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An Overview on Edible Oils with Integrity Approach

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ABSTRACT: The issue of the integrity of edible oils and fats can be considered in three main areas of safety, authenticity and quality in accordance with the standardization approach. Safety is the most essential part of the food, including edible oils, due to effects on health of consumers. Authenticity equivalent to purity is also an important aspect of this approach. The nature and prevention of fraud in the trade are examples of this part. The role of quality part in respect of nutritional value, durability during storage and apparent characteristics in terms of acceptance and satisfaction of consumers is indisputable.

Keywords: *Authenticity, Edible Oils, Integrity Approach, Quality, Safety*.

Introduction

Edible oils play a key role in the health issue, global trade and the economy chain. Oilseeds and edible oils are the third largest agricultural product after cereals and meat as the world's strategic products. Therefore these are considered as an important segment of agricultural economy of the world (Popkin, 2011). The production, consumption and application of edible oils, especially vegetable oils in the world are increasing due to its importance in the food industry. The impact of edible oils and fats in the production of energy, the supply of nutrients and essential fatty acids, functional properties, appearance and sensory evaluation of the consumption of the household and the industry is critical. On the other hand, base on health issue, placement of edible oils in the food pyramid and its consumption are also considered very serious matters. The type and amount of fatty acids in respect to chain length, saturation and unsaturation status and their spatial structure (in terms of cis and trans isomers), as well as the stereospecific number (sn) in the triglyceride structure according to WHO nutritional recommendations are health priority for selecting and consuming edible oils in each country (Ip, C. 1997 & Kostik *et al*., 2013). Therefore, regarding the importance of edible oils, the necessity for an integrated standardization evaluation is required (Shokroalahi & Piravi Vanak, 2013). Therefore the object of this study is oriented to apply an integrated approach based on three sections of edible oil assessment that include safety, authenticity and quality in terms of its key indicators that can be made sustainable.

- *Safety issues*

Contaminants are considered the main base of safety issue in respect of edible oils. In fact the presence of contaminants in edible oils as undesirable fraction might be

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related to many different origins. Chemical compounds such as metals, Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs), Dioxin and mineral oil can be induced by environment. Production process such as deodorization in physical refining can lead to the formation of 3- Mono Chloro Propane Diol (3-MCPD), and Glycidyl Esters (GE). Migration of lubricant and phthalates from packaging to edible oils can occur during transport and storage. Transportation and storage might also be sources of contamination with mineral oil and chemicals. Therefore the code of practice and rules of standard for the transport of fats and oils in bulks have been carried out in Codex as an international standard. (CAC/RCP 36, 2015)

- *Heavy metals*

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 times greater than that of water. Their multiple industrial, domestic, agricultural, medical and technological applications have led to their wide distribution in the environment. Therefore the main reason for the presence of heavy metals such as arsenic, lead, cadmium or mercury in oils is related to the environmental pollutants. For some of these metals, limited values in edible oils have been established by international organization such as Codex Alimentarius (Codex stan 193, 2017). Vegetable oil refining is an efficient process on metal removal, such as lead that might be present in virgin and cold pressed oils. Studies have shown that when the crop is cultivated in the soils that contains heavy metals; the metal is concentrated mostly in the meal after seed crushing. However regarding the existence of regulations and methods of recognitions and detections concerned with heavy metals, they are not considered as real risk. (Lacoste, 2014)

- *Polycyclic Aromatic Hydrocarbons (PAHs)*

Polycyclic Aromatic Hydrocarbons (PAHs) are formed by incomplete combustion or pyrolysis of organic material such as wood, petroleum products, coal or food. PAHs have been detected in different types of food particularly grilled meat, cereals, fats and oils. Their presence in vegetable oils may be linked either to environmental contamination or production process. PAHs are divided into two groups according to the number of aromatic rings (Figure 1). The light PAHs have two or three rings or low molecular PAHs and heavy PAHs that is consisted of four or six rings or high molecular weight (EFSA, 2008). A number of heavy PAHs are known to be carcinogens and/or mutagens, including 16 that have been proposed by the US Environmental Protection Agency (EPA). The European Commission has fixed a limit for PAHs in vegetable oils and the codex alimentarius developed a code of practice for the reduction of contamination of food with PAHs from smoking and direct drying processes (CAC/RCP 68, 2009). Referring to the European Food Safety Authority (EFSA) opinion from 2008 and Commission Regulation (EU) No. 835/2011 of 19 August 2011 benzo[a]pyrene (BαP) is not alone a suitable marker for the occurrence of other PAHs in food and hence a system of four heavy specific PAHs that include benzo[a]pyrene(BaP), benzo[a]anthracene(BαA), benzo[b]fluoranthene(BβF) and chrysene (CH) would be the most suitable indicators of PAHs in food and edible oils.

Vegetable oils due to the mentioned reasons can be contaminated with PAHs. Meanwhile some vegetable oils such as coconut oil, pomace olive oil, grape seed oil, sunflower seed oil and sesame oil contain more of these compounds. The common aspect among these vegetable oils is drying before oil extraction. When raw material is dried, if it comes into direct contact with combustion smoke, or if temperature is too high, contamination by PAHs is possible. Since PAHs are very lipophilic, they concentrate in the oil during extraction. Crude oil can therefore contain large quantity of PAHs. During the refining process all PAHs should normally be reduced or eliminated. Light PAHs are eliminated by the deodorization step, whereas heavy ones are eliminated when treated with acid activated earth or carbon active during bleaching process. If different refining stages are not managed correctly, refined oils might contain trace quantities of PAHs (Lacoste, 2014).

Despite the regulation and recognized methods for evaluation and determination of PAHs in vegetable fats and oils, the occurrence of PAHs in oils might present a risk if the seed or extracted oils and fats are not handled properly during pre, post harvest and refining stages. (Taghvaee *et al.*, 2016)

- *Mineral oils*

Mineral oils are complex mixtures of hydrocarbons varying in carbon number and structure. Mineral oil saturated hydrocarbons (MOSH) consist of linear and branched alkanes (paraffins), and alkyl-substituted cyclo-alkanes (naphthenes), whilst mineral oil aromatic hydrocarbons (MOAH) include mainly alkyl-substituted poly aromatic hydrocarbons (Biedermann & Grob, 2009). Contamination of vegetable oils with mineral oil might drive from environment, crop protection, production process, or transport and storage. The European Commission set a regulation in 2009 (EC No. 1151/2009) to limit oil mineral content in vegetable oils. The occurrence of mineral oil might present a risk for some vegetable oils.

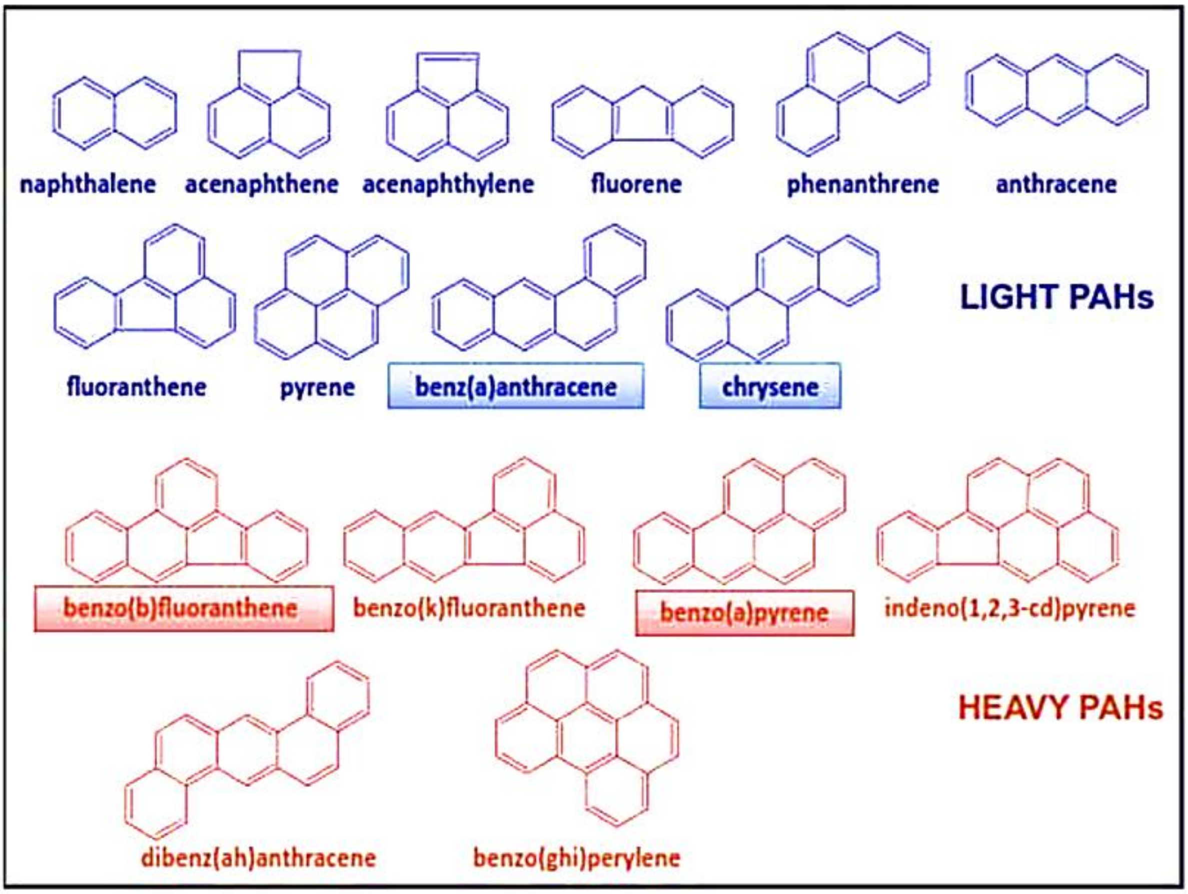

Fig. 1. The structure of PAHs

- *Phthalates*

Phthalates are esters of phthalic acids with different alcohols. The most important phthalate is di-(2-ethylhexyl)-phtalate (DEHP) that accounts for about 50% of the world production of phthalates. Phthalates are a group of chemicals used to soften and increase the flexibility of plastic and vinyl and as plasticizers are not chemically bounded to the polymer. Migration of phthalates from plastic materials in significant amounts is possible during production process, transport or storage. Due to their high affinity for fat, phthalates are soluble in oil and therefore are commonly found in fat-containing foods. Adverse effects of phthalates on the reproductive system have been reported based on animal studies. Phthalates are suspected to be endocrine disruptors. The effect of refining on phthalate removal was studied in chemical refining conducted to eliminate the phthalates and the removal was reported between 19% to 87% depending on the molecular weight of the phthalate, while, physical refining caused total removal of phthalates (Lacoste, 2014).

- *3-MCPD Esters and Glycidyl Esters*

3-monochoropropane-1, 2-diol (3-MCPD) and 2-monochloropropane-1, 3-diol (2-MCPD) (chlorinated propanols) have been known as food contaminants. These compounds are formed during high-temperature process of different food products such as coffee, edible oils, infant formula, potato based products, bakery products, malt, cooked meat, soya sauces and pickles (Figure 2). In vegetable oils, these compounds are formed during refining, particularly during deodorization stage. The studies concerned with MCPD content and the mechanisms of its formation in vegetable oil are new areas of research. Carcinogenic characteristics of these ingredients are a general concern these days. In refined vegetable oils, significant quantities of fatty acids are esterified to 3-MCPD and esterified glycidyl has been reported especially in palm oil. According to the latest scientific knowledge, 3-MCPD esters and glycidyl esters are formed during oil refining especially the deodorization step. 3-MCPD contents higher than 2 mg/kg are observed in palm oil. The presence of diacylglycerols (DAG) is usually associated with 3-MCPD because they have been identified as the potential precursors. The occurrence of 3-MCPD esters and glycidyl esters can be considered a risk for some vegetable oils such as palm oil (Cheng *et al.*, 2017).

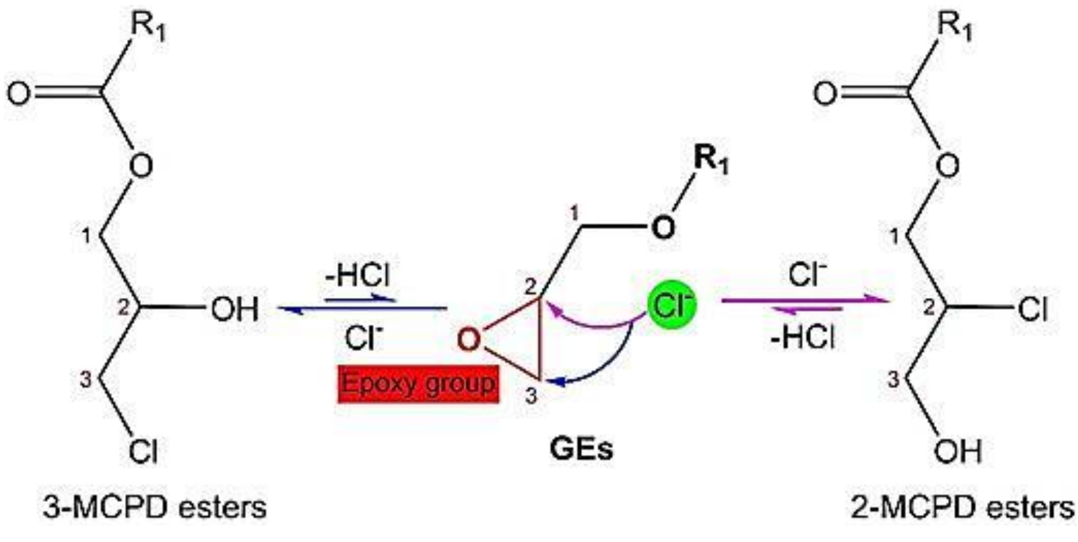

Fig. 2. Potential conversion mechanism of GEs to 3-MCPD esters or 2-MCPD esters.

- *Authenticity or purity characteristics*

This section is equal with compositional specifications which are necessary to determine the identity and purity of edible oils and fat. Regarding the unique properties of some edible oils that make them high in quality and price, their authenticity is a serious issue. Some edible oils and fats namely cold pressed oil, due to their high cost and temptation might be the subject of adulteration in order to provide the product with lower price. (Azadmard-Damirchi & Torbati, 2015). Today, adulterations are more sophisticated. To detect edible oils and fats adulteration, it is possible to use both major and minor components as detection tools. Since each oil and fat may have an especial component at a known level, their presence and concentrations should be considered as a detection tool. Several methods have been used to check the purity of edible oils and fats. There is a necessity for food related organization to develop and utilize reliable methods to detect such adulterations that can make consumers and markets more certain on authenticity and purity of edible oils and fats. These properties are well arranged in adulterated edible oil to mask the adulteration. Edible oils and fats consist of major and minor components. Major components in edible oils are triacylglycerols (TAG) and fatty acids and minor components are sterols, tocols (tocopherols and tocoterinols), polyphenols and color markers (carotenoids and chlorophylls) **(**Salmanizadeh & Piravi Vanak, 2013; Piravi-Vanak *et al*., 2009; Piravi-vanak, 2012**)**. According to global pattern, applying all of the factors due to fully evaluation is essential. The followings are some important purity factors:

- *Fatty acid composition*

Fatty acid composition is the main part of triacylglycerol structure. Based on the nature and concentration of fatty acids present one might recognize the source of edible oils and fats.

Although this item is considered as main parameter in international standards and trade but in recent years due to novel technologies and processes such as genetic manipulation, interasterification, and fractionation is not as effective as before. Meanwhile, to the specified limits it is possible to blend inexpensive oils with expensive ones. (Soha *et al*., 2015)

- *Sterol composition*

Sterols are the most important and major part of the nonsaponifable matter in edible oils and fats. This parameter might be used for determination of different varieties of oils. In fact sterol compositions for different sources of edible oils are different (Piravivanak and Pourfalatoon, 2015). The main phytosterol of vegetable oils is β-sitosterol and the main sterol of animal fats is cholesterol. The variation of phytosterols along with the concentrations is considered composition parameters regarding the edible oil purity.

Thermal processing particularly in the presence of bleaching earth might affect the sterol content and composition of the vegetable oils. The steroidal hydrocarbon produced might indicate the changes. (Soha *et al.*, 2015).

- *Tocols*

Vegetable oils contain various quantities of tocopherols and tocotrinols while body fats namely tallow and lard are deficient in these compounds. Therefore these compounds might be employed for identification of vegetable oils. The concentration of each tocopherol or tocotrienol and total tocols are important in detection and purity evaluation. A good example for applying this section is the identification of palm oil and its fractions which the content of tocotrienols are more than other vegetables oils. These compounds are sensitive to heat and chemical processing and have been affected during refining stages. (Azadmard-Damirchi and Torbati, 2015; Codex Stan 210 20017).

- *Triacylglycerol (TAG)*

TAGs are the most important structure in lipids and make up about 95 to 98 percent of the edible oils. Identification and determination of TAGs are the best way to achieve the nature and purity of edible oils. The positions occupied by the fatty acids are numbered relative to their (stereospecific numbering) sn in TAGs and can provide information concerned with identity and purity of the oils. Therefore TAGs is the best standard approach for edible oil authenticity and has been considered the efficient method for fraud detection and purity evaluation of milk fat, cocoa butter and olive oil (ISO17678). Beside that sn-2 in TAGs structure is helpful in identification of Interesterified fat. (Alavian and Piravi, 2014; Piravi-Vanak *et al*., 2009; Piravi-vanak, 2012).

- *Quality*

The quality of edible oils can be highlighted, with the safety and authentication items correctly implemented. In fact, a qualitative assessment, regardless of infrastructure elements (safety and authenticity) is worthless. Qualitative parameters related to edible oils have been categorized in appearance and/or sensory evaluation and sets of parameters that can be effective on the stability of oils for different applications and production condition. Moreover nutritional value and other information in the labeling has a key role as a guide for consumer. In the first category of quality that covers organoleptic assessment, parameters appearance such as color, turbidity, liquid or homogeneity and texture are considered. In addition flavor that is composed of odor and taste is applied as an important specification for classification and grading of edible oils in particular for virgin and cold pressed oils. The second category consists of oxidative criteria such as primary and secondary oxidation products that is determined by peroxide, anisidine, totox values, conjugated diene and extinction coefficient. Furthermore parameters such as free fatty acid, impurities, water content, minor metals, soap content that are able to affect the stability, shelf life and appearance regarding the production practices are considered quality parameters. (Codex stan 210, COI/T.20/DOC.15, CAC/GL2 1985).

Conclusion

Safety item such as heavy metals, PAHs, mineral oils, Phthalates**,** MCPD and GEs, along with purity criteria namely fatty acid profile, sterol composition, triacylglycerol structure, biomarkers, tocols and minor compounds and quality matter related to appearance and sensory assessment with a few parameters of products that indicate agriculture, production, storage and packaging conditions are considered the main basis of integrity of edible oils approach according to the standards. Safety issue and health concern is very critical due to their risks for the health of the people. Authenticity related to composition, nature and identity that might indicate the adulteration is the second part of this integrated approach. Quality function namely appearance, nutritional value and sets of parameters is related to the production and storage conditions is regarded as the third part of this approach.

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