA of the biscuits fried with it. As the storage period increases, there is a sharp increase in the FFA of the biscuits with that prepared with blend 3 exhibiting the highest value of 1.871% but the values were not significant.

4. CONCLUSIONS

The results of the study indicate that blending of the individual oils improved their FFA and PV with blend 3 (60% GO: 30% PO: 10% SO) being more stable by exhibiting the lowest FFA and PV during storage period and frying times. Frying of the biscuits with oil blends had no significant effect on the chemical composition, total energy and *in vitro* protein digestibility of the biscuits. In addition, the PV and FFA of the biscuits were also not significantly affected by blends used.

5. REFERENCES

[1] American Association of Cereal Chemists (AACC). (2000). Approved Methods of Analysis. The American Association of Cereal Chemists. St. Paul, Minnesota.

[2] Abd El-Rahman, M. S., El-Makhzangy, A., & Ramadan, M. F. (2006). Antiradical performance and physicochemical characteristics of vegetable oils upon frying of French fries: A preliminary comparative study. *Journal of Food Lipids*, *13*, 259–276.

[3] Anwar, F., Hussain, A. I., Iqbal, S., & Bhanger, M. I. (2007). Enhancement of the oxidative stability of some vegetable oils by blending with *Moringa oleifera* oil. *Food Chemistry, 103,* 1181-1191.

[4] American Oil Chemists' Society (AOCS). (2004). Official methods and recommended practices of the American Oil Chemists' Society (5th ed.) AOCS, Champaign Illinois, USA.

[5] Bolton, G. E., & Sanders, T. H. (2002). Effect of roasting oil composition on the stability of roasted high-oleic peanuts. *Journal of the American Oil Chemists' Society, 79,* 129–132.

[6] Che-Man, Y. B., & Wan-Hussin, W. R. (1998). Comparison of the frying performance of refined, bleached and deodorized palm olein and coconut oil. *Journal of Food Lipids, 5,* 197–210.

[7] Codex Alimentarius, 2003. Codex standard for named vegetable oils. Codex Stan 210-1999, pp 5-13.

[8] Grundy, S. M. (1988). Cholesterol and coronary heart disease: A new era. *Journal of the American Medical Association, 1,* 45-53.

[9] Hau, L. B., Young, P. K., & Hwang, L. S. (1986). Quality assessment of oils during heating and frying. *Journal of the Chinese Agricultural Chemical Society, 24,* 397–405.

[10] Jaswir, I., Che Man, Y., & Kitts, D. (2000). Optimization of physicochemical changes of palm olein with phytochemical antioxidants during deep-fat frying. *Journal of the American Oil Chemists' Society, 77,* 1161-1168.

[11] Lin, S. W. (2002). Palm oil. Vegetable oils in Food Technology. Composition, Properties and Uses. Gunstone, F.D (Eds.), SRC Press LLC, pp. 59-86

[12] Masih, S., Iqbal, Z., Arif, A. M., Rafiq, M., Rasool, G., & Rashid, A. (2014). Effect of linseed oil substitution on physico-chemical properties of cookies. *Journal of Agricultural Research, 52(3)*, 425-437.

[13] Nor Aini, I., Hanirah, B., Flingoh, C. H. O., & Noraini, S. (1992). Resistance to crystallization of blends of palm olein with soybean oil stored at various temperatures. *Journal of the American Oil Chemists' Society, 69,* 1206-1209.

[14] Nor Hayati, I., Aminah, A., Mamot, S., Nor Aini, I., & Nor Lida, H. M. (2002). Physical characteristics of modified milk fat in high melting

fat preparation. *International Journal of Food Science and Nutrition, 53,* 43-54.
[15] Prevention of Food adulteration Act (PFA). (1954). Prevention of food adulteration act along with rules and notification and commodity index, 16th edn. EBC Publishing Company, Lucknow.
[16] Reyes-Hernández, J., Dibildox-Alvarado, E., Charó-Alonso, M., & Toro-Vazquez, J. (2007). Physicochemical and Rheological Properties of Crystallized Blends Containing trans -free and Partially Hydrogenated Soybean Oil. *Journal of the American Oil Chemists' Society, 84*, 1081-1093.
[17] Sharif, M. K., Butt, M. S., Anjum, F. M., Nasir, M., Minhas, R., & Qayyum, M. N. (2003). Extension of cookies shelf life by using rice bran oil. *International Journal of Agriculture and Biology, 5,* 455-57.
[18] Sharma, H. K., Kaur, B., Sarkar, B., & Singh, C. (2006). Thermal behavior of pure rice bran oil, sunflower oil and their model blends during deep fat frying. *Grasas Y Aceites, 57(4),* 376–381.
[19] Serjouie, A., Tan, C. P., Mirhosseini, H., & Bin Che Man, Y. (2010). Effect of vegetable based oil blends on physicochemical properties of oils during deep-fat frying. *American Journal of Food Technology, 5(5)*, 310-323.
[20] Susheelamma, N. S., Asha, M. R., Ravi, R., & Kumar, A. K. V. (2002). Comparative studies on physical properties of vegetable oils and their blends after frying. *Journal of Food Lipids, 9(4)*, 259–276.
[21] Toliwal, S. D., Tiwari, M. R., & Verma, S. (2005). Studies on Thermal stability of Palm-Corn Oil Blends. *Journal - Oil Technologists' Association of India, 37(3),* 18-20.
[22] Velasco, J., Marmesat, S., & Dobarganes, M.C. (2008). Chemistry of Frying. In: Sahin, S. & G. Sumnu, Taylor and Francis. Deep fat frying of foods. USA, pp. 33-56.
[23] Waheed, A., Rasool, G., & Asghar, G. (2010). Effect of interesterified palm and cottonseed oil blends on cookie quality. *Agricultural and Biology Journal of North America, 1(3),* 402-406.