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Edible oil adulterations: Current issues, detection techniques, and health hazards

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Abstract
Edible oils are used as cooking or frying medium, salad oil or in food products formulation. They are important from nutritional point of view but ensuring their purity is a concern since old times. Because of their greater demand in national and international market adulteration in high price oil with low price oil is a major issue. It can affect the health of consumers adversely. Mustard oil adulterated with argemone oil and butter yellow has been reported to cause gall bladder cancer. Similarly, argemone oil mixed with edible oils can lead to epidemic dropsy, glaucoma and loss of eyesight. Therefore there is an urgent need for authentication and prevention of adulteration for the sake of consumers. A spectrophotometric method for detection and quantification of adulteration of sunflower, corn and soybean oils in olive oil was developed. ESI-MS fingerprinting analysis has also been applied to differentiate olive oil from the five other edible oils. GC/MS is used to classify five kinds of edible oils into five groups for authenticity assessment. Argemone oil adulteration in mustard oil can be determined by HPTLC. The HPTLC fingerprinting can also be used for identification and estimation of mineral oil in various vegetable oils. The presence of palm kernel olein as adulterant in virgin coconut oil can be successfully detected by using FTIR spectroscopy as health of the consumers is top priority so the purity of edible items is of utmost concern. Utilizing advance techniques for adulteration detection, we can help to reduce consumer's health risks.

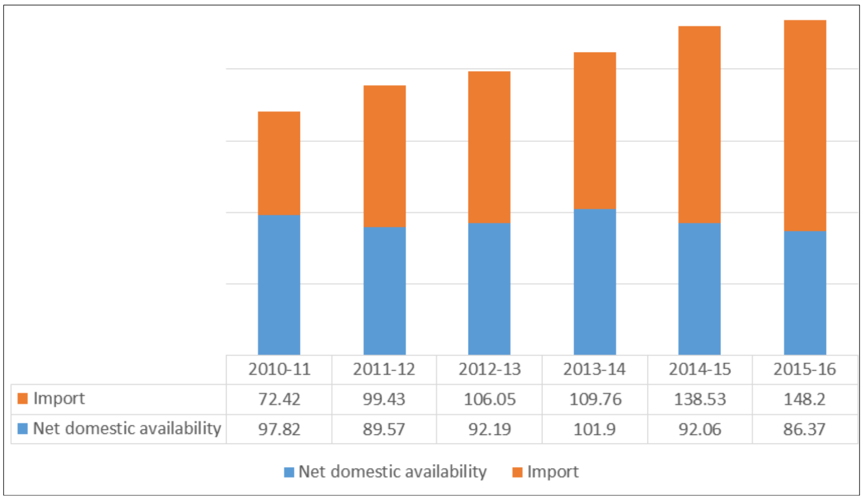
Keywords: Edible oil adulterations, authentications, health hazards, adulteration detection techniques

Introduction

Edible oils are a food substance of whatever origin, source or composition that is manufactured for human consumption wholly or in part from a fat or oil other than milk and dairy product. India is an importer of edible oil due to their less net domestic availability. The total production of edible oil in India was 25.3 million tonnes in 2015-16 and total area under edible oils was 26.13 million hectare. Maximum production of edible oils were reported in 2013-14 which was 32.75 million tonnes from area 28.05 million hectares. India imported 148.2 lakh tonnes of edible oils in 2015-16 and net domestic availability was 86.37 lakh tonnes (ICAR, 2016) [14]. Because of their greater demand in national and international market adulteration in high price oil with low price oil is a major issue. Therefore there is an urgent need for authentication and prevention of adulteration for the sake of consumers. Purity of edible oils is generally ascertained using saponification value, iodine value, acid value, specific gravity, refractive index etc. but these techniques are not sensitive in sophisticated adulterations so advance techniques are required. Further, it is possible to use oil's both major and minor components as adulteration detection tool. As health of the consumer's detection, we can help to reduce consumer's health risks. Oils are liquid at room temperature and is top priority so the purity of edible items is of utmost concern.

Current issues in edible oil adulterations

Admixing cold press oil with refined one: Refined oils are used in the adulterations of cold press oil. During refining processes, trans fatty acids and steradienes are formed which are generally absent in cold press oil. Trans fatty acids are not essential and they do not promote good health. The consumption of trans fatty acids increases risk of coronary heart disease. Trans fats from partially hydrogenated oils are more harmful than naturally occurring oils (Damirchi and Torbati, 2015) [3].



Source: ICAR. Handbook of Agriculture, Sixth edition, Directorate of Information and Publication of Agriculture, New Delhi, 2016, 1120-1194.

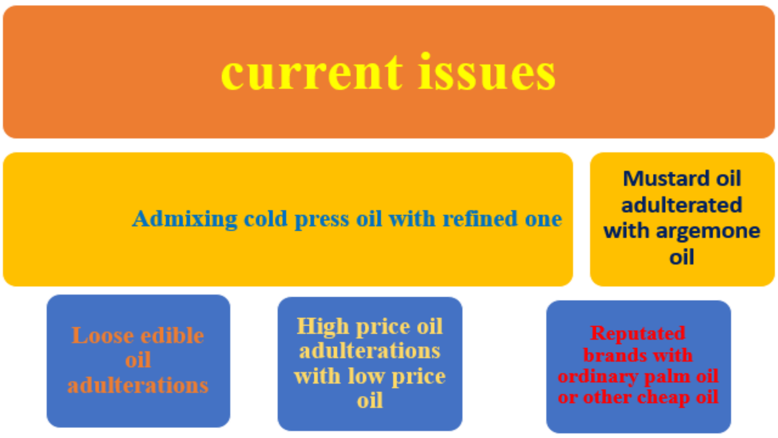
Fig 1: Net Domestic availability and Import of Edible Oils (Lakh Tonnes)

Mustard oil adulterated with argemone oil: In number of cases, adulteration of Argemone mexicana (Family: Papaveraceae) seed oil in edible oils has been reported as cause of epidemic dropsy. Sanguinarine and dihydrosanguinarine are toxic principles (alkaloids) present in Argemone (Das and Khanna, 1997) [4].

High price oil adulterations with low price oil: The substitution of more expensive oil by cheaper one is so profitable for producers and there are inspires to do it oil. the substitution of expensive oil by lower price one is usual respecting economic point of view. Some oils are more prone to be adulterated due to their higher price and limited accessibility. Because of the high price of virgin olive oil, there is a great temptation to adulterate it with oils with similar fatty acid and sterol profiles (Damirchi and Torbati, 2015) [3].

Loose edible oil adulterations: The poor who buy loose edible oil across the country run the risk of cancer, paralysis, liver damage and cardiac arrest as such oils are heavily adulterated [11].

Besides these reputed brands also found to be adulterated with ordinary palm oil or other cheap oils. In many cases it has been found that Mineral oil, karanja oil, castor oil, and artificial colours are heavily used in edible oil adulterations (Navya *et al*., 2017) [20].



The report by consumer voice

Highest adulteration found is 85%- coconut oil, 74.07% - cottonseed oil, 74%-sesame oil and 71.77% in mustard oil. New Delhi: Consumer Voice, the Voluntary Consumer Organization working in interest of consumer education and rights of consumers has recently done laboratory tests of loose edible oils of 8 varieties namely Mustard, Sesame, Coconut, Sunflower, Palmolein, Soybean, Groundnut and Cottonseed. 1, 015 samples of loose edible oils were taken from 15 states including Delhi. The base of the tests was both on quality and safety parameters as per FSSAI standards and samples were tested at NABL accredited laboratory. The 15 states covered for the samples collections are Delhi, Haryana, Uttar Pradesh, Gujarat, West Bengal, Bihar, Jharkhand, Maharashtra, Kerala, Tamil Nadu, Andhra Pradesh, Telangana, Karnataka, Rajasthan and Madhya Pradesh (Consumer voice, 2016) [7].

Table 1

Edible Oils	Total	Failed	% Failure
Coconut Oil	149	126	84.56%
Cottonseed Oil	54	40	74.07%
Sesame Oil	50	37	71.77%
Mustard Oil	124	89	71.77%
Groundnut	152	90	59.21%
Palmolein	50	16	32%
Soyabean	230	46	20%
Sunflower	206	34	16.5%
	1,015	478	47.09%

Source: Consumer Voice New Delhi, 2016

Edible oil Adulterations and its effects

Adulteration usually refers to mixing other matter of an inferior and sometimes harmful quality with edible oil intended to be sold. As a result of adulteration, oil becomes impure and unfit for human consumption. [10]

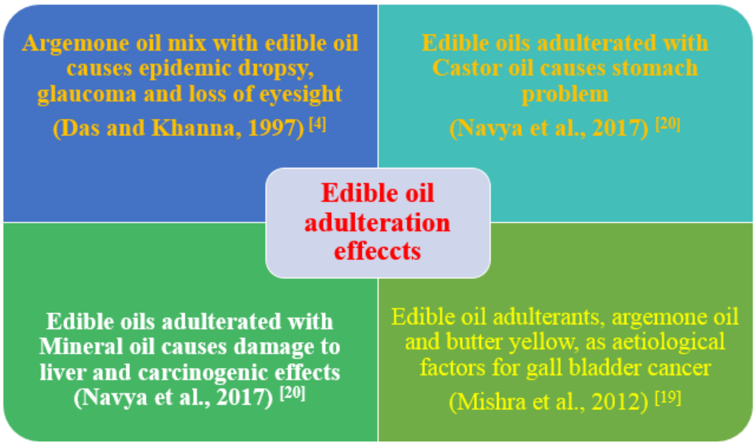


Fig 2: Techniques for edible oils adulterations detections

Saponification Value: It is the number of milligrams of KOH required to completely saponify one gram of edible oil. Since each carboxyl group of a fatty acid reacts with one mole of KOH during saponification, therefore, the amount of alkali needed to saponify certain weight of edible oil depends upon the number of fatty acids present per weight. Thus, edible oil containing short-chain acids will have more carboxyl groups per gram than long chain fatty acids and consume more alkali, i.e., will have higher saponification number.

Iodine Value: It is the number of grams of iodine absorbed by 100 grams of edible oil. It is a measure for the degree of unsaturation of the edible oil, as a natural property for it. Unsaturated fatty acids absorb iodine at their double bonds, therefore, as the degree of unsaturation increases iodine number and hence biological value of the edible oil increase. It is used for identification of the type of edible oil, detection of adulteration and determining the biological value of edible oil.

Acid Value: It is the number of milligrams of KOH required to neutralize the free fatty acids present in one gram of edible oil. It is used for detection of hydrolytic rancidity because it measures the amount of free fatty acids present.

Specific Gravity: Specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume. Apparent specific gravity is the ratio of the weight of a volume of the substance to the weight of an equal volume of the reference substance. It can be observed that the substitution of the edible oil with other types of edible oil, the specific gravity is increasing or decreasing greater than the maximum allowable value for the specific gravity. It can be observed a positively correlation between the substitution of edible oil and specific gravity.

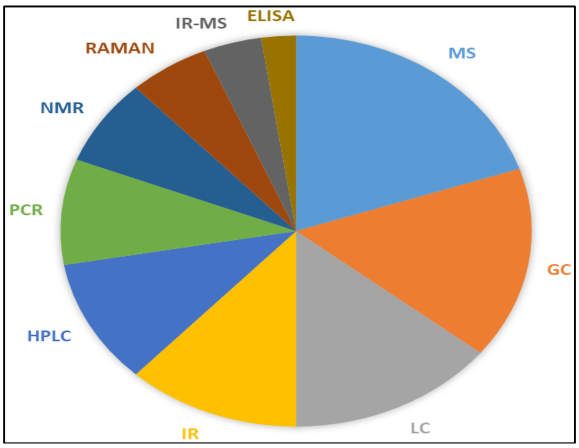
Refractive Index: In optics, the refractive index or index of refraction of a material is a dimensionless number that describes how light propagates through that medium. It is defined as: $n = c/v$

Where c is the speed of light in vacuum and v is the phase velocity of light in the medium. According to the EU regulations, the refractive index for extra virgin olive oil (EVOO) must range between 1.467 and 1.470. The EVOO substation with groundnut oil (in all the substitution percentages) decreases the value of the refractive index. The substitution of EVOO with 10%, 20%, 30%, 40% and 50% corn oil and sunflower oil maintain the refractive index at normal levels. The substitution of EVOO with sunflower oil had the highest influence on the refractive index.

Limitations

These are Insensitive at lower concentration and time consuming. They usage chemicals and requires maximal Sample preparations. They are insensitive in sophisticated adulterations.

Major Advance Techniques for Adulteration Detection in Edible Oils and Fat, as reported in the literature from 2005 to 2015



Source: Gromadzka and Wardencki, 2011

Fig 3

Fourier transform infrared (FTIR) spectroscopy is used in detecting adulteration of virgin coconut oil with palm kernel olein. Multi-bounce attenuated total reflectance measurements were made on pure and adulterated samples of virgin coconut oil. Detection of adulteration up to 1% was possible. Discriminant analysis using 10 principal components was able to classify pure and adulterated samples on the basis of their spectra (Manaf *et al*., 2007) [18].

Table 2: Fatty Acid composition (%) of Virgin coconut oil and Palm kernel olein

Fatty acid	Virgin coconut oil	Palm kernel olein
Iodine value	4.9	21.0
C6-C8	11.91	9.0
C12	49.69	45.0
C14	19.94	13.0
C16	8.83	9.0
C18	2.06	3.0
C18:1	6.36	19.0
C18:2	1.21	2.0

Source: Manaf *et al*., 2007

In number of cases, adulteration of Argemone mexicana seed oil in mustard oils has been reported as cause of epidemic dropsy. Oils are extracted from the seed and samples were analysed by HPTLC and it determined argemone oil adulteration up to lower concentration 0.5% v/v. Further quantitative evaluation may be used as quality control tool at manufacturer's level and public health laboratories (Sheler *et. al*., 2011) [22].

HPTLC fingerprinting is used for Adulteration detection of vegetable oil by mineral oils. Due to scarcity of vegetable oils, often it is adulterated with mineral oils. Mineral oils are listed as group 1 carcinogens to humans. The proposed HPTLC method was found to be simple, rapid, accurate and reproducible for the identification and estimation of mineral oil in various vegetable oils (Kumar and shree, 2014) [17].

The detection of adulteration of high priced oils is a particular concern in food quality and safety 28 fatty acids were identified and employed to classify five kinds of edible oils by using GC/MS. Fatty acid profiles of these edible oils could classify five kinds of edible vegetable oils into five groups and are therefore employed to authenticity assessment. Moreover, adulterated oils were simulated by Monte Carlo method to establish simultaneous adulteration detection model for five kinds of edible oils by random forests (Zhang *et. al*., 2014) [26].

A spectrophotometric method for detection and quantification of adulteration of olive oil with sunflower, corn and soybean oils was developed. This was done by measuring the characteristics of the absorption bands between 200 and 400 nm. It was found that max absorbance frequencies related to conjugated diene and triene systems which characterize the chemical composition of sunflower, corn and soybean refined oils was a wave length 268 nm. If the absorbance measured is higher than 0.2, this indicate that the sample is subjected to adulteration with other seeds and vegetables oils since olive oil at this wave length doesn't show high absorption values at 268 nm referring to the lack of poly unsaturated fatty acids (Amereih *et. al*., 2014) [1].

Table 3: Fatty acid composition of olive oil

	Type of oil (%)			
Type of fatty acid	**Olive oil**	**Corn oil**	**Soybean**	**Sunflower**
Stearic acid	05-5	2.0-5.0	0.3-4.1	1-7
Oleic acid	55-83	19.0-49.0	2.4-23.3	14-40
Linoleic acid	3.5-21	34.0-62.0	2.6-52.2	48-74
Linolenic acid	0-1.5	0-1	3.5-5.6	0.09-0.12
Absorbance at 268nm	0.17	1.97	2.5	1.49

Source: Amereih *et al*., 2014

Electrospray ionization mass spectrometry (ESI-MS) is used to analyse vegetable oils. This fingerprinting analysis was applied to genuine samples of olive, soybean, corn, canola, sunflower, and cottonseed oil, to admixtures of these oils, and samples of aged soybean oil. ESI-MS fingerprints in the negative ion mode clearly differentiate olive oil from the five other refined oils. The method is also shown to detect aging and adulteration of vegetable oils (Catharino *et. al*., 2005) [2].

Conclusion

It can be concluded that there is constant development of advance techniques for edible oil adulteration detection such as ESI-MS fingerprinting analysis which is applied to genuine samples of olive, soybean, corn, canola, sunflower, and cottonseed oil, to admixtures of these oils, and samples of aged soybean oil. ESI-MS fingerprints in the negative ion mode clearly differentiate olive oil from the five other oils. This method also detect aging and adulteration of vegetable oils. Now a days new advance techniques are appearing which use modern instruments, which are partially or fully automated. Most often their main advantage is the simplicity of performance and short times needed for individual analysis. Such methods include chromatographic techniques such as GC/MS, which is used to detect adulteration of edible oil with other vegetable oils about the level of 10% in peanut, sunflower, sesame, soybean and rapeseed oils. This model could identify five kinds of edible oils. This is very popular techniques in vegetable oil analysis. Spectrophotometric method for detection and quantification of adulteration of olive oil with sunflower, corn and soybean oils was developed. HPTLC method is developed for the identification of mineral oil and argemone oil in various vegetable oils. The presence of palm kernel olein as adulterant in virgin coconut oil can be successfully detected by using FTIR spectroscopy. A multivariate classification method such as discriminant analysis was able to classify pure and adulterated virgin coconut oil samples successfully down to an adulterated level of 1%.

Path/ Future prospects ahead

Edible oil adulteration detection by advance techniques, based on fatty acid profile is not so popular, so it should be considered in future research. Similarly, Geographical and seasonal variations in fatty acid profile of edible oils other than olive oil should also be considered in future research for authentication of edible oils.

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