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Change in Physicochemical Characteristics of Sunflower, Groundnut and Cottonseed Oils used in Frying Doughnut and Tamiya

Sara Y. A. Younis[1], Atif A. A.Yassin[2], Ahlam A. Hussein[3], and Eman O. Basheer[4]

1. Ministry of Agriculture and natural resources/ General Administration for Planning Agriculture. Economic Planning and Policy Management.
2. Faculty of Engineering and Technology, University of Gezira, P.O. Box (20), Medani, Sudan.
3. National Food Research Center (NFRC) / Oils Department, Sudan.
4. National Food Research Center (NFRC) / Animal Products Department, Khartoum, Sudan.

Abstract

This study was conducted to evaluate the physicochemical characteristics of sunflower, groundnut and cottonseed oil as frying doughnut and tamiya. The frying process was achieved at 180±2°C. Physicochemical analysis was achieved before and after frying for one hour up to six hours using standards analytical procedure. Higher specific gravity (SG) was recorded for cottonseed oil 43.37% while, lowest SG was recorded for cottonseed oil 43.23%. Concerning frying doughnut, sunflower, groundnut and cottonseed oils were viscosity of 20.22, 23.37 and 21.52cp, respectively. There were significantly ($P \leq 0.05$) differences of yellow and red colour among the different oils. Free fatty acid (FFA) is affected by oil type significantly ($P \leq 0.05$). Peroxide value (PV) of oil samples significant ($P \leq 0.05$) affected by oil type. Continuous frying for several hours process had significant ($P \leq 0.05$) differences on the relative specific gravity of oils, in contrast, no significant ($P \geq 0.05$) on relative index. Viscosity of oil increased as frying continuous. Red and yellow colour had significant ($P \leq 0.05$) influence by oil type. Moisture content increased from 0.1401% to 0.1550% at the end of continuous frying process. FFA increased as the number of frying cycle increase. Sunflower, groundnut and cottonseed oils at initial time of frying were recorded FFAs of 0.310, 0.580 and 0.233% respectively. The FFA of the same samples at the end time of continuous frying process was 0.373, 0.887 and 0.423%, respectively. Statistical analysis showed that number of frying cycles had significant ($P<0.05$) effect on PV of oils under investigations. Continuous frying process influence on dienes and trienes significantly ($P \leq 0.05$). Conjugated dienes increased from 14.08 to 28.27 at the end of frying cycle. The study recommended that, encourage and support basic research focused on understanding the dynamics of deep-fat frying and the frying process.

Keywords: Frying process, Doughnut, Tamiya

Introduction

Frying is the highly complex process where a series of phenomena occur simultaneously throughout the entire process (Kardam, 2017). More specifically, there is simultaneous heat, moisture and oil transfer taking place between the products and heating medium (frying oil) (Tameshia, 2003). Frying is one of the most common food preparation techniques that is defined as a process of drying and cooking of food by immersing food in oil at a high temperature, usually 165°-190°C (Moreira, 2009). Some food can be found as early as the late 17th century in Europe, French fries, invented in the late 18th century, became popular in the early 19th century western Europe. In 1860 Joseph Malin combined deep fried fish with chips (French fries) to open the first fish and chip shop in London (Lapetina, 2015). The frying technique has improved over the years and has evolved from kitchen frying to large-scale industrial frying (Farah, 2004). Many different types of edible fats and oils are available for frying purposes. These include the animal fats (i.e. lard and tallow) and vegetable oils such as palm oil, rapeseed oil (low erucic acid), olive oil, soybean oil, cottonseed oil, corn oil, etc.… (Yousif, 2014).

During the frying process, two main changes may occur as physical and chemical changes in oils. Physical changes are increasing of viscosity, darkening in colour and foaming and decreased the smoke point of the oil (Farah, 2004). The major chemical reactions that occur during frying include: hydrolysis, oxidation, oligomerization, and nonenzymatic browning reactions along with numerous physical changes (Kardam, 2017). In deep-frying process, oxidation, hydrolysis and polymerization reaction occur, and the structure changes to form volatile compounds and non-volatile monomeric, polymeric components, geometric isomers of unsaturated fatty acids, etc. Oxidized monomeric, dimeric and oligomeric triacylglycerols formed from the native triacylglycerols may have negative effects on human health (Baixauli *et al.*, 2002).

In Sudan, the production of oil seeds is variable due to the change in climatic conditions. The main oil seeds grown in Sudan are sesame seeds, groundnut, cottonseed and sunflower seeds. Sudan is the biggest producer of annual oil seeds among the Arab Countries and a major world exporter of sesame seeds and groundnuts (Arab Agricultural Statistics, 2013). Sunflower seed and cottonseed are considered major sources of edible oils in Sudan. Sunflower oil the non-volatile oil pressed from the seeds of sunflower (*Helianthus annuus*) (Avci, 2015). It has been extensively used in salad dressing, margarine and shortening industry as well as in deep - frying. Sunflower high quality of edible oil enjoys an important position in the world among the new oil-seed crops. The seed of sunflower has high oil content (40-50%) and 30% digestible protein and can be used as a source of food for humans or as poultry feed. Sunflower cake can also be used as an animal feed (Ahmed, 2017). Cottonseed oil as well as sunflower seed oil is being produced and utilized in Sudan (Farah, 2004). Cottonseed oil is a cooking oil extracted from the seeds of cotton plant of various species, mainly *G.hirsutum* and *G.herbaceum* (Ahmed, 2002). Cottonseed oil consists of 70% UFAs (18% MUFAs, and 52% PUFAs) and 26% SFA. Crude Cottonseed oil has a mild taste and dark reddish-brown colour, because of the presence of highly coloured material extracted from the seed. After processing, it typically has a rich golden yellow colour; the amount of colour depending on the amount of refining (Yousif, 2014). Groundnut, also considered one of common and important Sudanese frying oil. In Sudan, groundnut is considered one of the major oil sources, and the crop continues to play an important role in the Sudan foreign trade (Arab Agricultural Statistics, 2013). The main objective of this research is to study the effect of re-frying process on quality characteristics of some Sudanese oil (Sunflower, groundnut and cottonseed).

MATERIALS AND METHODS

Materials

Sunflower, groundnut, and cottonseed oils were purchased from the local market at Khartoum state. Chickpea granules, onion, wheat flour, kitchen yeast (*Saccharomyces cerevisia*), salts and spices were purchased from local market at Khartoum city. All Chemical reagents used were obtained from Seisaban Companies Ltd for medical labs requirements, Khartoum, Sudan. All the chemicals and reagents were of analytical grades.

Doughnut preparation

One kg of wheat flour, half liter of a clean water, 10 gm sodium chloride salt and 10gm of kitchen yeast (*Saccharomyces cerevisia*) were mixed well to obtained homogenized dough, the mixture was leave about 1hr for complete the fermentation process.

Frying doughnut

The fermented dough was divided into three groups. Group A, B and C. It was fried in sunflower, groundnut and cottonseed oils at 180° C ± 2°C for 3 - 4 minutes, by using a thermostat frying ban (Seb- France). The frying system was repeated at each hour up to six times. The doughnut from the different treatments were subjected to physicochemical analysis in terms of; moisture content, Colour, viscosity, RSG, RI, and chemical parameters such as; PV, FFAs, in addition to, conjugated Dienes and Trienes.

Chickpea

Chickpea cleaned from the dust and foreign materials manually by hand. Then it was soaked in distilled water at ratio for 4 hours. After that, ground by using grinder machine.

Chickpea preparation

Chickpeas were mixed with garlic (5gm), onion (150gm), salt (sodium chloride 15gm, sodium bicarbonate 20gm) and spices 10gm.

Frying tamiya

Chickpea mixture was divided into three groups; group A, was frying in sunflower oil, group B, was frying in groundnut oil and the final group C was frying in cottonseed oil. The frying process was achieved at 180°C ± 2° for 4-5 minutes by using a thermostat frying pan (Seb-France). The frying process was repeated at each hour up to six times. The tamiya from different treatments were subjected to the physicochemical analysis in terms of; moisture content, Colour, viscosity, RSG, RI, and chemical parameters such as; PV, FFAs, in addition to, conjugated Dienes and Trienes.

Analysis

Moisture

A sample of 5ml was weighed into a dried dish. Then, the sample was placed in to a moisture analyzer system oven (HND-50), and left to dry at 105 ºC for 2-3 minutes. The reading was recorded directly from the system.

Colour

The colour intensity of oils were measured by using a lovibond tintometer apparatus (WSL-2) as unit of red, yellow and blue, according to a method described by Wail *et al*. (1995).

Relative Index (RI), Relative Specific Gravity (RSG) and Viscosity

RI and RSG were determined according to the AOAC (2005). and AOCS (2004), respectively.

Free Fatty Acids (FFAs), Peroxide Value (PV) and Conjugated dienes and trienes

The FFAs, PV and Conjugated dienes and trienes of the oil samples were determined according to AOCS (2005) and AOAC (2005**),** respectively.

Statistical analysis

The data collected from the different treatments were subjected to Completely Randomized Design (CRD) in factorial arrangement using analysis of variance (ANOVA) and Duncan's Multiple Range test was employed (Steel and Torrie, 1980). The SAS program (SAS, 2002), was used to perform the general of liner model (GLM) analysis.

RESULTS AND DISCUSSION

Moisture content

Figure1, shows that significant variations of moisture content among the different oils type Sunflower, groundnut and cottonseed oils had moisture content of 0.1307, 0.1267 and 0.1400%, respectively. Moisture content of oil significantly ($P \leq 0.05$) influence by continuous frying process. As for Sunflower oil, it decreased from 0.1307% at hour one to reach 0.1167% at the second hour of continuous frying, then it increase to 0.1433% at third hour of frying, then it reduced to reach 0.1100% at the end of frying. It isSimilarly noticed for Groundnut oil. During frying, a considerable amount of moisture from the food products escapes into the frying oil as steam. At elevated frying temperatures in the range 160 to 200°C, this steam reacts with triglycerides to form FFAs, monostaglycerides, di-glycerides and glycerolas (Yousif, 2014).

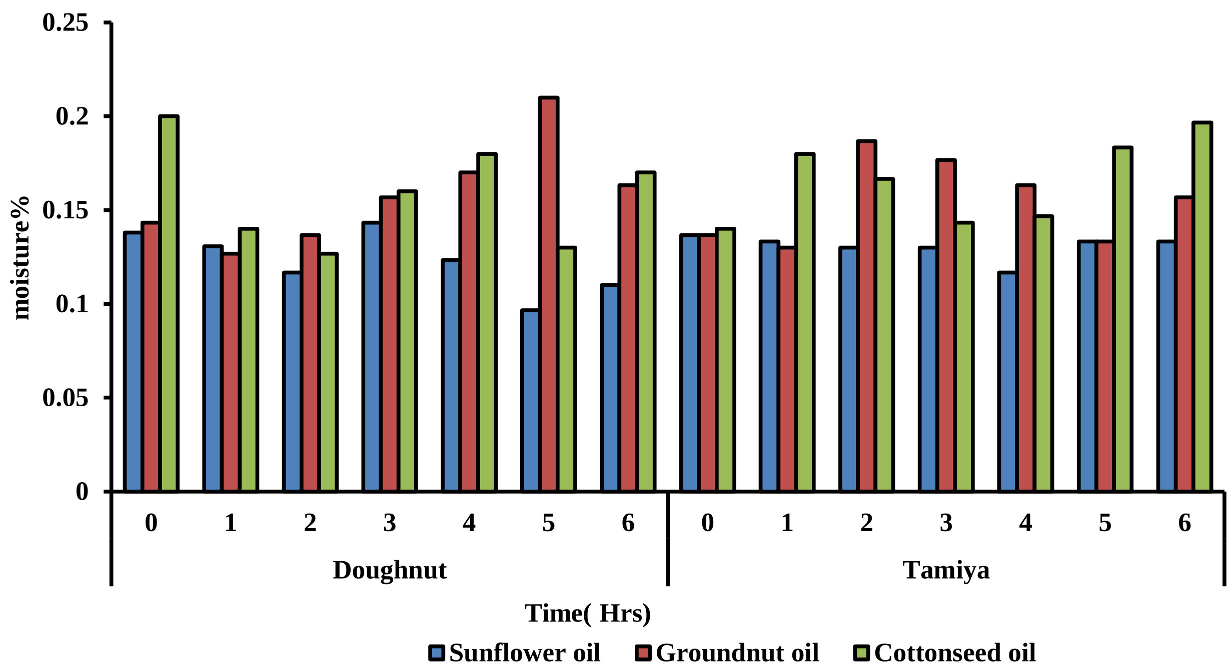

Figure 1: Moisture content

Relative specific gravity (RSG)

Figure2 revealed that, there was a significant ($P \leq 0.05$) difference of the relative specific gravity among the different oil type. Regarding doughnut frying, cottonseed, groundnut and sunflower oils were RSG of 43.36%, 43.25% and 43.34%, respectively. Regarding tamiya frying, cottonseed, groundnut and sunflower oil were RSG of 43.37%, 43.23% and 43.34%, respectively. Continuous frying for several hours process had significant ($P \leq 0.05$) differences on the RSG of oils. This may be attributed to the fact that, the oil absorption decrease as the specific gravity of the food increases. An increase in specific gravity of the food generally means an increase in the moisture content. Similar observation was noticed by (Abuzaid, 2008). Higher moisture content produces larger quantity of steam, which reduces the oil-to-food contact time (Yousif, 2014).

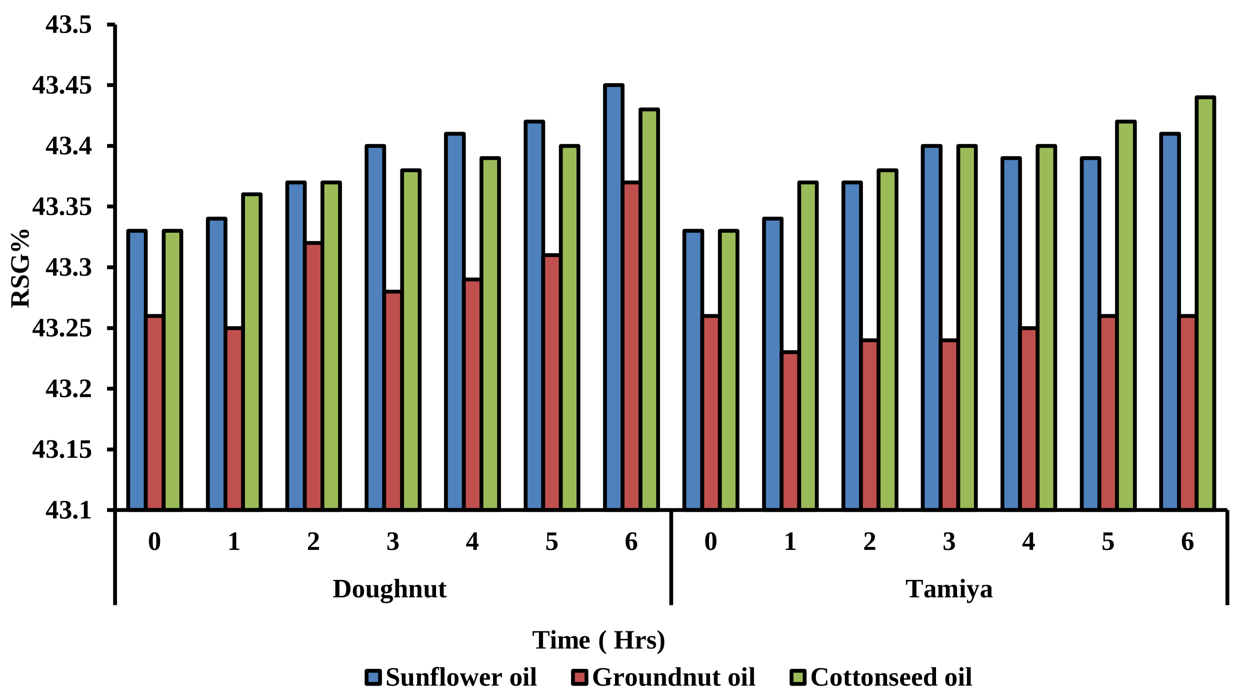

Figure 2: Relative Specific gravity

Relative Index (RI)

Figure3, illustrated that, the differences of oil type and continuous frying for several hours process of doughnut and tamiya had no significant ($P \geq 0.05$) effected on the RI. The mean of RI for different oils which frying doughnut and tamiya was ranged between 1.46. (Jar Elnabi, 2001) reported the RI of crude sunflower oil as1.47. (Bashir,1986) found that, the RI of three fresh sunflower oil grown in Sudan is 1.47, 1.47 and 1.47. The current results on line with that reported by AOAC (2009) who reported that, RI varies with the specific gravity. Regarding re-frying process for several hours. These may be attributed to, the production of oxidation and polymerization products (Yousif, 2014). Generally, re- frying process had no significant (P≥0.05) influence on relative index of oil. The present result agreed with reported result (Abuzaid, 2008).

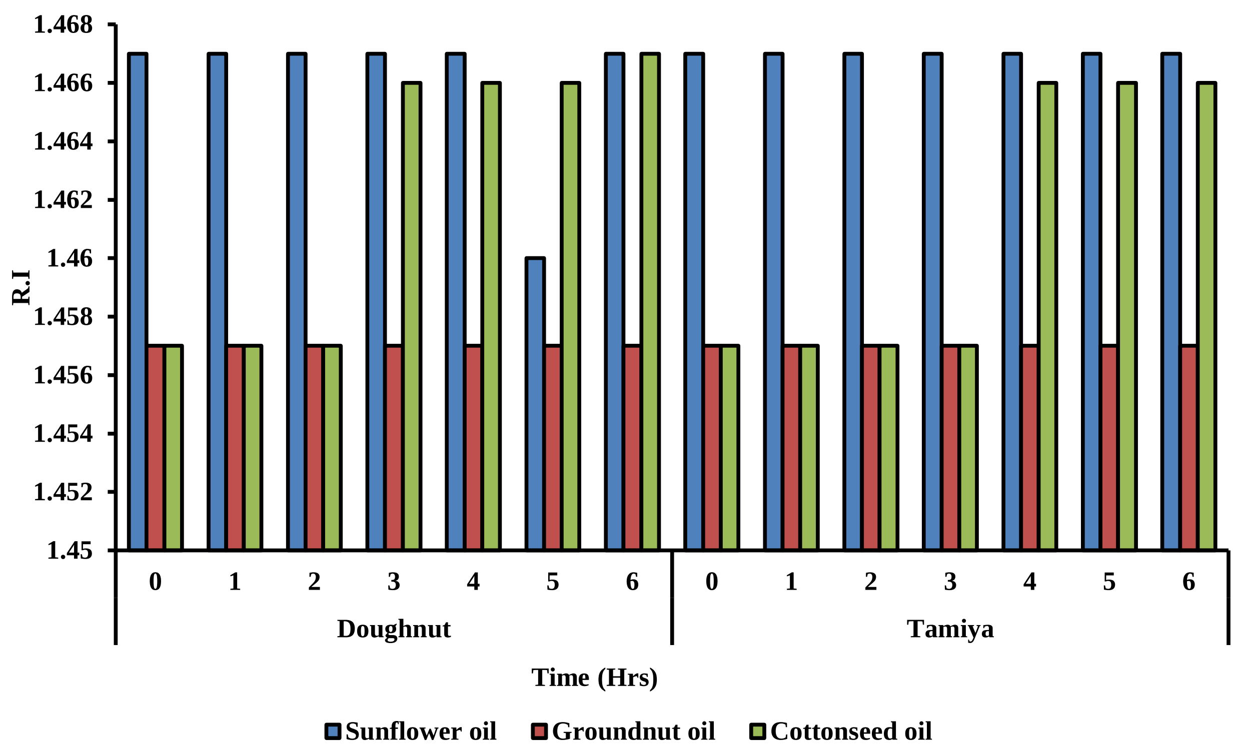

Figure 3: Relative Index

Viscosity

Figure4 demonstrated that, viscosity of frying oil significant (P≤ 0.05) influence with oil type and continuous frying process for several hours. Concerning frying doughnut, sunflower, groundnut and cottonseed oils were viscosity of 20.22, 23.37 and 21.52cp, respectively. Regarding continuous frying process for several hours of doughnut, viscosity of oils increased as frying continuous (Balla, 2001) found that the viscosity of groundnut ranged between 46.0 and 52.43 cp at 30°C. Generally, viscosity of different oils increased as continuous frying process. Similar increment was noticed by by (Ibrahim, 2014). (Yousif, 2014) reported that, the viscosity of groundnut oil increased the range was between 35.40 - 41.17 sec/ml during the 20th cycle of frying oils. (Balla, 2001) reported that the viscosity of oil decreased with temperature rise while saturation and large molecules such as along chain fatty acids or polymerized oil increased the viscosity.

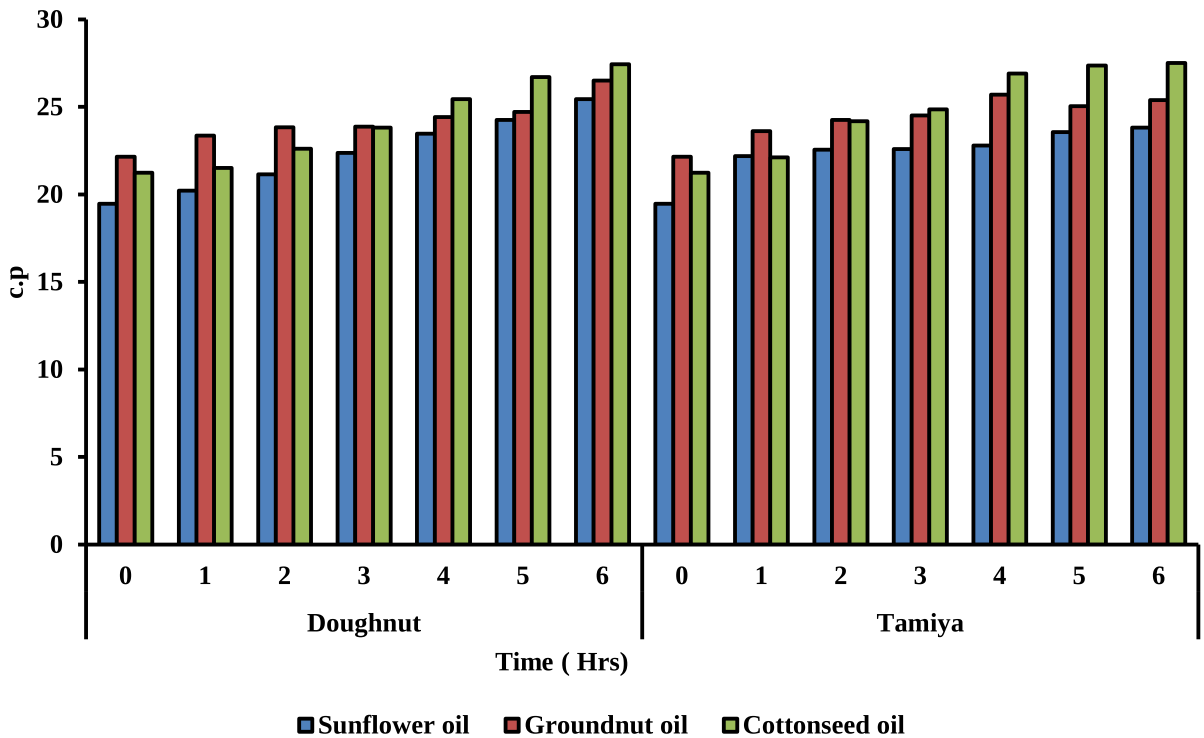

Figure 4: Viscosity

Colour

Yellow colour

Figure5 shows that, there were significantly (P≤0.05) differences of yellow colour among the different three oils. Sunflower oil had yellow colour of 10.00, groundnut and cottonseed oil had yellow colour of 46.60 and 42.30 respectively. (Mohammed *et al.*, 1998) found that, sunflower oil had yellow colour with mean of 44.30. Sunflower oil high significantly (P≤0.05) differences yellow colour 10.00, while, groundnut and cottonseed oil had yellow colour of 46.60 and 46.30, respectively. These variations could be attributed to the fact that, the natural colour in vegetable oils is differences due to presence of the natural pigments or of their decomposition and their companying substance e.g. Zanthophyll and the colour substances related to them as reported

(Ibrahim, 2014). Continuous frying for several hours of the oil had no significant (P≥0.05) influence on yellow colour. On line, (Yousif, 2014) found that, colour of cottonseed oil was rabidly increased and change to darker than that of sunflower oil. (Ahmed, 2002) reported that, re-frying process had significantly (P≤0.05) influence on yellow colour. Furthermore, carotenoid compounds are responsible for yellow fraction in oil as stated (Avci, 2015).

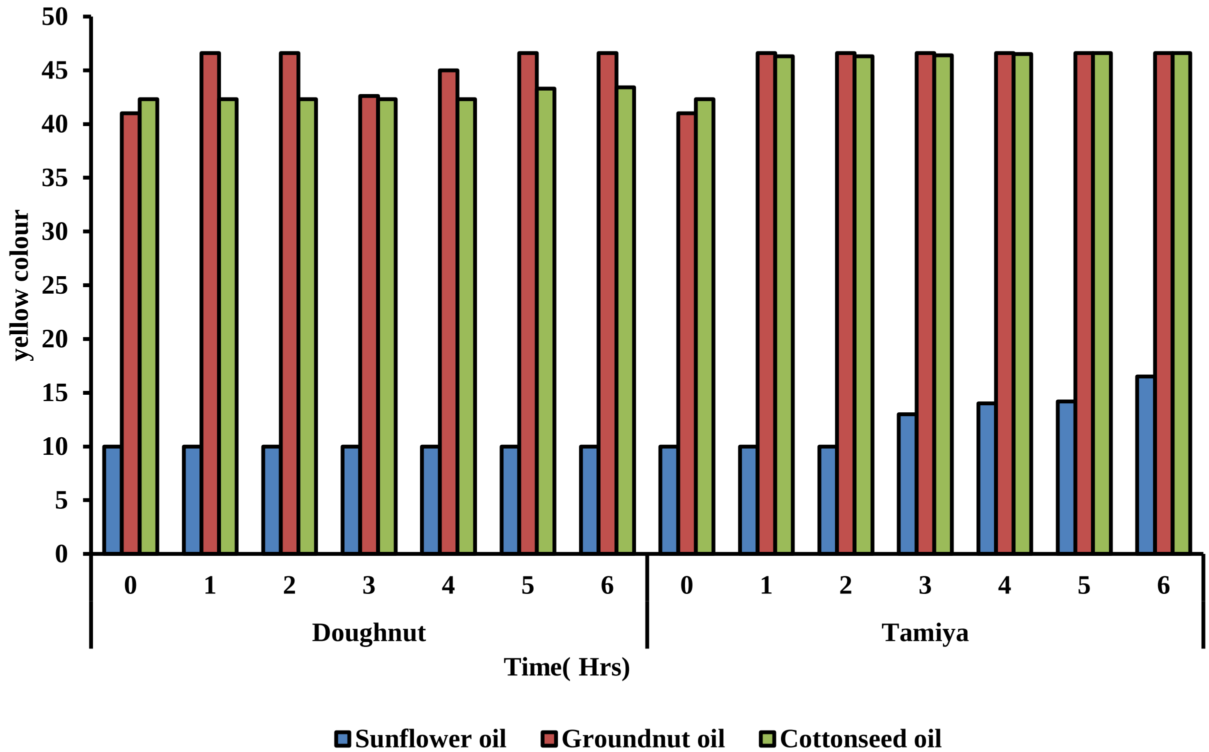

Figure 5: Yellow colour

Red colour

Figure6, shows that, red colour significant (P≤0.05) influence by oil type and continuous frying for several hours process. Sunflower oil had stable red colour 1.00 throughout the frying process of doughnut and tamiya. Cottonseed oil was a stable red colour 5.00 during the continues frying process of doughnut, while it increased from 4.00 to 5.00 for frying tamiya. (Yousif, 2014) found that, colour of groundnut oil was increased as number of frying tamiya cycle increase. In addition, (Abuzaid, 2008) reported that, change in colour of oils during frying is a complex process where components of oils, such as pigment and fried food are involved. This is the main cause of darkening of oil with frying time.

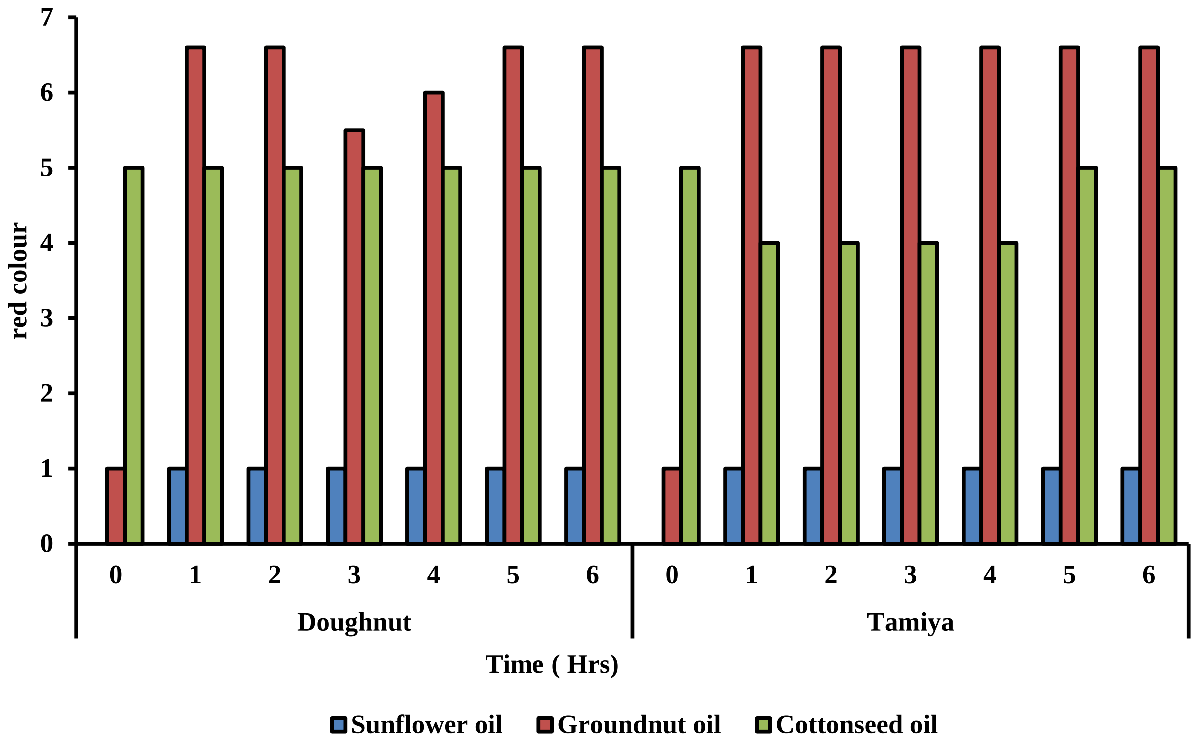

Figure 6: Red color

FFAs

Significant (P≤0.05) differences of FFAs were noticed among the sunflower, groundnut and cottonseed oils. figure7 showed that FFAs was reported for groundnut oil was 0.580 %, cottonseed oil was 0.233 % and sunflower oil was 0.310% FFS. Higher free fatty acids of cottonseed oil were 0.08% recorded by (Hasson, 2012). In contrast, (AbdAlla, 2004) found that, FFAs of cottonseed oil were 0.11%. The FFA of groundnut oil in the present study was higher than that result obtained by (AbdAlla, 2004) who found hat, FFA of groundnut oil was 0.06% .It worth noted that, all these values within Codex standard who recommended that FFA of crude oil must be not exceed 2%. The present results showed that FFAs increased as number of frying cycle increased. (Yousif, 2014) reported that, FFA increased significantly (P≤0.05) with the prolongation of frying process. In the case, the hydrolysis was triggered by water vapor escaping from the doughnut and tamiya being fried. (Hasson, 2012) reported that cottonseed oil initially had FFA 0.08% and finally after 70 hr of frying tamiya reached 2.54%. In addition, FFA mainly from hydrolysis of triglyceride and partly from cleavage and oxidation of fatty acids double bond (Avci, 2015).

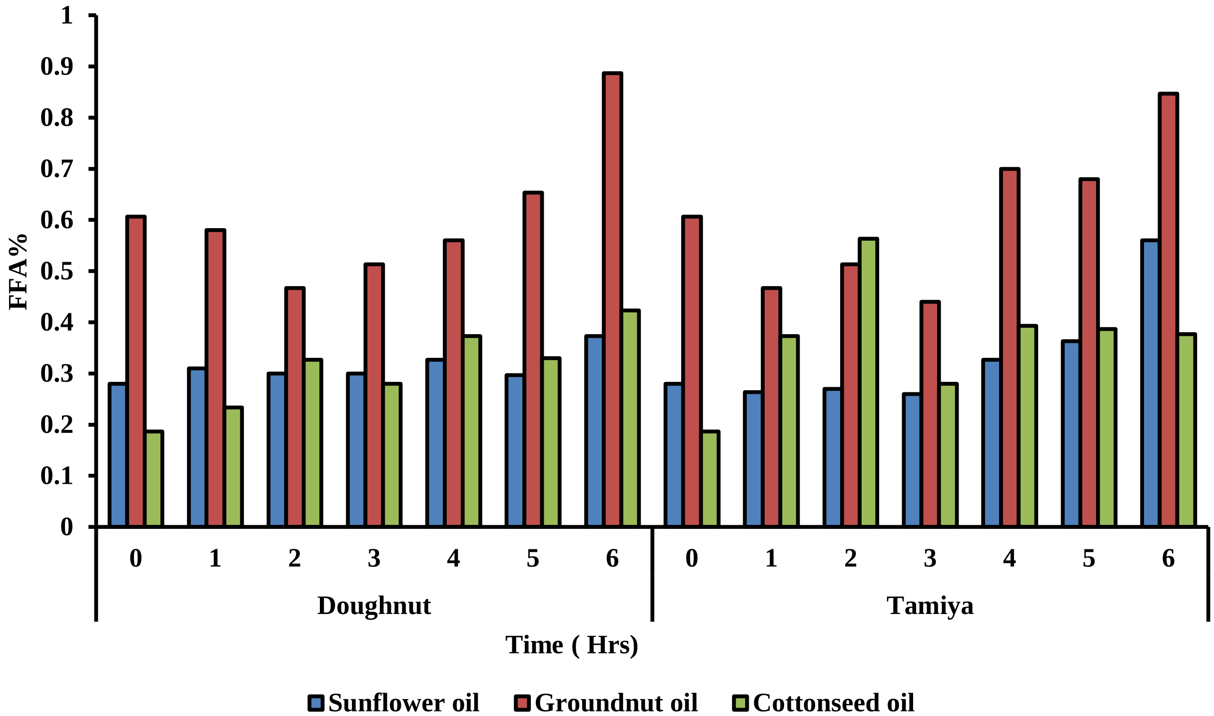

Figure 7: Free Fatty Acids

Peroxide Value

Figure8, illustrated that, the PV of oil samples significant ($P \leq 0.05$) affected by oil type. The PV of sunflower oil, groundnut oil and cottonseed oil were 17 (meq O_2/ kg oil), 5.15 (meq O_2/ kg oil) and 14.37 (meq O_2/kg oil) respectively. These could be attributed to, the present of high polyunsaturated fatty acid levels, mostly linoleic acid as the characteristic of sunflower oil, since it is highly inclined to oxidation when compared to other oils as reported by (Avci, 2015). Lower PV was reported by (AbdAlla, 2004) who found that, sunflower, groundnut and cottonseed oils were PV of 1, 5 and 7 (meq O_2/ kg oil), respectively. The statistical analysis showed that number of frying cycles had significant ($P<0.05$) effect on P.V of all oils under investigations. Peroxide value of sunflower oil increased from 17.36 (meq O_2/ kg oil) at the one hour to 25.18 (meq O_2 / kg oil) at sixth hour of continuous frying process. P.V of groundnut oil increased from 5.15 (meq O_2/ kg oil) at the hour one of continuous frying to 16.55 mq/kg at hour sixth of continuous frying process. PV of cottonseed oil increased from 14.37 (meq O_2/ kg oil) at the hour one of continuous frying to 16.65 (meq O_2/kg oil) at hour sixth of continuous frying process. Similar noticed was found by (Yousif, 2014) who obtained that, PV of cottonseed oil increased from 4.33 at initial time of frying then, it reach to 10.47 (meq O_2/kg oil) at cycle 5 of re-frying

Tamiya. In addition, PV is applicable for the early stages of lipid oxidation. During the course of oxidation, PVs reaches a peak and then decline.

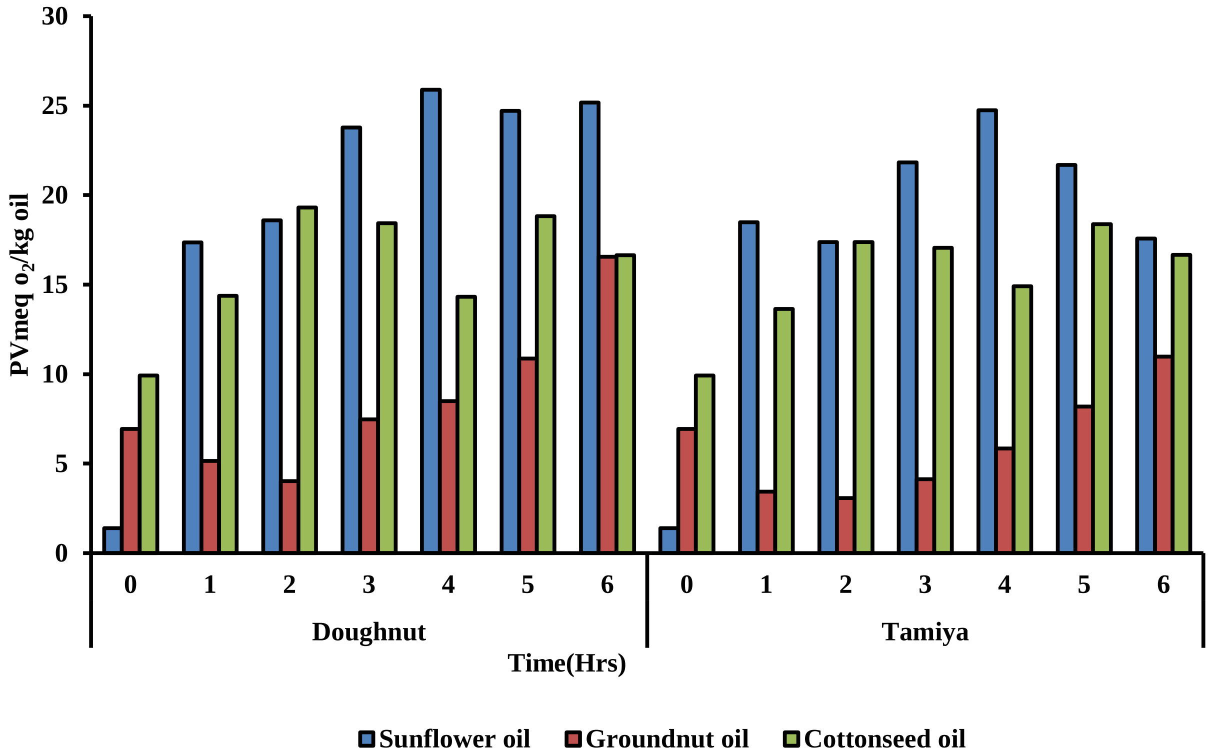

Figure 8: Peroxide Value

Dienes

Figure9, indicated that, significant ($P \leq 0.05$) differences in different oil used throughout frying for process. At the first hour the value of dienes recorded by cottonseed oil, sunflower oil and groundnut oil were 12.83, 12.59 and 9.11, respectively. (Ibrahim, 2014) found that, sunflower oil, groundnut and cottonseed oil were recorded dienes of 10.52, 4.72 and 1.06, respectively. Continuous frying process had effect on dienes of oil significantly ($P \leq 0.05$). A significant increment in Dienes values was noticed as frying process continued up to 6 hours. Sunflower oil at the second, third, fourth, fifth and sixth hours had dienes of 14.53, 17.56, 23.59, 33.78 and 20.56, respectively. Similar increment was noticed for groundnut and cottonseed oil. The results were matched with (Ibrahim, 2014) who reported that, dienes of groundnut increased from 5.90 to 21.81, while, dienes of cottonseed was decreased from 18.45 to reach 10.00 at end cycle of frying.

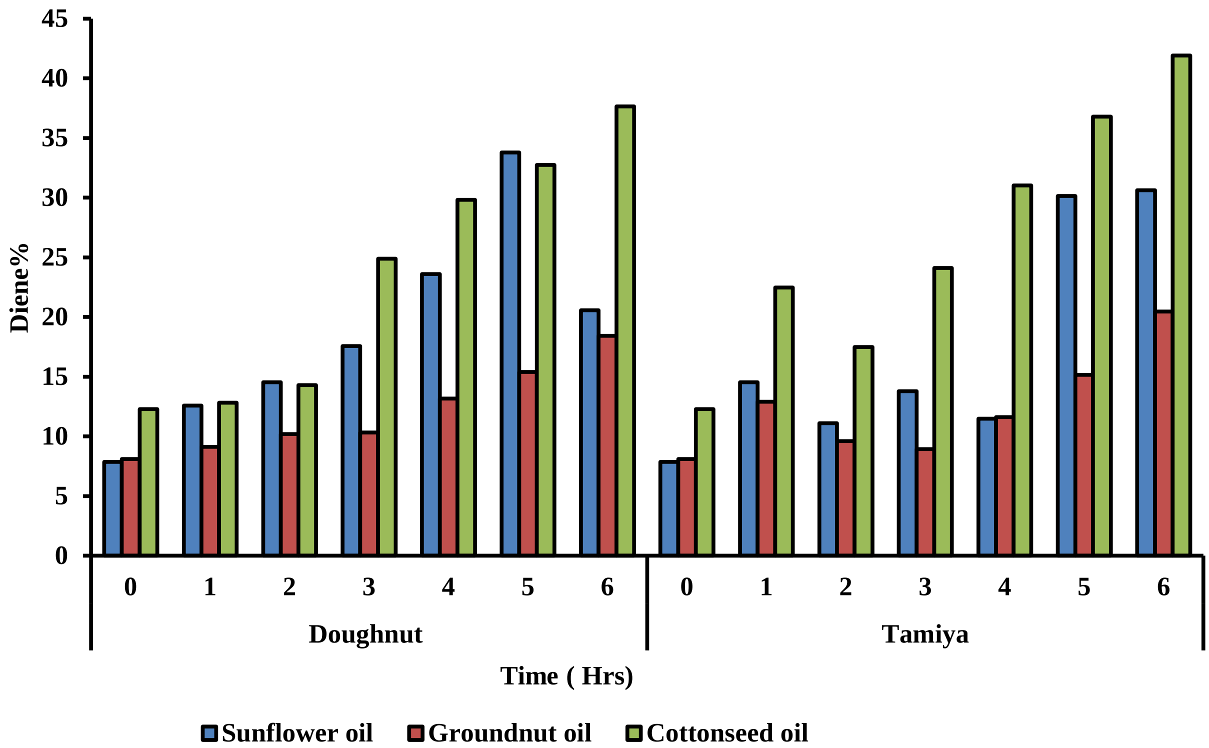

Figure 9: Diene

Trienes

Figure10 shows that, significant differences of trienes were observed among three oils. The fried of doughnut show that dienes of cottonseed oil, groundnut oil and sunflower oil were 4.98, 1.25 and 2.21, respectively. (Ibrahim, 2014) found that, cottonseed oil and groundnut oil had trienes of 1.00 and 4.22, respectively. Generally, trienes was increased throughout continuous frying process. Trienes of sunflower oil was increased from 2.21 to 11.71 then, it fall suddenly to reach 4.14. Trienes of groundnut oil was increased from 1.25 to 3.94. Trienes of cottonseed oil was increased from 4.98 to reach 29.20 at the hour sixth of frying process. The present results agreed with that noticed by (Ibrahim, 2014) who observed that, conjugated trienes increased throughout re-frying from 4.02 to reach 5.23 at end of frying cycle. In addition, (Yousif, 2014) reported that, oxidation of fatty acids lead to changes in conjugated dienes and trienes.

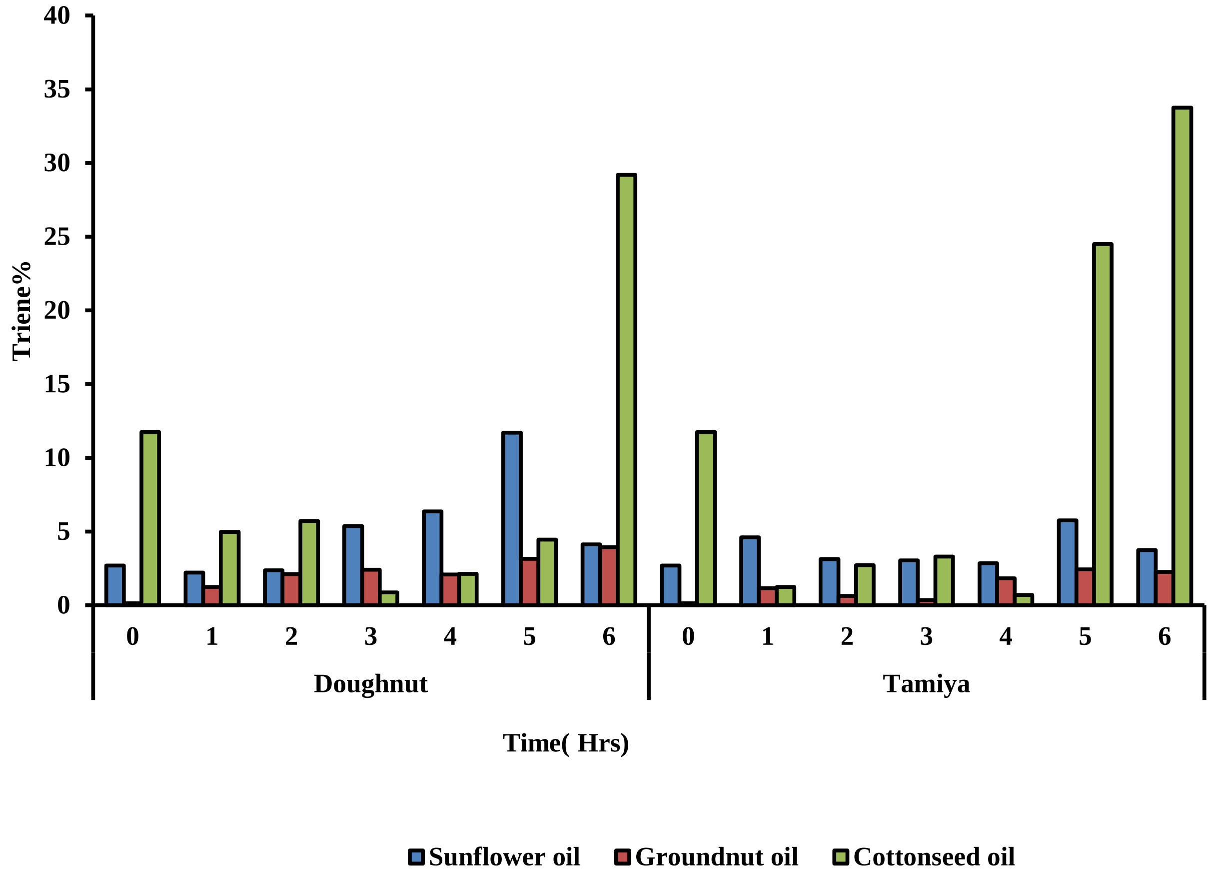

Figure 10: Triene

Conclusions

Physicochemical characteristics of some Sudanese oils in terms of': Moisture content, RSG, RI, viscosity, yellow and red colour, FFAs, PV, conjugated dienes and trienes are significantly ($P \leq 0.05$) influenced by oil type. Continuous frying process of the doughnut and tamiya had significant ($P \leq 0.05$) differences on the relative specific gravity of oils, in contrast, refrying had no significant ($P \geq 0.05$) on refractive index. Viscosity of oil increased as frying continuous. The continuous frying process had significant effect ($P < 0.05$) on FFA, PV, dienes and trienes. The finding of this study was highly reliable and showed that the continuity of frying process affects the quality of oils.

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