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# Effects of Chicken Frying on Soybean, Sunflower and Canola Oils

M. Younis Talpur[1], S. T. H. Sherazi[1]*, S. A. Mahesar[1] and Aftab Ahmed Kandhro[1,2]

[1]*National Center of Excellence in Analytical Chemistry University of Sindh, Jamshoro 76080, Pakistan*
[2]*Pakistan Council of Scientific and Industrial Research Laboratories, Karachi 75280, Pakistan*

**Abstract**

Consequences of discontinuous chicken frying on some important parameters of soybean (SBO), sunflower (SFO) and canola oil (CLO) at constant temperature (190 $^0$C) for 12h were examined. The quality parameters such as fatty acid composition (FAC) with special emphasis on *trans* fatty acids (TFA's), free fatty acids (FFA's), iodine value (IV) and peroxide value (PV) of soybean, sunflower and canola oils were evaluated by taking out the oil samples from the fryer at an interval of 2 h. The total *trans* fatty acids increased during frying of chicken in the range of (0.77-1.67, 1.02- 2.62 and 1.29-3.14 %) in SFO, SBO and CLO. Other chemical parameters such as free fatty acids (0.03-0.78, 0.05-0.49 and 0.19- 1.47 %), peroxide value (1.51-3.04, 2.11-6.07 and 2.90-8.02 meq/kg) increased where as iodine value (154.21-140.69, 134.50 and 116.10-99.70 g/100g) was decreased with respect to time of frying in SFO, SBO and CLO, respectively.

***Keywords:*** chicken meat, frying, chemical parameters, fatty acid composition

## Introduction

Deep fat frying is a food preparation process esteemed by consumers for the pleasurable taste and texture goes by on to food. This process involves both mass transfer, mainly represented by water loss and oil uptake, and heat transfer [1]. In deep fat frying, thermoxidative and hydrolytic reactions take place that adversely effect the quality of the frying oil [2-4]. Fried foods are admired all the way through the world contributing to daily total energy intake [5, 6]. During deep fat frying of foods, the fat is heated rapidly to the position where water is vaporized, and the ensuing steam causes a boiling deed in the oil, following an increased oxidation of the oil with the establishment of hydroperoxides. The repetitive use of oil most likely will affect the shelf life of fried foods due to the increase of rancidity in the frying oil [7]. The continual or repeated use of oil at high temperature results in several oxidative, polymerization and thermal degradation reactions causing changes in its physical, chemical, dietary and sensory properties [8]. Many of the degradation products of the edible oils are detrimental to health as these destroy vitamins, inhibit enzymes and could cause mutations or gastrointestinal irritations [9].

*Corresponding Author Email: sherazi@yahoo.com

The rate of oxidation is reported to be quicker in the case of the oil used to fry chicken. Chicken fats are mostly unsaturated and during frying, these will melt and seep out into the frying medium, where rapidly oxidized [10]. Repetitive use of oil at high temperature in the presence of wetness and air causes thermal degradation of oil. Deep fat frying can lead to formation of *trans* fatty acids and changes other chemical parameters like free fatty acids, peroxide value and iodine value of the fat used. The extent of deep frying can result in the formation of varied amounts of *trans* fatty acids depending upon the frying temperature and the oil used [11, 12]. The interest in *trans* fatty acids has increased in days gone by few years, because of the relation among *trans* fatty acid intake and the risk of cardiovascular, chronic respiratory, neural and degenerative diseases and certain cancer [13-15].

The fatty acid composition of the frying oil is an essential factor affecting fried food taste and its stability. Nonetheless, most *trans*-fatty acids in these foods have been considered to come from the oil used and not from the process itself [16]. The changes in quality during frying are of extreme importance, as

frying oil is immersed by the fried food and constitutes an important part of the diet.

The aim of present study was to identify the quality changes occurring during deep chicken frying in pure SFO, SBO and CLO, specially fatty acid composition with particular allusion to *trans* fats among other chemical characteristics like FFA, PV and IV.

## Materials and Methods

### *Chemicals, reagents and samples*

All reagents, chemicals and solvents used were from E. Merck (Darmstadt, Germany). *Trans* and *cis* fatty acid methyl esters (FAMEs) standards (GLC 481-B and 607) were purchased from Nu-Check Prep, Inc (Elysian, MN). Refined, bleached and deodorized soybean, sunflower and canola oils were purchased from the commercial sources in Hyderabad, Pakistan.

### *Frying process*

Fresh chicken pieces were purchased from the local market of Hyderabad, Pakistan. The pieces were scrupulously washed, cleaned and dried for 30 min. The west point deep fryer (E-2016) was used for execution frying operations. The capacity of fryer was 3-L with thermostatic temperature control from 0 to 190 $^0$C. The batches of 200 g of chicken pieces were fried at 15 min intervals for 6 h per day for successive two days at constant frying temperature (190 $^O$C) in three different oils (SFO, SBO and CLO). At the end of each 2 h frying, about 25 ml of the frying oil was removed and filtered into a screw-cap vial and punctually stored in the dark at 4 $^O$C until further analyses. The volume of oil was not replenished during the frying operation. The total six samples were drawn from each three different oils (SFO, SBO and CLO) during twelve hours of chicken frying.

### *Parameters studied*

The fatty acid composition and other chemical parameters like free fatty acids (FFA's), peroxide value (PV) and iodine value (IV) were determined for fresh and fried oil samples.

### *Determination of fatty acids profile and GC-MS conditions*

For the determination of fatty acid profile of fresh and used commercial oil samples, FAMEs were prepared using standard IUPAC method 2.301 [18]. The GC-MS analysis of FAME was carried out using an Agilent Technologies gas chromatograph (GC-6890 N, Little Fall, NY, USA) equipped with an Agilent autosampler 7683-B injector and MS-5975 inert XL Mass selective detector. Analytical separation was achieved using Rt-2560 Biscyanopropylsiloxane capillary column (100m x 0.25mm i.d x 0.25 *micron* film thickness) for the separation of fatty acid methyl esters. The initial temperature of 140 $^0$C was maintained for 2 min, raised to 230 $^0$C at the rate of 4 $^0$C/min, and kept at 230 $^0$C for 5 min. The split ratio was 1:50, and helium was used as a carrier gas with a flow rate of 0.8 ml/min. The injector and detector temperatures were 240 and 260 $^0$C, respectively. The mass spectrometer was operated in the electron impact (EI) mode at 70 eV; with an ion source temperature of 230 $^0$C, a quadrupole temperature of 150 $^0$C, and a translating line temperature of 270 $^0$C. The mass scan ranged from 50 – 550 *m/z* with an Em voltage, 1035 V. Peak identification of the fatty acids in the analyzed fresh and after frying oil samples was carried out by the comparison with retention times and mass spectra of known standards. Standard methyl esters of myristic, palmitic, stearic, oleic, linoleic, linolenic, elaidic, and linolelaidic and linolenelaidic acids were used for the confirmation of GC-MS libraries result.

### *Calculations and statistical analyses*

Two samples of each fresh and frying oil were collected and each sample was analyzed three times. The data obtained were put into Origin 7 program and reported as mean (n = 2 ×3).

### *Free fatty acid*

The Free fatty acid content as % of oleic acid was determined by AOCS Official Method Ca 5a-40. [17].

### *Peroxide value*

The peroxide value was determined by AOCS Official Method Cd 8-53 [17].

### *Iodine value*

The iodine value of the oil is the number of grams of iodine absorbed by 100 grams of the oil determined by Wijs method IUPAC Official Method 2.205 [18].

## Result and Discussion

### *Fatty acid composition*

The fatty acid composition of fresh sunflower (SFO), soybean (SBO) and canola oil (CLO) is shown in Table 1. The saturated fatty acids like palmitic and stearic acids were found in the range of (6.94, 11.33,

4.78 % and 5.90, 4.55, 2.03 %) in SFO, SBO and CLO, respectively. The oleic acid was major monounsaturated fatty acid (MUFA) found in the range of 19.49, 22.24 and 56.89 % SFO, SBO and CLO, respectively. Among the MUFA, elaidic acid was also detected in considerable amounts at 0.79, 1.02 and 1.29 % in SFO, SBO and CLO, correspondingly. The polyunsaturated fatty acids (PUFA) like linoleic, linoelaidic, linolenic and linolenelaidic acid were present at SFO, SBO and CLO in the range of 64.87, 54.67, 24.33 %, 0.01, 0.01, 0.03 %, 1.90, 6.07, 10.61 % and 0, 0.01, 0.04 %, respectively.

***Table 1.*** **Fatty acid profile (%) of fresh Soybean, Sunflower and Canola Oils.**

| Fatty acids | SFO | SBO | CLO |
|---|---|---|---|
| ***C*14:0** | 0.10±0.003 | 0.10±0.001 | ND |
| ***C*16:0** | 6.94±0.14 | 11.33±0.56 | 4.78±0.23 |
| ***C*18:0** | 5.90±0.10 | 4.55±0.19 | 2.03±0.06 |
| ***C*18:1cis** | 19.49±0.76 | 22.24±0.28 | 56.89±1.53 |
| ***C*18:1 n- 9 *trans*** | 0.79±0.02 | 1.02±0.02 | 1.29±0.06 |
| ***C*18:2 n 9,12cis** | 64.87±1.94 | 54.67±0.98 | 24.33±0.48 |
| ***C*18:2 n- 9,12 *trans*** | 0.01±0.00 | 0.01±0.00 | 0.03±0.00 |
| ***C*18:3 n 9,12,15 cis** | 1.90±0.06 | 6.07±0.17 | 10.61±0.26 |
| ***C*18:3t n 9,12,15 *trans*** | ND | 0.01±0.00 | 0.04±0.00 |

*Values are Mean ± SD for triplicate determinations.
*SFO= Sunflower oil, *SBO= Soybean oil, *CLO= Canola oil.
*n =indicates the position of double bond, *ND= Non detected

Table 2. shows the fatty acid profile of oil samples after lab frying of chicken from 2-12 hours at constant temperature 190 °C. It was observed that saturated fatty acids were increased during frying of chicken. The highest amount of palmitic and stearic acid 2.14 and 0.90 % was observed in CLO after 12 hours of frying. The myristic acid was also increased in the range of 0.10-0.56, 0.21-1.03 % for SFO and SBO, respectively except CLO. Along with the unsaturated fatty acids, oleic acid (C18:1 cis-9) was decreased in the range of 19.44-19.17, 22.23-22.12 and 56.86-56.63 % in SFO, SBO and CLO. Elaidic (C18:1 *t*), linoelaidic (C18:2 *t-t*) and linolenelaidic (C18:3 *t-t-t*) were determined in all samples. The maximum elaidic, linoelaidic and linolenelaidic acids were determined in CLO 1.69, 0.09 and 0.04 % after 12 hours of frying with chicken. The levels of *trans* fatty acids in the 12 hours of chicken frying in SFO, SBO and CLO oils were significantly increased with compared to their initial frying oil samples. The results of the previous studies in which it was reported that repeat use of frying oils may increase the TFA concentration due to the exchange of fatty acids between the fried food and the oil as well as the high temperature and prolonged frying process [19, 20] support the outcome of present work. PUFA in all analyzed oils were decreased during frying of chicken. The major decrease in percentage of linoleic and linolenic acid were observed for SFO (2.62, 17.58 %), SBO (4.33, 31.13 %) and CLO (5.87, 32.79 %) from initial to last frying cycle. The highest amount of linoleic and linolenic acids 5.87 and 32.79 % were decreased in CLO. The decrease in unsaturation may be attributed to the destruction of double bonds by oxidation and polymerization [21].

Figure 1 (A) and (B) shows the plots of frying time versus their respective level of linoleic and linolenic acids. The decreasing trends of linoleic and linolenic acids were observed for SFO, SBO and CLO from 0 to 12 hours frying. Three different investigated oils behave the similar style which is very clear from their Figure 1 (A) and (B). The regression results for these plots are placed in Table 3 (A) and (B). The over all decreasing trend of linoleic and linolenic acids for SFO, SBO and CLO from 0 to 12 hour frying were 2.45, 4.03 and 5.64 %, and 17.11, 29.27 and 31.37 %, respectively. Therefore, comparatively high decline was observed (5.64 and 31.37 %) for the both linoleic and linolenic acid in canola oil.

Data typified in Table 4, shows the groups and fatty acid ratios of SFO, SBO, and CLO oils during frying of chicken. From the results, it is very clear that with the increase of frying time, total saturated fatty acids were increased, while unsaturated fatty acid were decreased. The maximum increase percentage of saturation after 12 hour frying was determined at 11.59, 17.77 and 47.72 % in SFO, SBO and CLO, respectively. Similarly, decrease in percentage of unsaturation was observed at 1.72, 3.38 and 3.48 % in SFO, SBO and CLO, respectively. The highest percentage of total saturation was increased in CLO and also total unsaturation decreased in CLO. Chicken fats are mostly unsaturated fatty acids, during frying these fats was melt and leach out into the frying medium where they rapidly oxidized. This degradation in the lipids takes place mainly in PUFA which are essential nutrients in human tissue progress [22]. As per report [23], the most significant decreases >25 % occur in the most highly polyunsaturated fatty acids. In this study we have observed that maximum percentage of PUFA was

***Table 2*. Fatty acid composition (%) of Sunflower, Soybean and Canola oils after frying of Chicken with different hours at 190 $^0$C.**

| Fatty acids | Hours of Frying | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | | | 4 | | | 6 | | | 8 | | | 10 | | | 12 | | |
| | SFO | SBO | CLO | SFO | SBO | CLO | SFO | SBO | CLO | SFO | SBO | CLO | SFO | SBO | CLO | SFO | SBO | CLO |
| ***C*14:0** | 0.10 ±0.00 | 0.21 ±0.01 | ND | 0.16 ±0.00 | 0.29 ±0.00 | ND | 0.23 ±0.01 | 0.46 ±0.02 | ND | 0.33 ±0.01 | 0.69 ±0.02 | ND | 0.49 ±0.01 | 0.84 ±0.03 | ND | 0.56 ±0.02 | 1.03 ±0.02 | ND |
| ***C*16:0** | 6.97 ±0.27 | 11.41 ±0.30 | 4.91 ±0.14 | 7.09 ±0.09 | 11.59 ±0.11 | 5.16 ±0.15 | 7.18 ±0.28 | 11.74 ±0.48 | 5.31 ±0.11 | 7.34 ±0.13 | 11.80 ±0.48 | 6.00 ±0.20 | 7.48 ±0.10 | 12.05 ±0.36 | 6.32 ±0.08 | 7.63 ±0.32 | 12.64 ±0.39 | 7.05 ±0.33 |
| ***C*18:0** | 6.01 ±0.16 | 4.64 ±0.04 | 2.11 ±0.03 | 6.07 ±0.09 | 4.70 ±0.08 | 2.19 ±0.02 | 6.14 ±0.06 | 4.77 ±0.34 | 2.43 ±0.04 | 6.18 ±0.40 | 4.88 ±0.07 | 2.54 ±0.03 | 6.21 ±0.18 | 5.03 ±0.07 | 2.90 ±0.05 | 6.25 ±0.10 | 5.31 ±0.06 | 3.01 ±0.06 |
| ***C*18:1 n- 9cis** | 19.44 ±0.50 | 22.23 ±0.46 | 56.86 ±0.62 | 19.40 ±0.38 | 22.19 ±0.22 | 56.90 ±2.27 | 19.32 ±0.21 | 22.19 ±0.57 | 56.84 ±2.72 | 19.25 ±0.57 | 22.18 ±0.22 | 56.79 ±1.19 | 19.22 ±0.30 | 22.14 ±0.39 | 56.7 ±1.30 | 19.17 ±0.88 | 22.12 ±0.68 | 56.63 ±1.69 |
| ***C*18:1 n- 9*trans*** | 0.84 ±0.01 | 1.06 ±0.04 | 1.38 ±0.02 | 0.94 ±0.01 | 1.13 ±0.05 | 1.52 ±0.07 | 1.06 ±0.01 | 1.53 ±0.04 | 1.69 ±0.03 | 1.18 ±0.07 | 1.87 ±0.02 | 1.83 ±0.03 | 1.34 ±0.04 | 2.09 ±0.08 | 2.33 ±0.04 | 1.64 ±0.07 | 2.30 ±0.03 | 3.07 ±0.04 |
| ***C*18:2 n 9,12cis** | 64.76 ±1.35 | 54.50 ±1.09 | 24.27 ±1.45 | 64.50 ±1.80 | 54.38 ±0.65 | 24.06 ±0.98 | 64.33 ±1.92 | 53.80 ±0.91 | 23.77 ±0.47 | 64.07 ±1.34 | 53.37 ±2.18 | 23.5 ±0.65 | 63.61 ±2.54 | 53.1 ±0.90 | 23.0 ±0.92 | 63.17 ±1.76 | 52.30 ±1.51 | 22.90 ±0.93 |
| ***C*18:2 n 9,12trans** | 0.01 ±0.00 | 0.03 ±0.00 | 0.05 ±0.00 | 0.02 ±0.00 | 0.02 ±0.00 | 0.07 ±0.003 | 0.01 ±0.00 | 0.03 ±0.00 | 0.07 ±0.003 | 0.01 ±0.00 | 0.05 ±0.00 | 0.08 ±0.00 | 0.02 ±0.00 | 0.06 ±0.01 | 0.10 ±0.03 | 0.03 ±0.00 | 0.07 ±0.00 | 0.14 ±0.001 |
| ***C*18:3 n 9,12,15 cis** | 1.87 ±0.03 | 5.91 ±0.23 | 10.39 ±0.23 | 1.82 ±0.03 | 5.69 ±0.17 | 10.06 ±0.15 | 1.73 ±0.10 | 5.47 ±0.16 | 9.86 ±0.09 | 1.64 ±0.03 | 5.12 ±0.14 | 9.17 ±0.13 | 1.63 ±0.03 | 4.63 ±0.19 | 8.53 ±0.34 | 1.55 ±0.05 | 4.18 ±0.20 | 7.13 ±0.09 |
| ***C*18:3 n 9,12,15 *trans*** | ND | 0.01 ±0.00 | 0.03 ±0.00 | ND | 0.01 ±0.00 | 0.04 ±0.01 | ND | 0.01 ±0.00 | 0.03 ±0.00 | ND | 0.04 ±0.01 | 0.06 ±0.01 | ND | 0.05 ±0.01 | 0.06 ±0.02 | ND | 0.05 ±0.01 | 0.07 ±0.003 |

***Values are Mean ± SD for triplicate determinations**
***SFO= Sunflower oil, *SBO= Soybean oil, *CLO= Canola oil**
***n =indicates the position of double bond, *ND= Non detected**

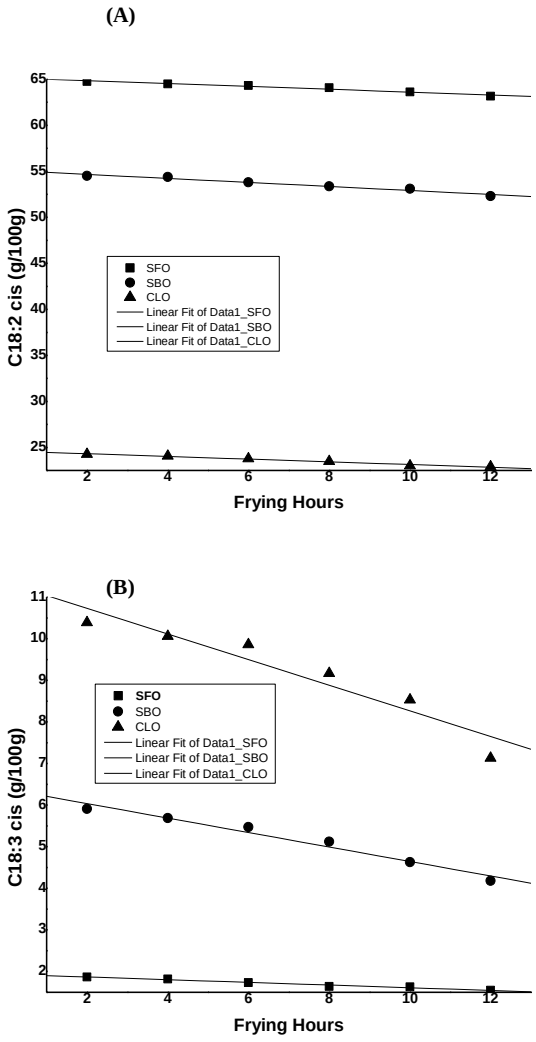


***Figure 1.*** **Decreasing trend of linoleic (A) and linolenic acid (B) for SFO, SBO and CLO from 0 to 12 hours frying.**

degraded in CLO about 13.62 % during frying of chicken, because it contained high amounts of unsaturated fatty acids mostly linolenic acid. The level of total *trans* (C-18:1*t*, C-18:2 *t-t* and C18:3 *t-t-t*) fatty acids in SFO, SBO and CLO oil was determined at 0.77-1.67, 1.02-2.62, and 1.29-3.28 % during chicken frying. The maximum percentage of *trans* fat was increased in CLO 141.17 %, due to the conversion of PUFA mostly high content of linolenic acid. The ratio of saturated/unsaturated FA shows the relation between two major FA groups during chicken frying. As frying time increased the saturated/unsaturated FA ratio was also increased 0.15-0.19, 0.19-0.23 and 0.07-0.11 in analyzed oil samples. The maximum increased percentage was found in CLO 57.14 which indicates a high proportion of saturated FA produced during the frying, while lowest in SFO 13.33. The occurrence of saturated over unsaturated FA, smaller ratio is considered good for nutritional value of the oil. Changes in fatty acid composition of oils during frying, in particular the decrease in linoleic acid content, and the drop in linoleic to palmitic acid ratio, are considered to be valid indicators of the level of deterioration [24, 25]. Monitoring showed that as frying progressed, the linoleic acid (C18:2) content in fried oil decreased gradually and the ratio of linoleic acid to palmitic acid dropped. B. Onal et al [26] reported a decrease in the ratio from 4.04 to 3.49 at the end of frying time. D.P. Houhoula et al [27] reported a reduction of the ratio from 2.39 to 2.03 for cottonseed oil heated at 185 $^0$C for 12 h. Present study also revealed the same decreasing manner in this ratio from 9.35-8.28, 4.82-4.14 and 5.04-3.25 during frying of chicken at 190 $^0$C for 12 h in analyzed oil samples .A highest ratio was dropped in CLO 35.51, while lowest in SFO 11.42. The decrease in ratio of linolenic acid to palmitic acid (0.27-0.20, 0.53-0.33 and 2.22-1.02) was observed in SFO, SBO and CLO, the ratio dropped to 25.92, 37.73 and 54.05 in SFO, SBO and CLO, respectively. The ratio of linolenic acid to palmitic acid is faster reducing than linoleic acid to palmitic acid ratio [28]. These both ratios indicated that CLO is unstable as compared to SFO and SBO with regards to changes in the fatty acid composition.

***Table 3(A).*** **Regression results of Linoleic acid (C18:2 cis) for Sunflower (SFO), Soybean (SBO) and Canola (CLO) oils after 12.**

| Frying oils | Decrease % (2-12 hours) | $R^2$ | Slope | Intercept | SD |
|---|---|---|---|---|---|
| SFO | 2.45 | -0.98298 | -0.15543 | 65.16133 | ±0.12 |
| SBO | 4.03 | -0.98296 | -0.21814 | 55.102 | ±0.17 |
| CLO | 5.64 | -0.98956 | -0.14714 | 24.61333 | ±0.08 |

***Table 3(B).*** **Regression results of Linolenic acid (C18:3 cis) for Sunflower (SFO), Soybean (SBO) and Canola (CLO) oils after 12 hours frying.**

| Frying oils | Decrease % (2-12 hours) | $R^2$ | Slope | Intercept | SD |
|---|---|---|---|---|---|
| SFO | 17.11 | -0.98678 | -0.03229 | 1.93267 | ±0.41 |
| SBO | 29.27 | -0.9855 | -0.174 | 6.38467 | ±0.12 |
| CLO | 31.37 | -0.95299 | -0.30829 | 11.348 | ±0.02 |

***Table 4.*** **Groups and ratios between the types of fatty acids from the composition of fresh and after frying of chicken in Sunflower, Soybean and Canola oils with different hours at 190 $^0$C.**

| Samples (Hours) | | Σ SFA | Σ UFA | Σ MUFA | ΣPUFA | Σ TFA | SFA/ UFA | C18:2/ C16:0 | C18:3/ C16:0 |
|---|---|---|---|---|---|---|---|---|---|
| | **Fresh** | 12.94 | 87.06 | 20.28 | 66.78 | 0.80 | 0.15 | 9.35 | 0.27 |
| | 2 | 13.08 | 86.92 | 20.29 | 66.64 | 0.85 | 0.15 | 9.29 | 0.27 |
| | 4 | 13.32 | 86.68 | 20.34 | 66.34 | 0.96 | 0.15 | 9.09 | 0.26 |
| **SFO** | 6 | 13.55 | 86.45 | 20.38 | 66.07 | 1.07 | 0.16 | 8.95 | 0.24 |
| | 8 | 13.85 | 86.15 | 20.43 | 65.72 | 1.19 | 0.16 | 8.73 | 0.22 |
| | 10 | 14.18 | 85.82 | 20.56 | 65.26 | 1.36 | 0.16 | 8.38 | 0.22 |
| | 12 | 14.44 | 85.56 | 20.81 | 64.75 | 1.67 | 0.17 | 7.99 | 0.20 |
| | **Fresh** | 15.98 | 84.02 | 23.26 | 60.76 | 1.03 | 0.19 | 4.82 | 0.53 |
| | 2 | 16.26 | 83.74 | 23.29 | 60.45 | 1.10 | 0.19 | 4.77 | 0.52 |
| | 4 | 16.58 | 83.42 | 23.32 | 60.10 | 1.16 | 0.20 | 4.69 | 0.49 |
| **SBO** | 6 | 16.97 | 83.03 | 23.72 | 59.31 | 1.57 | 0.20 | 4.66 | 0.47 |
| | 8 | 17.37 | 82.63 | 24.05 | 58.58 | 1.96 | 0.21 | 4.45 | 0.44 |
| | 10 | 17.92 | 82.08 | 24.23 | 57.85 | 2.20 | 0.23 | 4.20 | 0.39 |
| | 12 | 18.98 | 81.18 | 24.62 | 56.52 | 2.30 | 0.23 | 3.91 | 0.33 |
| | **Fresh** | 6.81 | 93.19 | 58.18 | 35.01 | 1.36 | 0.07 | 5.04 | 2.22 |
| | 2 | 7.02 | 92.98 | 58.24 | 34.74 | 1.46 | 0.08 | 4.94 | 2.12 |
| | 4 | 7.35 | 92.65 | 58.42 | 34.23 | 1.63 | 0.08 | 4.66 | 1.96 |
| **CLO** | 6 | 7.74 | 92.26 | 58.53 | 33.73 | 1.79 | 0.08 | 3.94 | 1.86 |
| | 8 | 8.54 | 91.46 | 58.62 | 32.84 | 1.97 | 0.09 | 3.65 | 1.54 |
| | 10 | 9.22 | 90.78 | 59.05 | 31.73 | 2.49 | 0.10 | 2.86 | 1.36 |
| | 12 | 10.06 | 89.94 | 59.70 | 30.24 | 3.28 | 0.11 | 2.30 | 1.02 |

### *Free fatty acids*

Other chemical parameters such as free fatty acids (FFA's), peroxide value (PV) and iodine value (IV) of SFO, SBO and CLO oils were also determined. Fig. 2 shows the FFA's (% oleic acid), in chicken frying at fixed temperature for 12 hours. FFA's are formed during oxidation and thermal degradation of unsaturated fatty acids [29], hydrolysis [30], and pyrolysis as a result of the cleavage of triglyceride [31, 32]. It was observed that as frying lengthen; FFA's increased significantly in CLO, SFO and SBO during chicken frying. Higher amount of FFA's was detected in CLO and SFO 1.28, 0.75 %, and less in SBO 0.45 %.

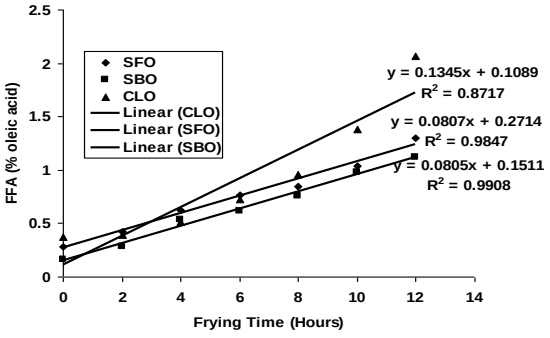


***Figure 2.*** **Change in FFA's with frying time in three oils for chicken product.**

### *Peroxide value*

The peroxide value (PV) is used to measure the peroxides in oils and fats which quantify the primary oxidation [10]. It was observed that after discontinuous 12 hours chicken frying, PV increased significantly in SFO, SBO and CLO with increasing time during chicken frying as showing Fig. 3. Previous studies have also reported increases rapidly in SBO and CLO during frying [33], which may be due to the high amount of linolenic acid in SBO and CLO. Significant increase noticed in CLO and SBO was 5.12 and 3.96 meq/kg, respectively while in SFO it was comparatively low at 1.53 meq/kg.

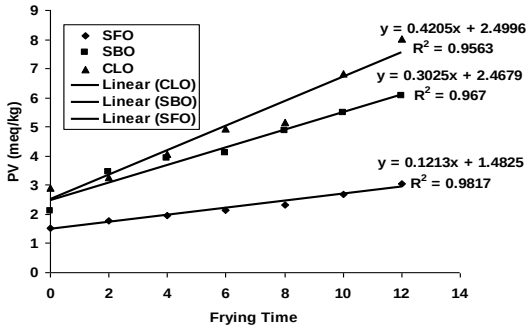


***Figure 3.*** **Change in PV with frying time for chicken product.**

### *Iodine value*

The iodine value (IV) is a quality assessment parameter to measure the unsaturation of oils and fats. Figure 4 shows the effect of 12 hours of chicken frying on the quality of SFO, SBO and CLO. A decreasing trend of 13.52, 14.17 and 16.40 g/100g was observed in SFO, SBO and CLO, respectively. The decrease in iodine value with the increase of frying cycle could be attributed to the changes occurred in fatty acids during frying process [34, 35]. The highest decrease (16.40 g/100g) in iodine value was found in CLO due to the presence of high amount of unsaturated fatty acids.

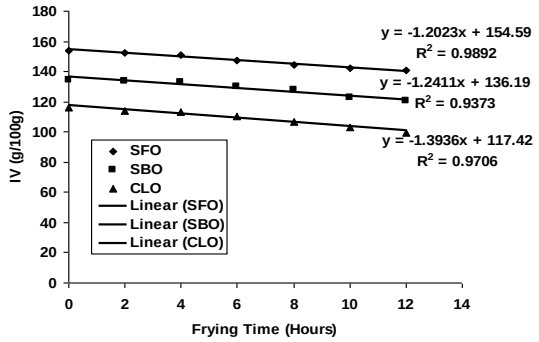


***Figure 4.*** **Evolution of IV (g/100g) in the oils with frying time at 190 °C.**

## Conclusion

Analysis of quality parameters such as fatty acid composition (FAC) with special emphasis on *trans* fatty acids (TFA's), free fatty acid (FFA's), iodine value (IV) and peroxide value (PV) of soybean, sunflower and canola oils revealed that the quality of frying oil started deteriorating with the increase of frying cycles and would be more dangerous for the health point of view when it cross some limits. Frying stability of soybean, canola and sunflower oil under the same conditions of frying were compared. Comparatively sunflower oil was found t o be more stable for chicken frying as compared to soybean and canola oil.

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