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LATEST TRENDS IN EDIBLE OIL QUALITY ANALYSIS – A REVIEW

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ABSTRACT:

Edible vegetable oils are commonly used from olden days for cooking of various types of foods. The edible oil quality and safety is a major issue for the final product quality and consumer health. The edible oil usually undergoes deterioration when not processed or packed properly due to the exposure of the edible oil to heat, light and oxygen. The quality of the edible oil is majorly affected by the adulteration of the oil by mixing the raw product with alternate low-cost oil or mixing virgin with refined oils which eventually alters the physical and chemical characteristics. Presently, there are many analytical methods based on physical and chemical characteristics. There has been has been a need in faster and rapid test in various food industries. Thus, this paper discusses about latest study and designs related to non-destructive and rapid test to test the quality of the edible oil and adulteration level in the edible oil.

Keywords: Analytical methods, non-destructive testing and rapid tests.

INTRODUCTION:

Edible vegetable oils and fats which are usually derived from plant sources, such as oilseeds like soybean, canola, sunflower seeds, cottonseed and peanuts have a big contribution in our diet as cooking or frying oil, salad oil or in food products formulation S. Azadmard-Damirchi et.al, 2015. Edible oil quality is very much important as it decides the end product or the cooked product quality and health concern. The edible oil of various vegetables is usually expensive and it has always found a way to be adulterated with

other low-quality oil to compensate the cost of the original raw product. These not raise an issue in the quality characteristics of the original product but also an issue of health and safety. It has been found that the oil deteriorates when not processed, packed or handled properly. It leads to rancidity, polymerization and formation of other derivative as when they are exposed to air, water or heat. The continuous cooking or frying of the oil leads to increase in carbon compounds, total polar compounds and other derivatives. This process involves the changes in both physical and chemical properties thus adversely affecting the quality of the final product. The frying oil turns into waste oil or can be unusable after more than one or more time depending on the type of oil. Thus, the overall quality including physical and chemical characteristics are very important to define the final product quality and safety.

To identify the quality and adulterant of the oil which has deteriorated with time and has been used for frying for a long time various analytical and rapid tests are available. The analytic tests which are generally done are usually based on various physical and chemical parameters. These tests are also time consuming and destructive type of tests. Thus, the need for rapid testing of the quality and the adulterant level has increased and studied. This review paper discusses about the characteristics of the deteriorated and the adulterated oil and also the latest rapid tests which are been designed, fabricated and evaluated by various different authors.

EDIBLE OIL DETERIORATION MEASUREMENT CHARACTERISTICS:

Edible oil deterioration occurs when the oil is exposed to moisture or water, heat or frying process or not proper processing and packaging of the oil. The characteristics which can be identified are done by both physical and chemical characteristics (https://extension.okstate.edu/) and Ratnesh kumar, et.al., 2019:

The physical characteristics include:

Density: The density of edible was calculated by mass of the sample per unit volume. During the storage of individual and blended oil, density was reduced with raising the storage period and different storage condition, such as refrigeration, BOD and room temperature.

Colour: The color compounds present in the edible oil mainly consist of carotenoids, chlorophyll, gossypol and related compounds which are generally extracted or removed after the refining process. It is used as an indicator to identify the adulterated and non-adulterated oil and also the deterioration of the oil.

Specific gravity: The specific gravity of the fats is less than 1 (about 0.86). Solid fats are lighter than the liquid fats. Oils spread on water to form thin monomolecular layers. In general, either unsaturation of the fatty acid chains or increase in chain length of the fatty acid residues tend to increase the specific gravity.

Melting point: The melting point of fats depends on the chain length of the constituent fatty acid and the degree of unsaturation.

The chemical characteristics or the measures of the oil are:

Acid Value: It is often used as a general indication of the condition and edibility of the oil. It is expressed as the amount of potassium hydroxide (KOH, in milligrams) necessary to neutralize free fatty acids contained in 1 g of oil.

Thiobarbituric Acid Index: It is an old test used for evaluating lipid oxidation in foods. When heated under acidic conditions, thiobarbituric acid (TBA) reacts with a number of compounds including nucleic acids, amino acids, proteins, phospholipids and aldehydes to produce a pink chromophore that can be measured by UV or fluorescence detection.

Free fatty acid content: Crude oils and fats in natural form, not refined, contain small amounts of FFA, which are usually removed during the refining process. FFA are not desirable in edible oils because when oils with high FFA content are used in foods, they lower the oxidative stability of the product, increase acidity and lead to off-flavor formation.

Peroxide value: It is an index used to quantify the amount of hydroperoxides present in fats and oils. These hydroperoxides are the primary oxidation formed products.

p-Anisidine Value: It is the secondary oxidation products that are formed by breakdown of the primary oxidation products during extensive oxidation. The secondary oxidation products are mainly aldehydes such as 2,4-dienals and 2-alkenals. These are generally used as the odor intensity indicator.

Polar compounds: These compounds are generally formed after the frying of the edible oil. These are generally formed as dimeric and higher polymeric triacylglycerides after the breakdown of the triglycerides.

Unsaponifiable Matter: It is the fraction of vegetable oils naturally contains hydrocarbons, terpene alcohols, sterols, tocopherols and other phenolic compounds present in the edible oil. These generally act as oxidation inhibitors. Vegetable oils typically contain 0.5-2.5 percent USM while some others have higher amounts, 5-6 percent.

FRYING OIL CHARACTERISTICS:

Frying is one of the most common and oldest method of cooking food, where the raw is introduced to high heated oil where the cooking and physical transformation takes place of the food. Edible oils when subjected to heating and frying can alter or change the physical and chemical properties. These changes depend on the temperature, type of food, frying medium, etc. The changes are Sergio et.al, 2016:

Self-oxidation: Occurs at 100 C

Thermal polymerization: Occurs between 200 and 300 C

Thermal oxidation: Oxidation that occurs at a high temperature

Physical: Changes in the physical characteristics

Nutritional: Changes in nutritional and physiological properties

Chemical: Hydrolysis of triglycerides that results in release in fatty acids, glycerin, etc.

The other changes in the edible oils after prolonged frying are polymerization resulting in more viscosity and higher acidity of the oil. The oxidation and the hydrolysis leading to sensory, physical and chemical changes and the deterioration of oil by increase in conjugated dienes and trienes from unsaturated bonds. It increases in the increases the levels of thiobarbituric acid, peroxides, iodine as well as the refraction and viscosity indexes of the triacylglycerol molecule.

Analysis properties of the frying oil:

The analysis of the frying oil can be done by both physical and chemical indicators or properties. The physical indicators are used to evaluate the quality of frying oil: smoke point, color, viscosity, taste, odor, and foam persistence. The chemical indicators used to assess the quality of the frying oil are peroxide value (PV), iodine value (IV), free fatty acid (FFA), polymeric triglycerides, anisidine value (AV), and polymerized and oxidized material (POM) Alfadhl et.al, 2015.

ADULTERATION OF EDIBLE OILS:

Adulteration is done is by mixing an compensate compound which is similar in physical and chemical quality and is of low cost. These are generally adulterated to avoid the high-cost production of the original compound. The Common edible oil is being adulterants with edible oil are castor,argemone, karanja and mineral including unnatural colors. The common methods of adulterating the oils are Pooja B et.al, 2013:

Fusing or admixing of oil: Cold press oil are produced by pressing and simple filtration with refined oil. The refined is made by various steps like bleaching, deodorizing, etc. The refined oil tends to develop trans fatty acids.

Expensive oil adulterated with inexpensive oil: It involves the involves the Dilution less expensive of the pure edible oil. It is also possible to characterize cheaper oil than adulterated oil as if there were any oil with pure oil content. Example: The Sesame oil is most commonly adulterated with corn, sunflower, and other low-priced oils.

Some of the common methods to detect the adulteration in oils:

FTIR spectroscopy: It is used for the detection of adulterants of oil like peanut oil, olive oil, pumpkin oil, corn germ oil with sunflower oil. It is marked with the level of absorbance of frequency.

UV-VIS spectroscopy: It is used to diagnose oils and fats for adulteration are based on variations in the quality and structure of the adulterant ‘s main or minor components and those of the unadulterated oils. Along with the adulteration compound it also identifies the residue level in it. It is effectively used in the detection of olive oil quality.

Chromatographic techniques: These are used to diagnose oils and fats for adulteration are based on variations in the quality and structure of the adulterant ‘s main or minor components and those of the unadulterated oils. Various chromatographic techniques like Gas Chromatography technique were used to evaluate the adulteration in hazelnut, crude sunflower and rapeseed with markers like esterified sterols, etc. Other technique includes HPLC and GC/MS to evaluate the level of tocorienols, tocopherols, fatty acid composition in range of oils like sunflower, coconut oil, etc.

Other techniques include: Raman spectrometer for adulteration identification in hazelnut, Diffuse light absorption spectrometer for olive oil quality detection, etc.

Latest Non-destructive and rapid quality and adulteration testing in oils:

The latest rapid non-destructive tests that have been studied and fabricated:

Sergio et.al, 2015, developed a non-destructive method for the analyzing the quality of the frying oil with the help of capacitive sensor. The capacitive sensor here allows the development of the quality parameter with the help of dielectric constant. The level of the deterioration and the level of the distance developed in the sensor is used as a measure of the quality of the edible oil. The capacitive impendence is calculated with the difference in the voltage which is connected to the AC supply. The capacitors were placed in parallel with different types of material and considering the melting point of these materials as a measure of the dielectric constant and temperature as a medium for the thermal stress. A low-cost prototype was developed by Saira Banu et.al, 2019, to check the quality of the frying oil in restaurant by indicating the quality of the sample oil as bad, fair or good. The quality check is done by the using a set of sensors like temperature, capacitive, transparency sensors embedded in an ARM controller. The deterioration level was done by carbon level with the help of capacitive sensor and temperature sensor for smoking point identification. The adulteration check was done with help of transparency sensor. The overall values after detecting is displayed in a LCD, thus providing a fast, simple and low cost evaluation method of edible oils.

Alfadhl et.al, 2015, designed a custom-built sensor custom built sensor to evaluate frying oil degradation. Here an Electrical capacitive based on spectroscopy technique was adapted. The variations of capacitance measurements had significant correlation with the changes of TPC and viscosity during the heating process in frying oil thus fabricating a simple and inexpensive way of monitoring the quality.Ultrasonic waves were used by Bibha Kumari et.al, 2015 as a non-destructive method to characterize the level of adulteration in the mustard and olive oils. The variation of rheological and ultrasonic parameters is used to identify adulteration. The changes in the quality of sample oil are studied from the changes in the ultrasonic parameters such as viscosity, density, ultrasonic velocity, acoustic impedance, adiabatic compressibility and intermolecular free length, from which can be easily perceived compared to analytical techniques. The chemical indicators used are Fatty acids (FA), free fatty acids (FFA), peroxide value (PV) of quality of sample and different sample oil compared to ultrasonic measurements.

B. Alouachea, et.al, 2015 fabricated a device using a 2.25 Hz ultrasound transducer along with a pulse echo mode with the help of the ultrasound parameters like propagation velocity and attenuation to determine the characterization of olive oil which has been adulterated with varies range of soya oil like density and viscosity.

The quality of the frying oil of various types of samples and different frying times by Yufeng Peng et.al, 2013 and designed a device with capacitance sensor controlled by microcontroller. The results were evaluated with difference in the value of the capacitance obtained for different oil variety and the number of frying times of the oil. The more the number of times the oil is fried the more the polarized compounds leading to the increased value in the capacitance obtained.

Mohd Faizul et.al, 2020, designed a inter digital electrode sensor for monitoring of degradation of repeated cooking oil. Here the IDE sensor is developed with different frequencies and here the sensitivity in respect to the capacitance value were evaluated with graphical representation. Thus, the frequency of the frying and the polarized molecules increased thus showing a varied range when subjected to 5 different variety of sensors.

Mohammad et.al, 2020, designed a device including the combination of two different non-destructive methods – ultrasonic pulse echo system and a gas sensor. The parameters used for the evaluation of the quality is by losses in ultrasound wave amplitude percentage, ultrasound signal's time of flight and difference between maximum and minimum output of TGS2620 gas sensor. Thus, the fraud detection was done successfully in olive oil sample.

Dr. S. Shanmugasundaram, developed a biosensor for the confirmative test of Virgin Coconut Oil for the level of adulteration by identifying the amount of peroxide value present in the virgin oil when compared to the oil by adulterated with other types of oil. The biosensor is based on the capacitance value and its dielectric properties.

A frying oil evaluation portable sensor was made by Mei Liu et.al,2019, which is based on the dielectric constant measurement i.e. capacitance value. An interdigital electrode, capacitance chip connected to a microprocessor was designed. As the frying increased the level of TPM and viscosity increased thus the capacitance level increased. Thus, a simple, cost effective and a portable method of evaluation of the frying oil can be detected on spot easily and effectively.

Jing Yana et.al, 2019, developed an ultrasonic pulse echo system which is a rapid non-destructive method developed for vegetable oil characteristics analysis. The differences in the ultrasonic properties of the oils were used to identify and calculate the viscosity and density. Eighty oil samples which includes olive oil, rapeseed oil, etc. A higher unsaturation degree of the oils were finally found out with the results of higher density and lower viscosity.

Keunsoo Lee et.al 2013, fabricated an edible oil-condition sensor using single-walled nanotubes (SWNTs) made using the spray deposition method which were dispersed in a dimethylformamide solution and then refabricated with prefabricated Au/Ti electrode. Here, oxidized edible oils with different values were tested. Thus, the results conducted showed conductivity of the sensors decreased as the oxidation level of the oil increased.

Jookyeong Lee et.al 2021, Investigated a chemosensory degradation of soybean and canola oils with repeated frying in order to estimate the quality of the oils with the help of electronic nose and electronic tongue. Here, the chemical compounds like oxygen induction time, acid value, p-anisidine value, malondialdehyde, and total polar compounds were analyzed and evaluated. All the chemical parameters increased with the value of frying time. The analysis was effectively found for compounds like ethyl butyrate, 2-heptenal, and 2,4-pentanedione as major volatiles for soybean oil and ethyl butyrate and linalool for canola oil with the electronic nose.

Sung-Sam Hong, et.al 2019, designed and fabricated rancidity sensors capable of measuring temperature and rancidity and by coupling a Bluetooth communication module and Internet of Things to the sensors. Thus, the high classification prediction accuracy of 91.3% and a short-term pattern prediction accuracy of 96.6% (weighted scaling), confirming its excellent potential for raw material quality management.

CONCLUSION:

Edible oils are of primary importance in preparation of various types of fried products and other type of consumables. The quality of oil is a major concern of health and safety in the final product for the consumers. The quality issues in edible oil are the due to deterioration with exposure to air, heat and water or due to rancidity or due to improper processing and packaging. The deterioration characteristics include polymerization, increase in free fatty acids, development of other by products, etc. The other issue related to

the quality of the oil is the adulteration of their original raw oil with other low-cost substitute raising the health concern and safety issues. There has been a lot of analytical tests to quantify the quality of the edible oil. These are generally destructive methods and time consuming. Thus, the need for rapid test and evaluation has been increased in various food industries. Thus, the paper lists the latest types of non-destructive rapid tests studied and designed by various authors.

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