

Fats and oils adulteration: present scenario and rapid detection techniques

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Abstract

Fats and oils are an essential part of everyday cooking as well as food products development and their purity are a concern since very early in human history. Adulteration of fats and oils is increased day by day throughout the world, a greater extent. Hence an attempt has been taken to review to identify different suitable rapid detection techniques for ensuring food quality and safety. The study was designed on the basis of extensive literature review for collecting relevant scientific evidence from various sources like Google Scholar, PubMed/Medline database, Science direct database, published journal, newspaper and periodicals. Various techniques have been utilized to assess the purity of edible fats and oils but yet they are costly and time-consuming. This study summarized the rapid detection techniques so that a common person can perform at the level of the household so as to have a broad picture of the status of adulteration in his food in case of doubt. Edible fats and oils are reported to be adulterated with other low-price oils. For example, mustard oil adulterated with argemone oil and butter yellow and ghee adulterated with vanaspati ghee. The leading challenges include the lack of market survey, lack of acceptance in the wholesale and retail market because of suspecting its purity, community health problem and decrease in consumer confidence.

1. Introduction

Edible oils and fats are essential nutritional requirements for humans and support the daily routine diet (Pitts *et al.*, 2007). But it's a matter of regret that, because of their greater demand in national and international market adulteration in high price oil with low price oil is a major issue (Yadav, 2018). Adulteration is not observed due to its small-scale use and its low impact but it is present in society for a long time. The main cause for adulteration is treachery, increasing their income by enhancing its volume and shortage of accidental quality assessment on suspected products. Also, adulteration is conducted by some selfish businesses by enhancing their margin of profit (Ayza and Yilma, 2014). As the world population is growing at an alarming rate, food is often adulterated to meet the needs of this growing population and to feed the large-scale population. Food adulteration is spread at a higher rate in most developed countries in the world. Among them, for

the last two decades, it turns into a very serious problem and causes serious threats of health risk of almost all populations (Majed *et al.*, 2016).

It was obvious from the past incidents of oil adulteration; palm stearin and olein (fractions of palm oil) have been mixed together or with palm oil to give a product of unknown and variable quality. Animal fats and hydrogenated oils are often mixed with Ghee to adulterate it. Synthetic flavours and colours are added to other fats in order to make their appearance as ghee (Choudhary *et al.*, 2020). Cheaper oil which is adulterated may also be characterized as if it were some oils of greater (pure) oil quality (Ebong *et al.*, 2014). Historically, detecting such deceit has been problematic because of the small database establishing appropriate purity criteria for authentic edible oils and fats. In several cases, it has been observed that castor oil, karanja oil, mineral oil, and artificial colours are profoundly used to adulterate edible oils (Navya *et al.*, 2017), edible

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soybean oil adulterated with linseed oil (Manandhar *et al.*, 1986) and virgin olive oil adulterated with cotton oil and sunflower oils (Kesen, 2019) and vegetable oil.

At present fats and oils adulteration has been a significant problem worldwide, and it is necessary to establish rapid detection methods (Kou *et al.*, 2018). It is very confusing for the consumers to select one food item because of deceptive advertisements, inappropriate media emphasis and food adulteration. As a result of these misconducts, the end-user gets victimized and subsequently suffers (Gupta and Panchal, 2009). Various procedures have been applied to assess the purity of edible oils and fats. In this study, a short review on edible fats and oils adulteration and their quick detection methods have been categorized. In order to find out adulterants from edible fats and oils different rapid and qualitative methods are being reported (Shukla and Dixit, 2005). Food organizations need to develop and adopt dependable techniques to sort out such impurities making markets and end-users more confident on the safety and purity of edible oils and fats.

The present study focuses on the rapid detection techniques for the identification of adulterated fats and oils. Also, this study expanded the horizon of knowledge regarding common food adulterants and to identify different types of food adulterants existing in various foodstuffs especially fats and oils.

2. Methodology

The extensive literature review was conducted for collecting relevant scientific evidence from various sources like Google Scholar, PubMed/ Medline database, Science direct database etc. using the keywords 'adulteration practice', 'detection technique of fats and oils' and 'adulteration scenario'. From the huge set of collected evidence, only those related to our concerned topic was screened for this brief narrative review.

3. Current scenario of fats and oils adulteration

It is seen that both branded and open edible oil selling within the markets and elsewhere are precariously polluted now. It was observed that about 31.25% of the packaged samples and 39.28% of the unpackaged samples were adulterated (Pal and Jain, 2018). The acts of pollution materialize at different platforms and phases of the production process right from the sector level right down to the consumers' end (Kamol, 2019). The research team has established adulteration in the samples of palm oil produced by Meizan and several other unbranded companies (Kamol, 2019). The mustard oil manufactured by Rupchanda, Radhuni, Teer, Fresh, Pushti, Shuresh, Danish and Boshudha have been found

to be adulterated because the moisture contents within the samples they have tested were found higher than the Bangladesh Standard Testing Institute (BSTI) limit of 0.25 per cent (Kamol, 2019). Other adulteration signs such as the saponification value, the peroxide value and the relative density value in many of these samples do not meet the standard, researchers disclosed (Kamol, 2019). Adulteration of food may be stated as reducing the purity of the food by replacement (intentional or unintentional) with some lower quality external element or by removal of some value-added food substitute from main food. The present scenario concerning the hygiene and safety standard of all foods markedly provide us with the shocking situation of adulteration globally.

4. Results and discussion

Foods are being adulterated by using various harmful chemicals and poisonous synthetic colours (Derek, 2013). It is easy to contaminate fats and oils among other food items. But from nutritional significance, their purity is a concern since very early in human history. Due to their higher demand in the market (both national as well as international) mixing of high price oil with cheap oil is a foremost concern (Yadav, 2018). Edible fats and oils are adulterated by mixing cold press oil with refined oil and also by replacing expensive fats and oils with cheaper ones. The replacement of more costly oil by lesser one is so profitable for related businesses and hence they get inspired to do that (Siger *et al.*, 2008) but detecting such adulterations are challenging. Common adulteration of mustard oil with butter yellow and argemone oil (Das and Khanna, 1997; Yadav, 2018) and also adulterated with cottonseed oil, mineral oil and castor oil (Navya *et al.*, 2017) was shown in Table 1. It was also observed from Table 1 that cold press oil is costlier than refined oil; hence, businesses get lured to admix them and thus refined oils are used to adulterate cold press oil (Azadmard-Damirchi and Torbati, 2015). It has also been found that synthetic colours, castor oil, karanja oil, and mineral oil are profoundly used in adulterations of edible oil (Navya *et al.*, 2017). Adulteration of pure cow and buffalo ghee with palm oil, soybean oil, vegetable oil, animal body fat, buffalo depot fat (Kumar *et al.*, 2013; Gandhi *et al.*, 2014), mixtures of oils and fats in cow milk fat (Kumar *et al.*, 2010; Azadmard-Damirchi and Torbati, 2015).

Some vegetable oils and fats (VOFs) have a great value which is alluring for defrauders and hence they adulterate them with lower grade less expensive fats and oils to get more profit. Adulteration of vegetable oil is a universal problem irrespective of area or country. Another case is mustard oil adulteration with noxious argemone oil (de la Paz *et al.*, 1996; Clemente and

Table 1. Different types of fats and oils and their adulterants

Fats and oils	Adulterants	References
Mustard oil/Edible oil	Argemone oil, papaya seed	Das and Khanna (1997)
	Argemone oil (poisonous)	Clemente and Cahoon (2009); de la Paz <i>et al.</i>
	Palm oil and others vegetables oil	Navya <i>et al.</i> (2017)
	Argemone oil, mineral oil, castor oil, prohibited color and dyes in fat	
Virgin olive oil	Argemone oil and butter yellow	Yadav (2018)
	fatty acids and sterols of similar composition	Azadmard-Damirchi and Torbati (2015)
	Adulterated with vegetables oil like peanut oil, soybean oil, mustard oil,	Christopoulou <i>et al.</i> (2004)
	Hazelnut oil	
Sunflower oil	Vegetable oil	Johnson (2014)
	castor oil , palm oil and Paraffin	Abhirami and Radha (2015)
	Argemone oil, mineral oil, castor oil	
Loose edible oil	Cottonseed oil and rapeseed oil	Navya <i>et al.</i> (2017)
	Palm oil or other cheap oils, castor oil, artificial colours and karanja oil	Azadmard-Damirchi and Torbati (2015)
Cold press oil	Refined oils	Safety and Road (2012)
Butter	Vegetable oil, anatta, banana, oleomargarine	Buchgraber <i>et al.</i> (2007); Ulberth and Buchgraber (2003)
	Mashed potato, sweet potato	
Cocoa butter	Non-cocoa fat, Cocoa butter replacers/substitute	Ayza and Belete (2015)
	Vanaspati, anatta, and oleomargarine, hydrogenated oils, animal fats and	
Ghee	Animal fat or palm oil	Majed <i>et al.</i> (2016)
	Coal tar	Navya <i>et al.</i> (2017)
	Vanaspati/margarine, starches and mashed potatoes, rancid stuff, coloring matter and coalter dye	
	Vanaspati, paraffin and smashed potato	
	Goat body fat	Kumar <i>et al.</i> (2010); Upadhyay <i>et al.</i> (2016)
Cow and buffalo ghee	Palm olein and sheep body fat	Gandhi <i>et al.</i> (2014)
	Vegetable oil	
	animal fats and vegetable fats/oils	
	Animal body fat	
	Soyabean oil	
Milk fat	Vegetable oil, Buffalo depot fat	Kumar <i>et al.</i> (2013)
	Foreign fats/oils	Gandhi <i>et al.</i> (2014)
		Kumar <i>et al.</i> (2010); Azadmard-Damirchi and Torbati (2015)

Cahoon, 2009) (Table 1). Among VOFs, some have a specific element that might be absent in another one. For example, (E)-5-methylhept-2-en-4-one (filbertone) is recognized as a flavouring constituent of hazelnuts which is present in moderate amounts in the oil of hazelnut (Fox *et al.*, 1988; Ruiz del Castillo *et al.*, 1998; Ntakatsane *et al.*, 2013). Brassica sterol is mainly found in canola oil and sesamol, sesamon or sesamol are present entirely in sesame oil (Azadmard-Damirchi and Torbati, 2015). Ghee provides many amazing health benefits but it's a matter of regret that it is adulterated with vanaspati, hydrogenated oils, animal fats, synthetic colours, and coal tar (Ayza and Belete, 2015), also adulterated with paraffin and smashed potato (Navya *et al.*, 2017). The overall adulteration summary of different fats and oils are given below with their possible adulterants (Table 1).

Today, adulterations are greater state-of-the-art. Therefore, it's far vital to apply superior and appropriate techniques to come across adulteration. Even though sophisticated laboratory protocols are reliable, precise and accurate but still they are expensive to conduct and also requires much time to operate. Hence it is useful to develop feasible and reliable "quick detection techniques" which a non-technical individual can carry out at the household level which will have a vast photograph of repute of adulteration in his foods in time of uncertainty. For the detection of adulterated mustard oil, about 3 mL of mustard was placed in a test tube. Then 2 mL of amyl alcohol, 1 mL of carbon disulphide and a little amount of sulphur were placed in the test tube. After plugging the mouth of the test tube, heated it and observed a red coloration that indicates the presence of cottonseed oil in

mustard oil (Azadmard-Damirchi and Torbati, 2015) (Table 2). It was also shown from Table 2 a separate colour layer was found when 5 mL of edible oils gently shaking with 5 mL of concentrated HCL, indicating the presence of prohibited colour in edible oils (FSSAI, 2012). The presence of cyanide in coconut oil was detected by adding 10 drops of alcoholic potash in 3 mL samples containing a test tube. Heated the test tube, and added addition of a little amount of each of the ferrous sulphate and ferric chloride in the test tube. After mixing properly 3 mL hydrochloric acid was added to it. The blue coloration indicates the presence of hydro cyanide acid due to the presence of cyanide in coconut oil

(FSSAI, 2012). The other sample of oil will get solidified after refrigerating leaving a separate layer of adulterant (FSSAI, 2012). By observing an orange colour of 5-phenylazo- γ -oryzanol or 5-phenylazoferulic acid when sample oil is treated with benzene diazonium chloride solution at 0-5°C, denotes the presence of adulterants in rice bran oil (Shukla *et al.*, 2004). The presence of mashed potatoes and sweet potatoes in a sample of ghee can easily be detected by adding a few drops of Iodine, which is brownish in colour turns to blue if mashed potatoes/sweet potatoes/other starches are present (FSSAI, 2012). The appearance of crimson colour in lower (acid) of vanaspati or margarine when

Table 2. Rapid detection techniques of fats and oils adulterations

Food Article	Adulterants	Detection ways of adulteration	References
Mustard oil	Super soybean oil	By detecting separate colors with the help of a HCL-based kit.	Supriya (2020)
	Cotton seed oil	By observing a red coloration after heating with amyl alcohol.	FSSAI (2012)
	Argemone Oil	By seeing a red color after adding nitric acid in the sample.	Abhirami and Radha (2015)
Soybean oil	Palm oil	Separate layer of color will be observed after gentle shake in a nitric acid based kit.	FSSAI (2012)
Edible oil	Prohibited color	A layer of color will be observed after adding and shaking the sample with HCL.	FSSAI (2012)
	Rancidity	The appearance of white color turbidity with the help of ammonium molybdate reagent	
Coconut oil	Any oil	Sample of oil will get solidified after refrigerating leaving a separate layer of adulterant.	FSSAI (2012)
	Cyanide	Presence of blue color in the sample after addition of alcoholic potash, ferrus sulphate and ferric chloride consecutively.	
Olive oil	Vegetable oil	Detected by conventional methods at below 5 % adulteration level	Christopoulou <i>et al.</i> (2004)
Rice bran oil	Any other oil	By observing an orange color of 5-phenylazo- γ -oryzanol or 5-phenylazoferulic acid when sample oil is treated with benzenediazonium chloride solution at 0-5°C	Ulberth and Buchgraber (2003)
Sunflower oil	Palm oil, castor oil and Paraffin	Using colorimeter	Abhirami and Radha (2015)
	Castor Oil	By the addition of 10 mL petroleum to the sample oil and observing the white turbidity.	
	Argemone oil	A layer of red-brown color will indicate adulteration with argemone oil when mixed with nitric acid.	FSSAI, 2012)
	Mineral oil	Heating with alcoholic potash and the presence of turbidity will indicate adulteration with mineral oil.	FSSAI, 2012)
Ghee	Super palm oil	By observing a color layer using a DPPH (2, 2-diphenyl -1-picrylhydrazyl) -based kit.	
	Rancid stuff (old ghee)	By seeing a pink-red color layer at the bottom after the addition of HCL and an ether solution	
	Synthetic coloring matter	The appearance of pink color or yellow color in acidic or alkaline solution will indicate coloring matter.	FSSAI (2012)
	Vanaspati	The presence of vanaspati will be detected by shaking the sample with furfural solution.	
Ghee/ Butter	Mashed potatoes, sweet potatoes and other starches	Can be detected easily by adding two drops of iodine and consequently observing a blue color.	FSSAI (2012)
	Vanaspati/ margarine	By adding HCL and observing a crimson color layer.	
Vegetable oil/Gingerly oil	Castor oil	Formulation of turbidity might be observed after adding ammonium molybdate reagent	
	Argemone oil	Yellow, orange or crimson color layer will indicate adulteration after adding HNO ₃	Abhirami and Radha (2015)
	Mineral oil	The appearance of turbidity after addition of alcoholic potash and 10 mL of water.	

one teaspoon full of the melted sample of ghee with equal quantity of concentrated HCL acid and a pinch of sugar in a stoppered test tube (FSSAI, 2012). The appearance of turbidity indicates the presence of mineral oil when 2 mL of alcoholic potash and 10 mL of water are added to 2 mL of oil sample (Abhirami and Radha, 2015), white turbidity might be observed after adding a few drops of ammonium molybdate reagent in the mixture of 1 mL of the oil and 10 mL of acidified petroleum ether (FSSAI, 2012). A study reported a test for detection of neem oil (0.5%) in others oil by observing the change in colour on heating at 200°C with the help of thin copper strip (Ramachandraiah et al., 1974). Another study observed colour reactions of vegetable oils with Carr-Price reagent (A chloroform solution of antimony trichloride) (Provedi, 1936). The summary of rapid detection techniques of fats and oils adulterations pointed in Table 2.

5. Conclusion

Various edible fats and oils such as mustard oil, olive oil, sunflower oil, ghee, butter and cocoa butter were commonly adulterated by the inferior seeds oil and low-price vegetable oils. In this current situation, some acid-based or alkali-based colour changing rapid detection kits were developed for the identification of fats and oils adulteration rapid and quickly in the market areas. To get purity of edible oils and fats, consumers should be aware of those adulteration processes and the law enforcement agencies should be more observant for proper implementation of the law.

Conflict of interest

The authors declare no conflict of interest.

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