Detection of adulteration in edible oils by using Fourier Transform Infrared Spectroscopy (FT-IR)

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Abstract:

Edible oil is an indispensable source of energy for human beings. There are two major adulterations in edible oils and fats namely admixing cold press oil with refined one and replacement of more expensive oils and fats with cheaper one (Jee, 2002). There are certain edible oils and fats which are expensive and have special place in our diet, food preparation and formulation. Fourier transform infrared spectroscopy (FT-IR) is a technique used in the food product adulteration area or quality control. It is a rapid, non-destructive technique with short time for the sample analysis. FT-IR can be also used for quantitative analysis purposes. The intensity of bands in the spectrum is proportional to the concentration of the studied compounds. In present study, FT-IR is developed for the detection of oils adulteration with other edible oils including sunflower, palm oil and Rice bran. Based on results and also because of simplicity and low cost, FT-IR can be applied as an alternative analytical method for the detection of oil adulteration. Selection of wholesome and unadulterated food is essential for daily life to prevent potential health hazards. It is not possible to ensure wholesome food only on visual examination when the toxic contaminants are present in ppm level. Argemone oil is used to adulterate mustard oil,vanaspati ghee is mixed with desi ghee, etc. This type of adulterants makes food items inferior and cause hazardous diseases. This ultimately results that the consumer is either cheated or often become victim of diseases. The Objective of this study is to find some of the common adulterants present in locally available edible oils and fat samples from different sources. Some of these samples are coconut oil, sunflower oil, olive oil, palm oil, fried palm oil,vanaspathidalda, ghee etc have been analyzed. The spectral features of the most noteworthy bands are observed.

Key words: FTIR, Adulteration, Edible Oil, IR spectrum

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Introduction:

Oils and fats recognised as essential nutrients in both human and animal diets. They provide the most concentrated source of energy of any foodstuff, supply essential fatty acidswhich are precursors for important hormones, the prostaglandins.Fats and oils are present in varying amounts in many foods. The principal sources of fat in the diet are meats, dairy products, poultry, fish, nuts, and vegetable oils and fats. Reports shows that approximately 75% of world production of oils and fats come from plant sources (Raven and Johnson 1999),oil is extracted primary from seeds of oil seed plants such as soyabean, cotton, palm, groundnut (okpuzoretal 2009).oils and fats are an integral part of human foods. Vegetable oils are mainly constituted by triacyiglyceraol and complex mixtures of minor compounds of a wide range of chemical nature. These minor constituents show a broad qualitative and quantitative composition depending on the vegetable species from which they are obtained. Agronomic and climatic conditions fruit or seed quality,refining procedure cause variation in the content and composition of the constituents of vegetable oil (cert etal 2000).There are two major adulterations in edible oils and fats. Admixing cold press oil with refined one and replacement of more expensive oils and fats with cheaper one.

Many efficient analytical methods have been developed for identifying adulteration in edibles such as mass spectrometer, Gas chromatography, laboratory chemical analysis and other techniques. They are not practical options for the food industry, since they require time consuming process as well as costly. The infrared(IR) and Raman Spectroscopy do not require chemical reagents and easy to use. It gives complimentary information and the molecular structure.Olive oil is the highest class of edible oil, it has high price,consequently subjected for adulteration with other oils having similar colour like corn and sunflower oils. Sunflower oil is premium light yellow with a very high linoleic acid. As the demand for sunflower oil is increased day by day, adulteration with palm oil is reported in many cases.

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Materials and methods:

Fourier transform infrared spectroscopy (FT-IR) is a technique used in the food product adulteration area of quality control. It is a simple rapid, non-destructive measurement. By using FTIR broker series instrument we have analysed the oil samples. The IR spectras were observed in the field of $500 – 4000$ cm^{-1} both for pure oils and their mixtures. In this the instrument gives 16 scans at a time with in fraction of minutes.FTIR spectrometer with a ATR module, a DLA TGS detector and KBr Beam splitter is connected to a computer with appropriate software.

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The Objective of this project is to study some of the common adulterants present in different edible oils. Eight edible oil and fat samples from different sources, either vegetable (coconut, sunflower, olive oil, palm, fried palm oil,sunflower, vanaspathidalda ,ghee etc have been analyzed. The spectral features of the most noteworthy bands are studied. [6] proposed a system in which this study presented the implementation of two fully automatic liver and tumors segmentation techniques and their comparative assessment. The described adaptive initialization method enabled fully automatic liver surface segmentation with both GVF active contour and graph-cut techniques, demonstrating the

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feasibility of two different approaches. The comparative assessment showed that the graph-cut method provided superior results in terms of accuracy and did not present the described main limitations related to the GVF method. The proposed image processing method will improve computerized CT-based 3-D visualizations enabling noninvasive diagnosis of hepatic tumors. The described imaging approach might be valuable also for monitoring of postoperative outcomes through CT-volumetric assessments. Processing time is an important feature for any computer-aided diagnosis system, especially in the intra-operative phase.

FTIR ATR measurements are performed by placing a small drop of edible oil on top of ATR base plate at room temperature. The collection time for each sample spectrum is roughly 2 minutes. The obtained spectras are subtracted against background air spectrum. After every scan the ATR base plate was cleaned with ethanol and dried with soft tissue before measuring the next sample. The spectras were recorded as absorbance values at each data point.From each oil sample measurements were taken three times. To detect edible oils and fats adulteration it is possible to use both major and minor components as detection tools, each oil and fat have its especial components. Combining FT NIR and FT MIR with multivariate stastical methods has been applied for authentication of original products with the adultared material. A large number of potential adulterants may be identified from a single spectrum. Some of the functional groups and corresponding band widths are presented in the table.

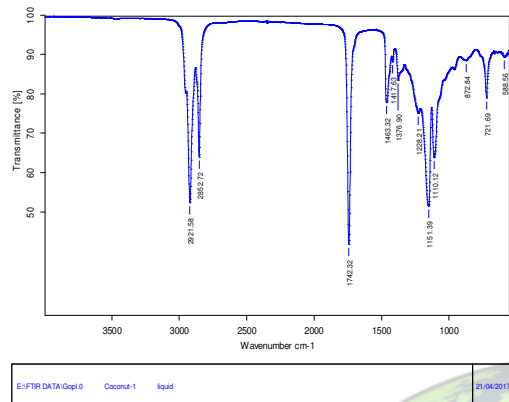| S.No	Name of bond	Type of bond	Band Width cm^{-1}
1	Tricycle glycerol ester bond	c=o	4000 – 3050
2	very intense bands with maxima at fatty acid chains as tricycle glycerol at 2924 and	c=H	3000 – 2800

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	2853 of CH_2 group with stretching vibrations		
3	Group with stretching vibrations.	CH_3	2962 – 2872
4	carbonyl group in esters linkage between fatty acid and glycerol	C=O	1746
5	group with bending vibrations	CH_2 and CH_3	1400 – 1200
6	several absorption bands appear	C-O and C-C	1125 – 1095
7	highlycharcterstic and utilized for isolated trans fatty acids in fats and oils.	C-H group	1500 – 900 968

Results and Discussion:

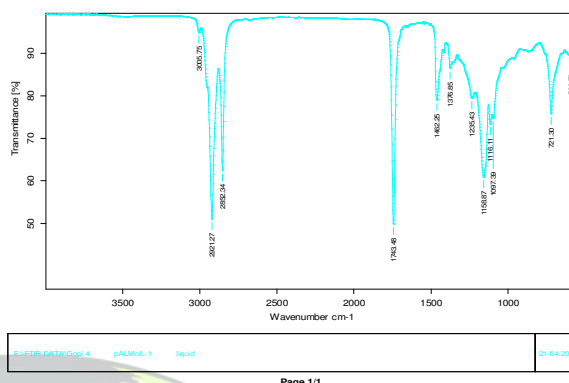FTIR spectra for pure edible oils and their mixtures were shown in the figures. It is difficult to differentiate between the oils by just visual examination. The spectra interpretations have to be done by comparing the obtained spectra with a series of preliminary data. An FTIR spectrum of vegetable oils and animal fat oils gives series of bands with different intensities and forms.Some regions of the spectra present a very good signal/ noise ratio which corresponds to various types of vibration characteristic to different types of atoms.The spectral structure of the edible oils is mainly due to lipid molecules oil containing fatty acids.This determines presence of characteristic absorption bands in the mid infra red region of the electromagnetic spectrum. It is difficult to differentiate between the oils by just visual examination. The spectrum interpretation has to be done by comparing the obtained spectrums with a series of preliminary original edible oils spectrum data. The pure olive oil and sunflower oil are located in well identified regions.
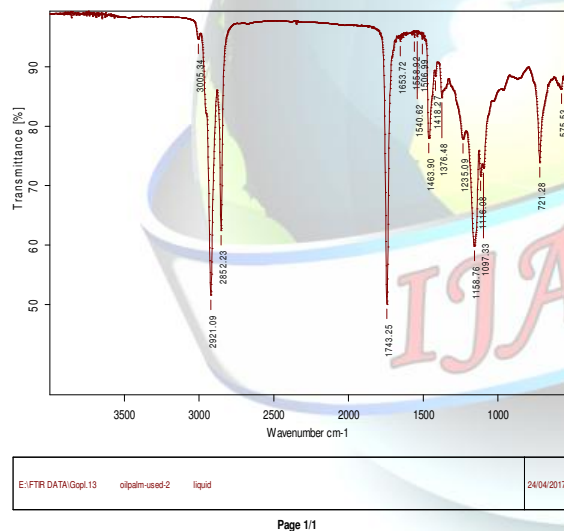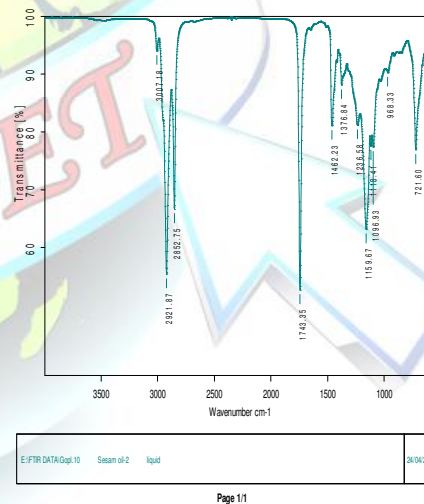
IR Spectrum of Coconut oil

IR Spectrum of palm oil

IR Spectrumof Fried Palm oil

IR SpectrumofSeasamn oil

IR spectrum of Sunflower oil
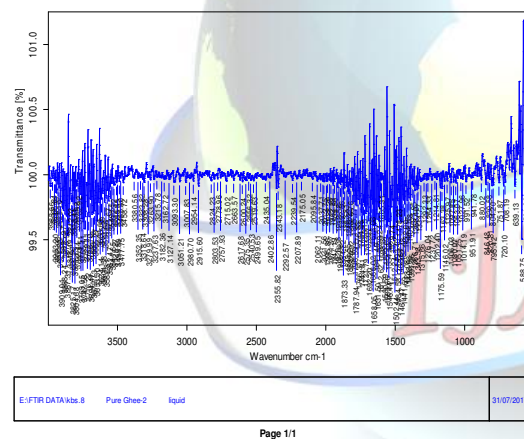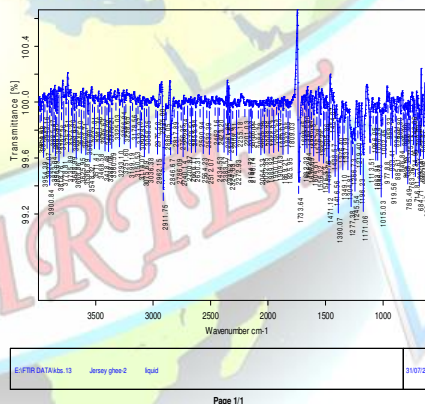
IR Spectrum of Castor oil
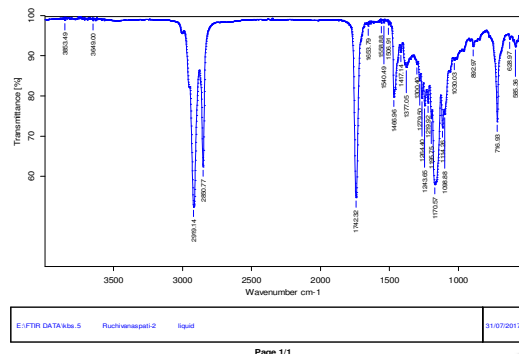

IR Spectrum of Pure Ghee

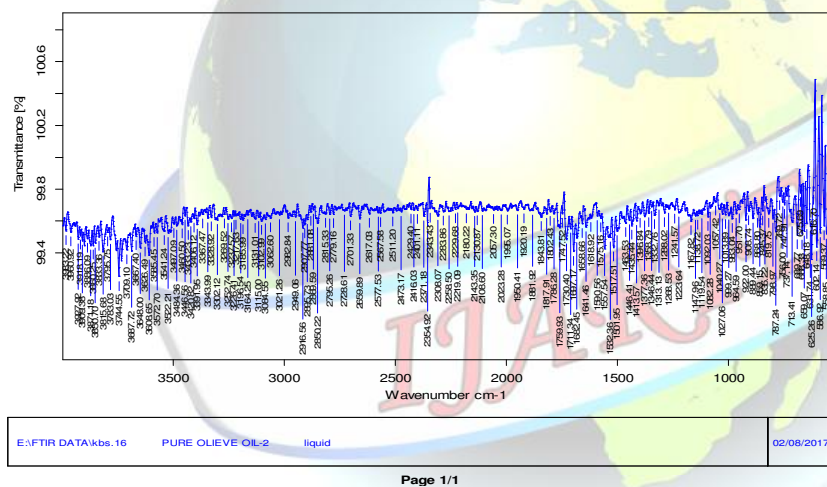IR Spectrum of Jersey cow Ghee
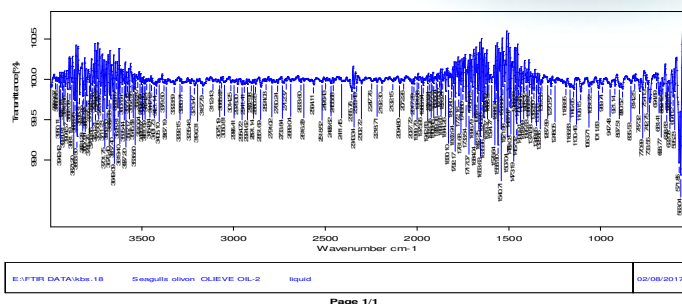
IR Spetrum of Ruchivanaspathi

IR Spectrum of Pure oliveoil:

3 samples of olive oil were analyzed, in this spectrum a major noise and bands intensities were observed in local made samples compared to pure olive oil sample imported from turkey.
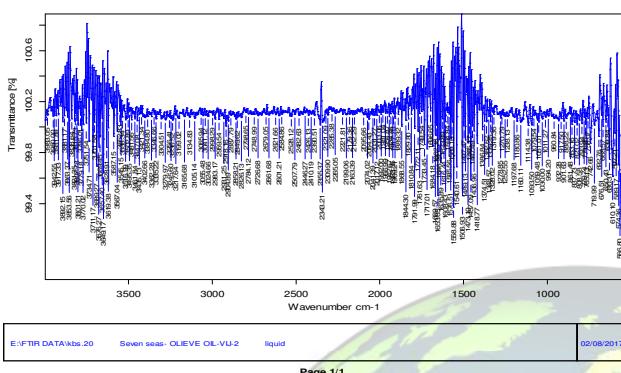

IR spectrum of Olive oil (Seagullusolivon) -local brand.

IR spectrum of Oilve oil (oil Seven seas) -local brand

From the literature it shows that the band at 1400cm^{-1} is due to the bending vibrations of the =C-H group and the bonds in the region 1300cm^{-1} to 1000cm^{-1} are due to stretching vibrations of C-O bond present in triglycerides, the bond at 914cm^{-1} is related to the bending vibrations of –HC = CH group. In the band region 3100cm^{-1} to 2800cm^{-1} the absorption bands are due to symmetrical and asymmetrical vibrations which are found large quantities in vegetable oils. Absorption near 3010cm^{-1} represents degree of unsaturated oil used for the identification of vegetable oils adulteration; at this frequency addition of other oils in the pure vegetable oil can be detected. In the 3005 cm^{-1} to 3008cm^{-1} there are no differences in the intensity of sunflower, for the sunflower, palm oil, seasam oil absorbance is observed at 1743 cm^{-1}. Hence it is easy to adulterate sunflower oil with cheaper palm oil.

The region 1600 – 1390 cm^{-1} is used to determine the total unsaturation, the IR spectrum of sunflower oils, sesame oil, palm oilhas a similarity at 1377 cm-1. This band related to –C-H(CH$_2$) functional group with bending symmetry. In the fingerprint region between 1500 and 900 cm^{-1} several absorption band appear. At 968 cm^{-1} the bands of isolated trans double present. It is highly characteristic and is utilized by official methods for determination of total isolated trans fatty acids in fats and oils.

Conclusions:

Even if differences in the infra red middle spectra are very low, because most of vegetable oils contain the same type of fatty acids and triglyceride content is similar, however spectral differences exist in various types of vegetable oils, so it is possible to identify the addition of adulteration in the samples, . Previous research results shows that we recommended

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the application of the spectral regions in assessment of the authenticity of edible oils. Lot of noise is observed in the local olive oils when compared to pure olive oil.

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