

Effect of Deep Frying Process on Degradation of Fatty Acids and Cis-Trans Fatty Acids Isomers of Selected Edible Oils

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Abstract: - Four edible oils namely Sunflower (Su), Groundnut (Gn), Soybean (Sb) and Mustard (Mt) has been taken for comparative study on the deterioration and thermal stability, sold in local market in Pune, India. For analysis two types of oil samples were prepared by treating four edible oils for prolong deep frying. The degradation of sunflower, groundnut, soybean and mustard oil after first frying and second time frying can be determined by FT-IR spectroscopy as well as by Iodine Value. The intensity of absorption at 3009cm^{-1} and 3006cm^{-1} were used for determination of linoleic or linolenic acid and oleic acid respectively. It is noted that due to deterioration of these fatty acids, absorption intensities of the bands in this spectrum decreases. By the FT-IR analysis it is observed that fatty acids composition of groundnut oil remains nearly same with prolong deep frying time. The intensity of absorption band at 966cm^{-1} is used for determination of formation of trans fatty acids. It is seen that intensity of absorption band at 966cm^{-1} increases gradually during prolong deep frying time of each Su, Gn, Sb and Mt oil samples. At 722cm^{-1} it is observed that the intensity of absorption band of each oil samples decreases gradually during prolong deep frying time which may be due to bending out of plane cis $-\text{CH}=\text{CH}-$. IV decreases maximum for Sunflower, Soybean and Mustard in comparison with Groundnut oil. Therefore analysis suggest that Sunflower, Soybean and Mustard oil possessing high PUFA undergoes degradation more on prolong deep frying in

comparison to Groundnut oil. It is indicated that Groundnut oil is more chemically stable than Sunflower, Soybean and Mustard oil during deep frying.

Keywords: *Edible oil, FT-IR, Iodine Value, Fatty Acids*

I. INTRODUCTION

Deep frying is an easy, economical and rapid method of food preparation. Deep frying provides desirable flavor and crunchy taste to the food product. Therefore, it is widely used in commercial and regular household for food preparation. Same frying oil may be repeatedly used at high temperature. During frying, oil undergoes lipid degradation, hydrolysis, oxidation and polymerization. The fatty acid composition is the main factor which affects the quality of fried food such as flavor and its stability. Therefore, it is necessary that these oils should be low level of polyunsaturated fatty acids such as linoleic acid and linolenic acid and high level of monounsaturated fatty acids such as oleic acid and saturated fatty acids. Saturated, monounsaturated and polyunsaturated fatty acid composition of Sunflower, Groundnut, Soybean and Mustard oil is shown in Table No.1. (2)

Table No.1 Fatty Acids Composition of oils

| Type of oil | Saturated | Mono Unsaturated | Poly unsaturated | Oleic acid C18:1(%) | Linoleic acid C18:2(%) | Linolenic acid C18:3 (%) |
|-------------|-----------|------------------|------------------|---------------------|------------------------|--------------------------|
| Sunflower | 11% | 20% | 69% | 14-40 | 48-74 | 0-0.3 |
| Groundnut | 18% | 49% | 33% | 35-69 | 12-43 | 0-0.28 |
| Soybean | 15% | 24% | 61% | 17-30 | 48-59 | 4.5-11 |
| Mustard | 13% | 60% | 21% | 8-23 | 10-24 | 6-18 |

Rashmi Sharma *et al* (8) studied on mustard, groundnut, soybean and safflower oils. Her comparative study suggest that the composition of mustard and groundnut oils do not vary either during long storage or thermal use but composition of soybean and safflower oils disturbed and complete elimination of linolenic and linoleic acids takes place to various reactions. Nazima Siddiqui *et. al.* (5) used IR spectroscopy for identification, analysis, determination of degree of saturation of fatty acids and detection of oils of plant origin.

Measurement of oil degradation should be based on the changes occurred after deep frying. FT-IR spectroscopy has become an excellent analytical tool in the study of edible oil. FT-IR spectroscopy allows the qualitative determination of organic compound. The use of FT-IR spectrum is to determined structural information about molecules. The absorption of each type of bond is regularly found only in certain small portion of the vibrational infrared region. Moreover, FT-IR spectroscopy is an excellent tool for quantitative analysis as the peak intensity in infrared spectrum is the concentration of molecules in the sample. (3) In India, Sunflower (Su), Groundnut (Gn), Soyabean (Sb) and Mustard (Mt) oil are mostly used for deep frying. Su, Sb and Mt has high level of polyunsaturated fatty acids and Gn oil has high level of monounsaturated fatty acids (Table No.1).(2) In the present study, four oils namely Sunflower (Su), Groundnut (Gn), Soyabean(Sb) and Mustard(Mt) were taken to assess their stability against during prolong deep frying. Based on this consideration, FT-IR spectroscopy and Iodine Value were used in order to assess the degradation of Sunflower, Groundnut, Soybean and Mustard oil during deep frying.

II. MATERIALS

Sunflower (Su), Groundnut (Gn), Soybean (Sb) and Mustard (Mt) oils were purchased from local super market, Pune, Maharashtra. Fresh oils (Su, Gn, Sb, Mt) were taken as first set of oil samples. Second set of oil samples (Su-a, Gn-a, Sb-a and Mt-a) were prepared by treating the fresh oil samples at high temperature (200°C) with prolonged deep frying. For this experiment, stainless steel frying pot and electric stove were used. About 1kg of each oil samples was used for frying. The oils were heated at frying temperature (200°C) and allowed to equilibrium at this temperature for 10 min then fried the Udad papad in 10 gm batches in the interval of 5 min. Total frying duration was nearly 40 min. After 24 hr. third set of oil samples (Su-b, Gn-b, Sb-b and Mt-b) were prepared by treating second set of oil samples at high temperature (200°C) with deep frying of Udad papad for same frying period.

III. METHOD

The study was carried out on a Bruker-Tencer-37 FTIR-ATR spectrophotometer capable of covering 4000-400 cm⁻¹.

For FT-IR spectra recording, small quantity of the twelve oil samples in a thin film was used. All spectra, both for pure and after deep frying, were recorded from 4000 to 400 cm⁻¹ and processed with computer OPUS software.

The iodine value (IV) of twelve oil samples was measured by wijs reagent (ISO/CD 3961, 2011) method.

RESULTS AND DISCUSSION

Fig.1 exhibits the FT-IR comparative spectra of fresh, first fried and second fried oil samples of Su, Gn, Sb and Mt at frequency region 4000-400 cm⁻¹. Spectra shows notable difference in the band near 3009cm⁻¹ assigned C-H stretching vibration of the cis-double bond (=CH), near 966 cm⁻¹ assigned *trans* -CH=CH- bending out of plane and 722 cm⁻¹ assigned *cis* -CH=CH- bending out of plane. It is noticed that there are visual difference in the absorption intensity register for fresh, first fried and second fried of Sunflower, Groundnut, Soybean and Mustard oil samples. Absorbance of Su,Gn,Sb and Mt oil samples at 3009 cm⁻¹, 3006 cm⁻¹, 966 cm⁻¹ and 722 cm⁻¹ is shown in table No.2

Table no. 2 Absorbance of Su,Gn,Sb and Mt oil samples at 3009 cm⁻¹, 3006 cm⁻¹, 966 cm⁻¹ and 722 cm⁻¹

| Oil Code | Absorbance at | | | |
|----------|-----------------------|-----------------------|----------------------|----------------------|
| | 3009 cm ⁻¹ | 3006 cm ⁻¹ | 966 cm ⁻¹ | 722 cm ⁻¹ |
| Su | 0.032746 | 0.032087 | 0.027912 | 0.090888 |
| Su-a | 0.032232 | 0.031592 | 0.028274 | 0.090284 |
| Su-b | 0.032063 | 0.031437 | 0.028464 | 0.089658 |
| Gn | 0.023352 | 0.023760 | 0.024301 | 0.079313 |
| Gn-a | 0.023310 | 0.023778 | 0.024577 | 0.07923 |
| Gn-b | 0.023191 | 0.023590 | 0.024959 | 0.079224 |
| Sb | 0.031031 | 0.030281 | 0.03144 | 0.08877 |
| Sb-a | 0.030593 | 0.029858 | 0.031601 | 0.088072 |
| Sb-b | 0.030374 | 0.029653 | 0.032012 | 0.088289 |
| Mt | 0.026272 | 0.026377 | 0.02202 | 0.085213 |
| Mt-a | 0.02599 | 0.02600 | 0.024788 | 0.085318 |
| Mt-b | 0.025742 | 0.025806 | 0.025706 | 0.08412 |

Fig.2 (a,b,c,d) exhibits comparative spectra of Su, Gn, Sb and Mt edible oil samples at frequency region 3050cm^{-1} to 2800cm^{-1} . FT-IR spectra of various oil samples shows that there exists notable difference in the band around 3006cm^{-1} assigned to the C-H stretching vibration of the cis-double bond (=CH) of monounsaturated fatty acids.(14) From this spectra of oil samples, it is seen that the absorbance intensity at 3006cm^{-1} of Su, Sb, and Mt oil samples decreases, but Gn oil samples shows nearly same absorbance after every deep frying may be due to presence of more monounsaturated fatty acids in Gn oil as compared to Su, Sb, and Mt oils.

In Fig. 2 Su, Sb, Gn and Mt oil samples show maximum absorbance at 3009cm^{-1} , due to their composition as vegetable oil contain higher proportion of linoleic or linolenic acids. Absorbance intensity of Su, Sb and Mt oil samples start decrease at 3009cm^{-1} during prolonging deep frying, in comparison with that Gn oil samples show stable absorbance intensity.

The weak absorbance band at 966cm^{-1} in oil samples may be due to the presence of C-H out of plane, deformation of isolated *trans* double bonds or some *trans* conjugated unsaturated fatty acids. From Fig. 3 it is observed that absorbance intensity at around 966cm^{-1} of fresh, first fried and second fried of Gn,Su and Sb edible oil samples increase than Mt oil. This study indicated that during prolong deep frying, as compared to Mt oil, Gn, Su and Sb oils show more changes from *cis* isomer into *trans* isomer of unsaturated fatty acids. This is due to Mt oil contains more monounsaturated fatty acids as compared to Su, Sb and Gn oils.

The absorbance band at 722cm^{-1} observed in oil samples due to the presence of *cis* -CH=CH- bending out of plane. The Fig. 4 shows that absorbance intensity at 722cm^{-1} of various oil samples decreases after every frying time. This may be due to formation of *trans* isomer of unsaturated fatty acids. The present study indicated that during prolong deep frying, Mt oil shows maximum decreases and Sb oil shows minimum decreases of absorbance intensity at 722cm^{-1}

IV. IODINE VALUE

IV of Su, Gn, Sb and Mt oil samples were measured by ISO/CD 3961,2011 (wijs reagent) method. The observed Iodine values are denoted in the Table No. 3. It is observed that fresh oils of Su exhibit higher IV and Gn exhibit lower IV. During prolong deep frying IV of oil samples decrease and it could be attributed to the fact that the constant destructed of double bond present in unsaturated fatty acids. From this study it is observed that IV of the Su, Sb and Mt

oil samples are decreases maximum as compared to Gn oil samples during prolong deep frying. It is may be due to presence of high content of polyunsaturated fatty acids in Su, Sb oils than Gn and Mt is not refined oil.

Table No. 3 IV(Iodine Value) of Su,Gn,Sb and Mt oil samples subjected to deep frying.

| Oil Sample | IV for edible oils subjected to deep frying | | |
|------------|---|--------------|---------------|
| | Fresh | First frying | Second frying |
| Sunflower | 125.65 | 122.42 | 120.43 |
| Soybean | 122.05 | 120.43 | 119.50 |
| Groundnut | 88.32 | 87.04 | 87.78 |
| Mustard | 109.74 | 107.60 | 105.61 |

CONCLUSIONS

It is concluded that the degradation of Sunflower, Groundnut, Soybean and Mustard oil after first frying and second frying time can be determined by FT-IR spectroscopy and by determination of Iodine Value. The intensity of absorption at 3009cm^{-1} and 3006cm^{-1} were used for determination of linoleic or linolenic acid and oleic acid respectively. Due to degradation of oils, during deep frying concentration of these fatty acids get decreases. It is observed that intensity of absorption band at 966cm^{-1} is increases and at 722cm^{-1} is decreases gradually after each frying time, this is may be due to formation of *trans* isomers of unsaturated fatty acids. The FT-IR and IV of four oils studies indicated that during deep frying Sunflower, Soybean and Mustard oils get deteriorated more as compared to Groundnut oil.

Fig.1 FT-IR spectra of pure, first fried, second fried oils. (a- Su, Su-a, Su-b, b -Gn, Gn-a, Gn-b, c-Sb, Sb-a, Sb-b, d- Mt, Mt-a, Mt-b) at 4000 to 400 cm⁻¹

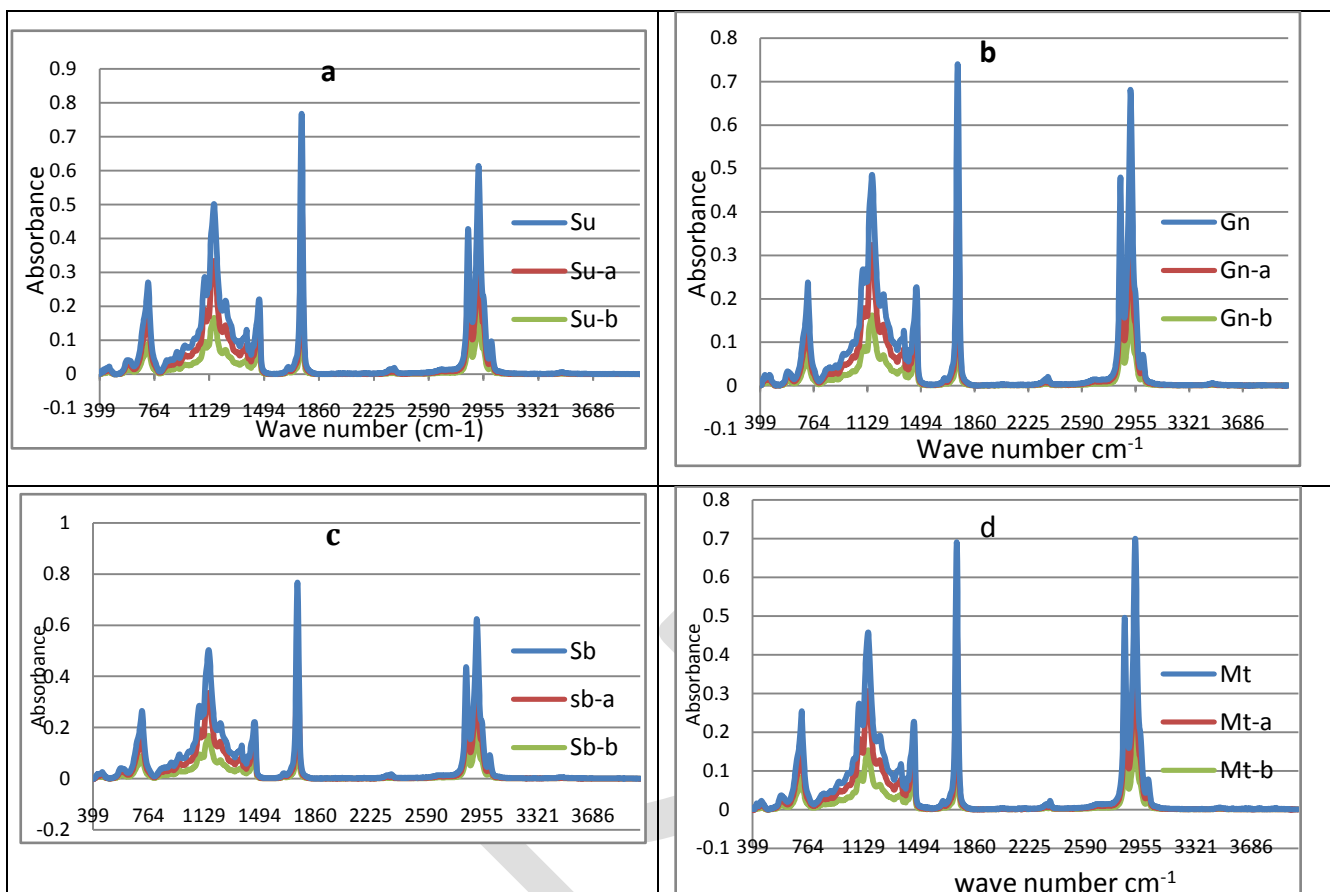
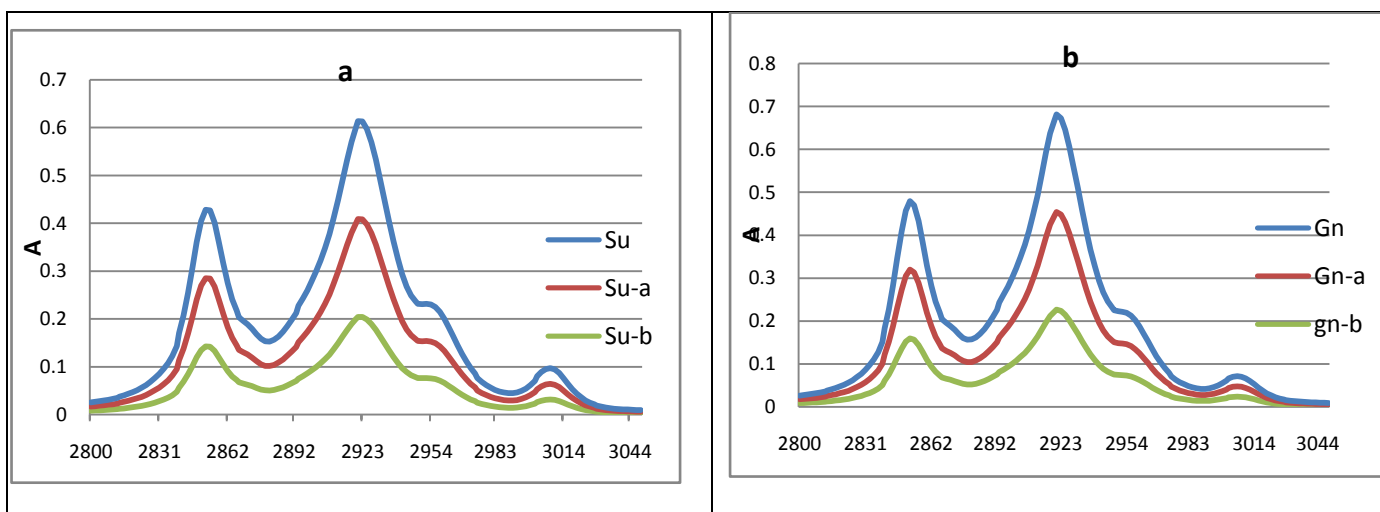


Fig.2 FT-IR spectra of pure, first fried, second fried oils. (a- Su, Su-a, Su-b, b-Gn, Gn-a, Gn-b, c-Sb, Sb-a, Sb-b, d- Mt, Mt-a, Mt-b) at 3050 to 2800 cm⁻¹



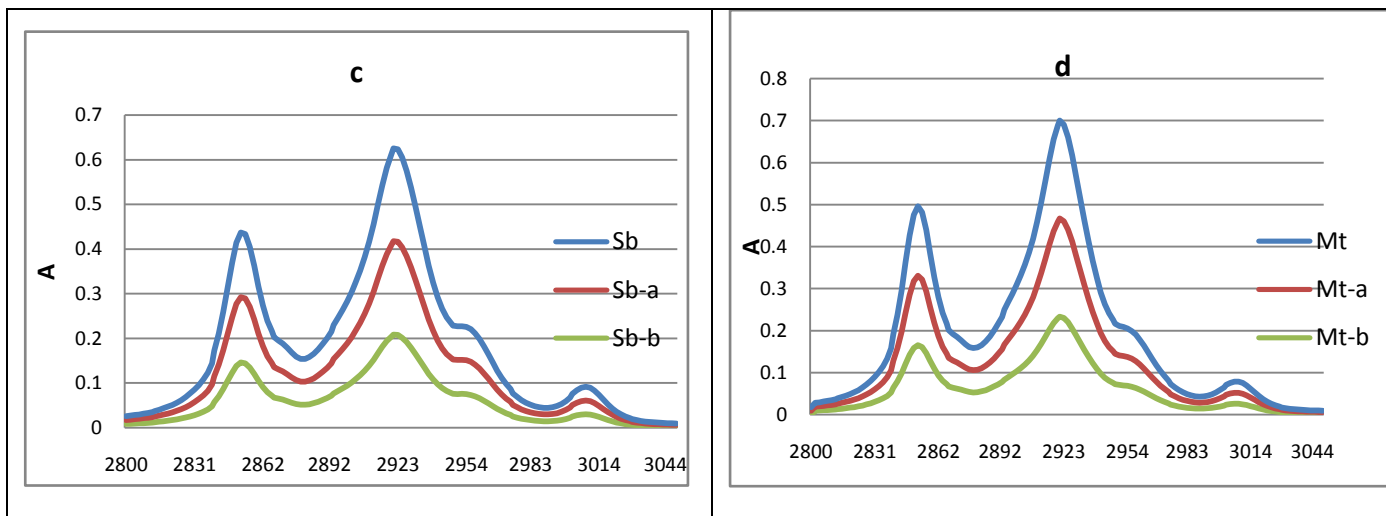


Fig.3 FT-IR spectra of pure, first fried, second fried oils. (a- Su, Su-a, Su-b, b-Gn, Gn-a, Gn-b, c-Sb, Sb-a, Sb-b, d- Mt, Mt-a, Mt-b) at 900 – 1000 cm⁻¹

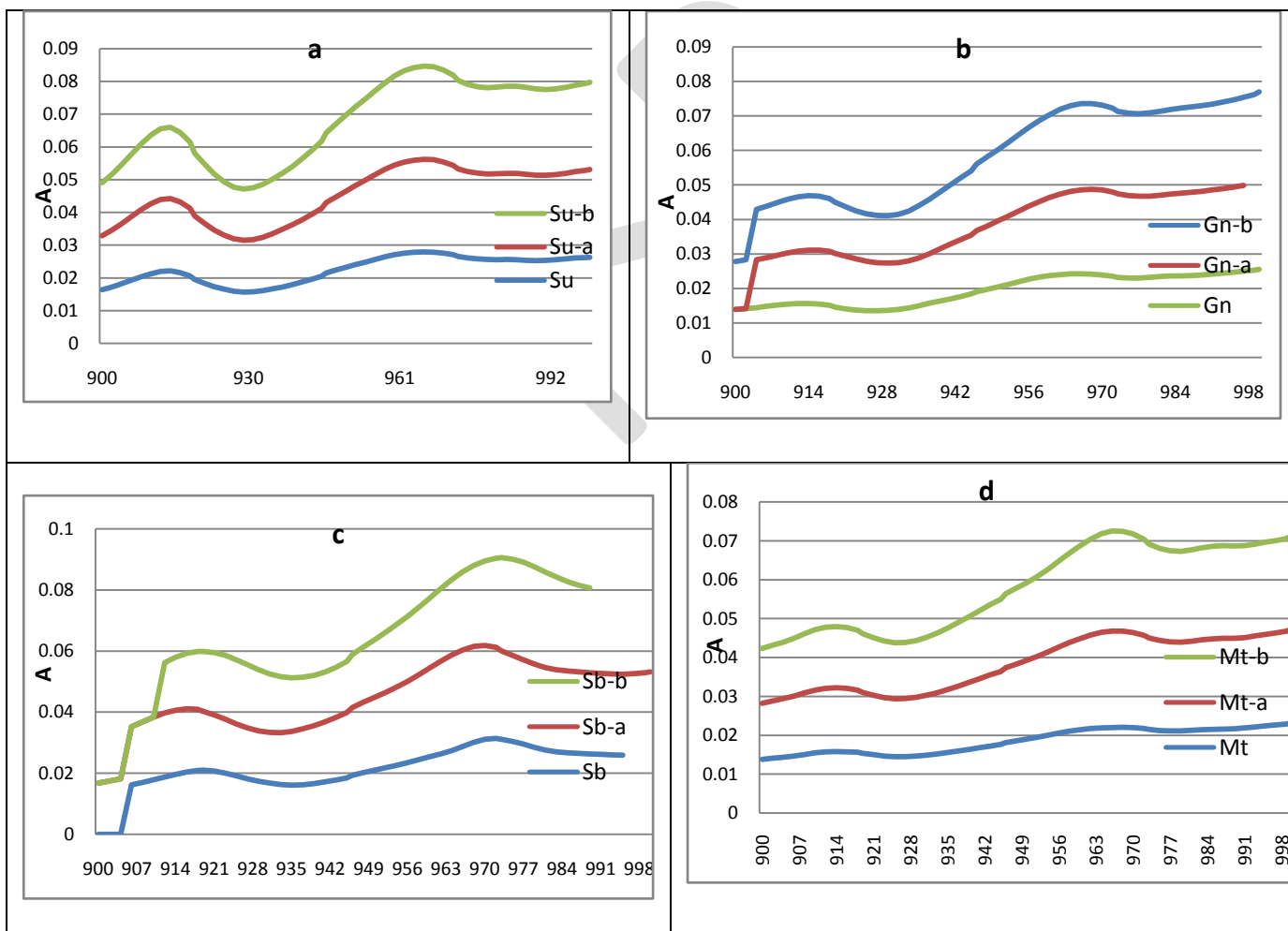
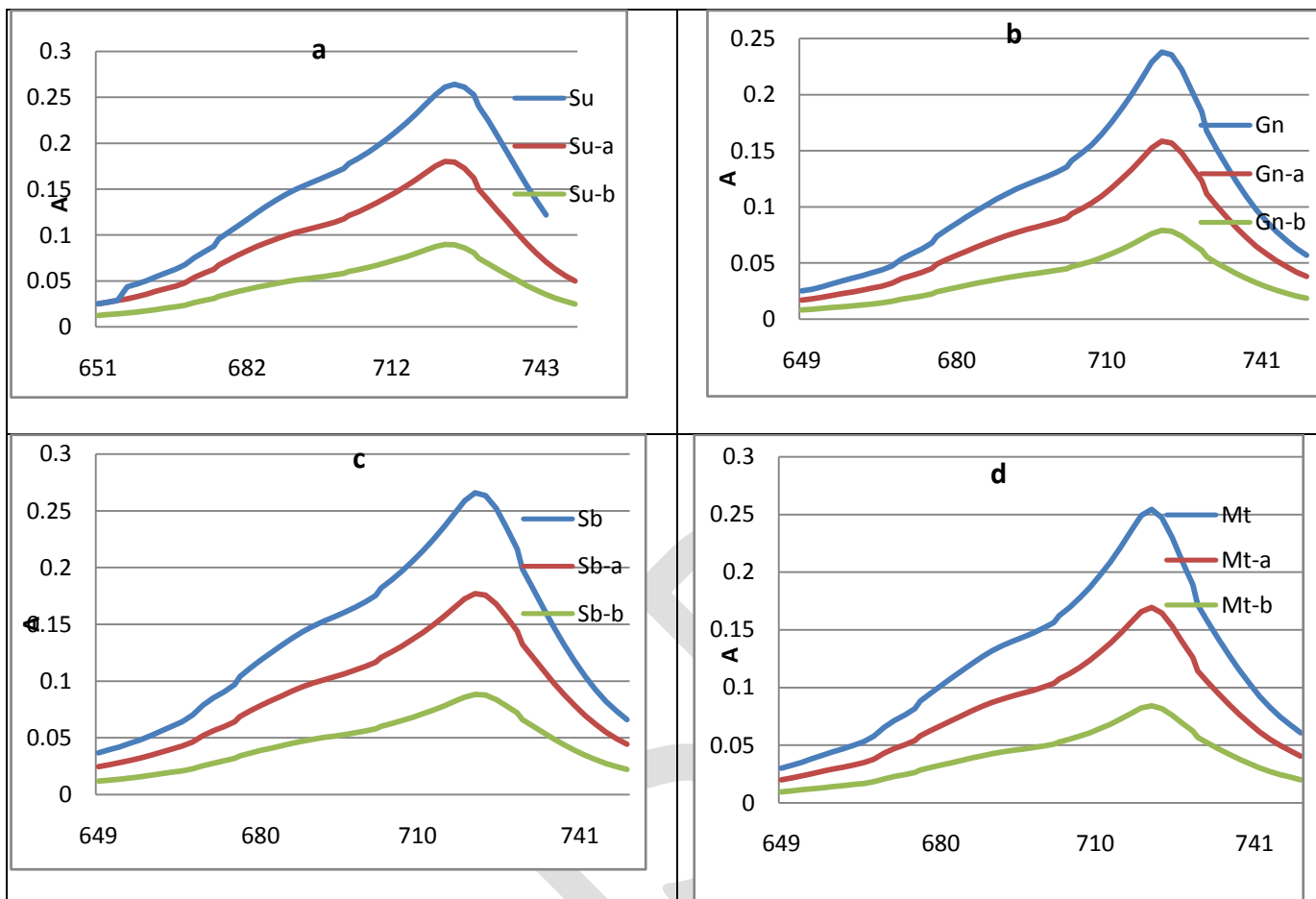


Fig.4 FT-IR spectra of pure, first fried, second fried oils. (a- Su, Su-a, Su-b, b-Gn, Gn-a, Gn-b, c-Sb, Sb-a, Sb-b, d- Mt, Mt-a, Mt-b) at 650 – 750 cm^{-1}



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