Bulletin of the National Research Centre

REVIEW Open Access

Production of vegetable oils in the world and in Egypt: an overview

Mona El-Hamidi* and Ferial A. Zaher

Abstract

This article throws a light on the recent situation of oilseed as well as vegetable oil production in the world referring to those in Egypt. Over the last 30 years, the oil crop production in the world increased 240%, while the increase in area and in yield was 82 and 48%, respectively. The main oilseed produced in the world is the soybean whereby it represents more than 50% of total oil crop production in the world. Most common oilseed types which are currently available in the world are categorized in this article according to the suitability for their oils for human consumption and whether they are considered as a source of some functional ingredients. Oils which are suitable for human consumption include sunflower, canola, soybean, cottonseed, groundnut, linseed, sesame, and moringa oils. The chemical composition of these oils as well as their content of specific functional components have been summarized and compared. In addition, oilseed which yields oils unsuitable for edible purposes such as high erucic acid rapeseed, jatropha, jojoba, and castor oilseed is also assessed for its suitable uses in non-edible purposes.

Keywords: Oilseed, Edible oil, Non-edible oil and vegetable oil

Introduction

In view of the exponential fast increase in the world population in addition to the increase in the consumption rate per capita of food as well as energy, two main crises are currently facing the whole world which are the food and energy crises. Global human population increases about 75 million annually or 1.1% per year (World Population Data Sheet, 2014). It has grown from 1 billion in 1800 to 7 billion in 2012. It is expected to keep growing, where estimates have put the total population at 8.4 billion by mid-2030 and 9.6 billion by mid-2050. On the other hand, Egypt's population increased from 59.6 million in 1996 to 72.6 million in 2006, and then, it increased to 94.8 million in 2017 (https://www.almasryalyoum.com/news/details/1198599, n.d.). Therefore, it seems that food and energy crises will definitely become worse in the very near future.

Vegetable oil which can be extracted from oilseed is considered one of the main components of our food, and it can be also used for the production of non-conventional alternative fuels. In view of the crises of food as well as energy facing the whole world, it becomes necessary to look for increasing the area of land to be cultivated with oilseed as to cover the needs of oil for edible and non-edible purposes. Also, it becomes necessary to improve the quality of some oilseed via genetic engineering as to yield oilseed richer in oil content and to modify the chemical composition of the oil so that it will become more suitable for edible purposes.

A huge variety of oilseeds is well known worldwide which can be classified into two main categories. The first category includes oilseeds which have a potential as a source of oils that can be safely used for human consumption. The other category, on the other hand, has a potential as a source of oils which cannot be used for edible purposes, but they have a potential for the production of several types of oleo-chemicals of multiple applications in the industry. Oilseeds which can yield edible oils are also categorized into two subclasses. The first is conventional oilseed that can yield oils for every day edible purposes such as sunflower oil, canola oil, and soybean oil. The other class of oilseeds is non-conventional that yield oils that have some beneficial functional properties such as flaxseed oil and is normally used in rather small doses.

This article will throw a light on the recent situation of oilseed as well as vegetable oil production in the

* Correspondence: mona32001@hotmail.com
Fats and Oils Department, National Research Centre, 33 Bohouth St. Dokki, Giza, Egypt

world referring to those in Egypt. Within this scope, the different common types of oilseeds available in the world will be categorized according to the type of oil that can be extracted from the seed and whether it is suitable or unsuitable for human consumption. The composition and properties of these oils will be outlined and compared. The opportunities of the use of non-edible types in industrial applications will be also discussed.

Current situation of oilseed and vegetable oil production in the world

World trends in oil crop production, yield, and growing area

World trends in oil crop production, yield, and growing area over the last 30 years are represented in Fig. 1 (FAOSTAT, 2014). The production increased 240%, while the increase in area and in yield was 82 and 48%, respectively. The world production of different oilseeds over the years from 2012 to 2016 is compared in Fig. 2 (European Commission, 2017). It is clear that soybean production is the highest being more than 50% of total production. The production of soybean in the different countries over the years 2012/2016 are compared in Fig. 3 (European Commission, 2017). It is clear that the USA is the largest producer followed by Brazil and Argentina.

Global oil production and their utilization

The change in global production of oils and fats shown in Fig. 4 (FAO-Trade and Markets Division, 2013) is indicating an increase from about 164 million tons in 2008/2009 to around 185 million tons in 2011/2012. It was under-utilized in 2011/2012 whereby the quantity utilized was less than the quantity produced.

Status of oilseed production in Egypt and the gap between consumption and production rates of edible oils in Egypt

Current situation of edible vegetable oils in Egypt

Edible vegetable oil production in Egypt has faced countless problems. During the 1960s, Egypt was independent in palatable vegetable oils, whereby self-sufficiency proportion was 95% (Hassan and Sahfique, 2010). This proportion has declined to be 31.6% in 2007. This has prompted the expanding of the volume of oil imports to achieve 5.6 thousand tons at an aggregate expense of L.E. 1.992 billion in 2007. The issue became more terrible because of the reliance of the edible oil industry in Egypt on imported crude materials so that the private area's reliance proportion was around 85%.

Current situation of oil crop production in Egypt

Most vital oil crops in Egypt are cotton, sunflower, and soybean despite the fact that olives, sesame, canola, peanuts, and safflower are also wellsprings of vegetable oils. Egypt does not rely on upon them for oil production. Cotton crop that is one of the dual-purpose crops is generally grown for textile industry. The cotton seeds are then utilized to produce crude cottonseed oil either by pressing or by solvent extraction or by both of the two technologies together. Cotton seeds contribute to

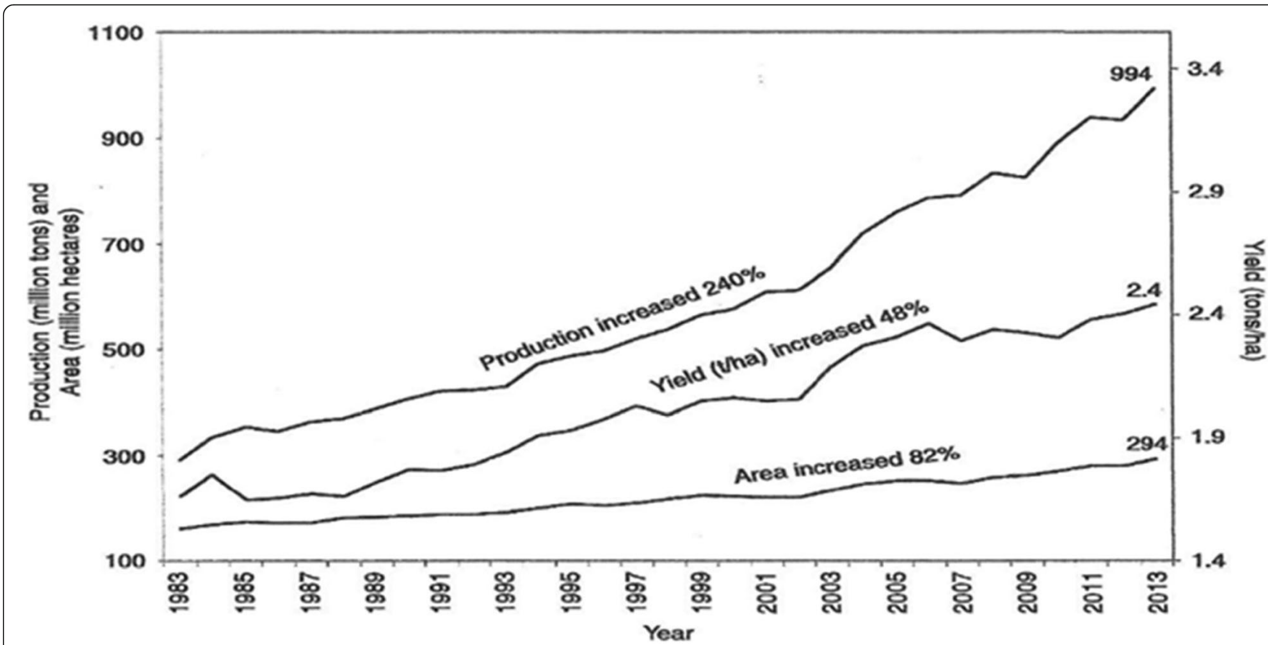

Fig. 1 World trends in oil crop production, yield, and growing area over the last 30 years. [Source: FAOSTAT (FAOSTAT, 2014)]

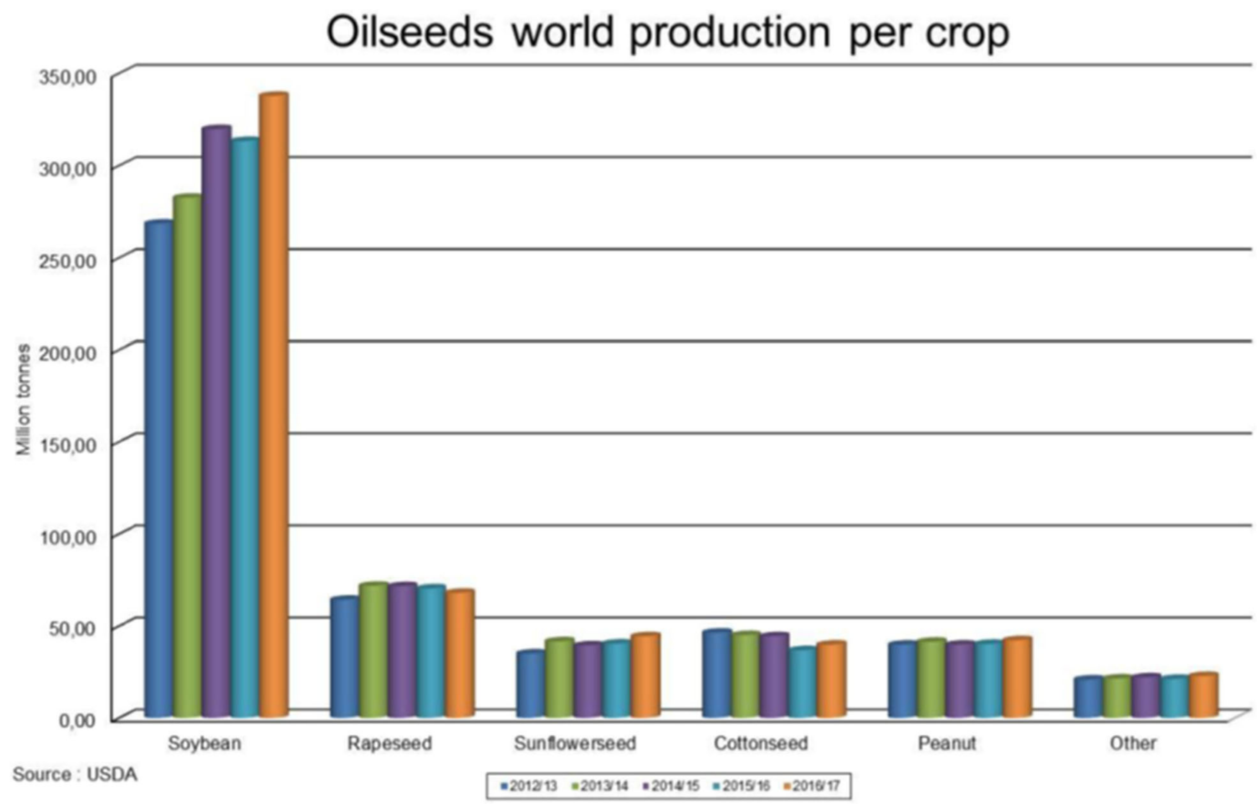

Fig. 2 Oilseed world production per crop over the years from 2012 to 2016. [Source: USDA (European Commission, 2017)]

Egypt's production of vegetable oils by about 90% (Ministry of Agriculture and Land Reclamation, 2007).

The area cultivated by cotton was 993 thousand feddans in 1990, but it declined to 471 thousand feddans in 2007. Seed production increased from 476 thousand tons in 1990 to 518 thousand tons in 2007, up by 8.8% due to the rise in productivity during that period. The approximate oil content in cotton seed is 19% (The Arab League for Nutrition Industries, 2007).

Soybean is believed to be the main basis of vegetable oil at the global level even though its oil content represents merely 20% of its weight. The area cultivated by soybeans in Egypt has been declined recently, where it declined from 99 thousand feddans in 1990 to 18.5 thousand feddans in 2007, down by 81% compared to 1990. Total production of soybeans decreased from 106 thousand tons in 1990 to 25.6 thousand tons in 2007. This represents about 24% of the total production volume of soybean in 1990 (Ministry of Agriculture and Land Reclamation, 2007).

Sunflower crop was introduced in Egypt in 1987, and the oil content of its seed ranges between 39 and 46% (The Arab league for Nutrition Industries, 2007). The Minister of Supply and Internal Trade indicates that Egypt will accomplish sunflower oil creation self-sufficiency by nurturing lands and refining edible oils in bordering Sudan. The present Egypt-Sudan agreement calls for Sudan to furnish 2 million feddans (roughly 840,000 ha) north of Khartoum for some purposes as a biofuels, pharmaceutical, and supplementary unspecified uses (USDA, 2015). There has been no authorized clarification to date as to how far edible oil will be produced in Sudan for Egypt as portion of this arrangement. Egypt and Sudan have a poor trail record on requesting joint venture projects. Transportation links are additionally lacking (USDA, 2015).

Regarding the cultivation of canola in Egypt, an experimental work has been done by Elewa et al., 2014 on the field of growth, yield, and seed quality of three canola varieties in Egypt during the two successive winter seasons 2011–2013. They concluded that the three canola varieties can be grown successfully in newly reclaimed sandy soil in winter season in Egypt.

Recently, jatropha tree has been cultivated in Egypt to be a source of oilseed that yields an oil which has a potential as an alternative fuel for diesel engines. Plantation of Jatropha was started since 2005 in Luxor governorate (Upper Egypt). The current area planted by Jatropha is 200 ha which is expected to yield 378 tons jatropha oil annually (El Diwani et al., 2009). Surprisingly, Jatropha plantation in Luxor has proved to be better than its counterparts in other countries. Moreover, Egypt had successfully grown jatropha trees and harvested seeds by using wastewater.

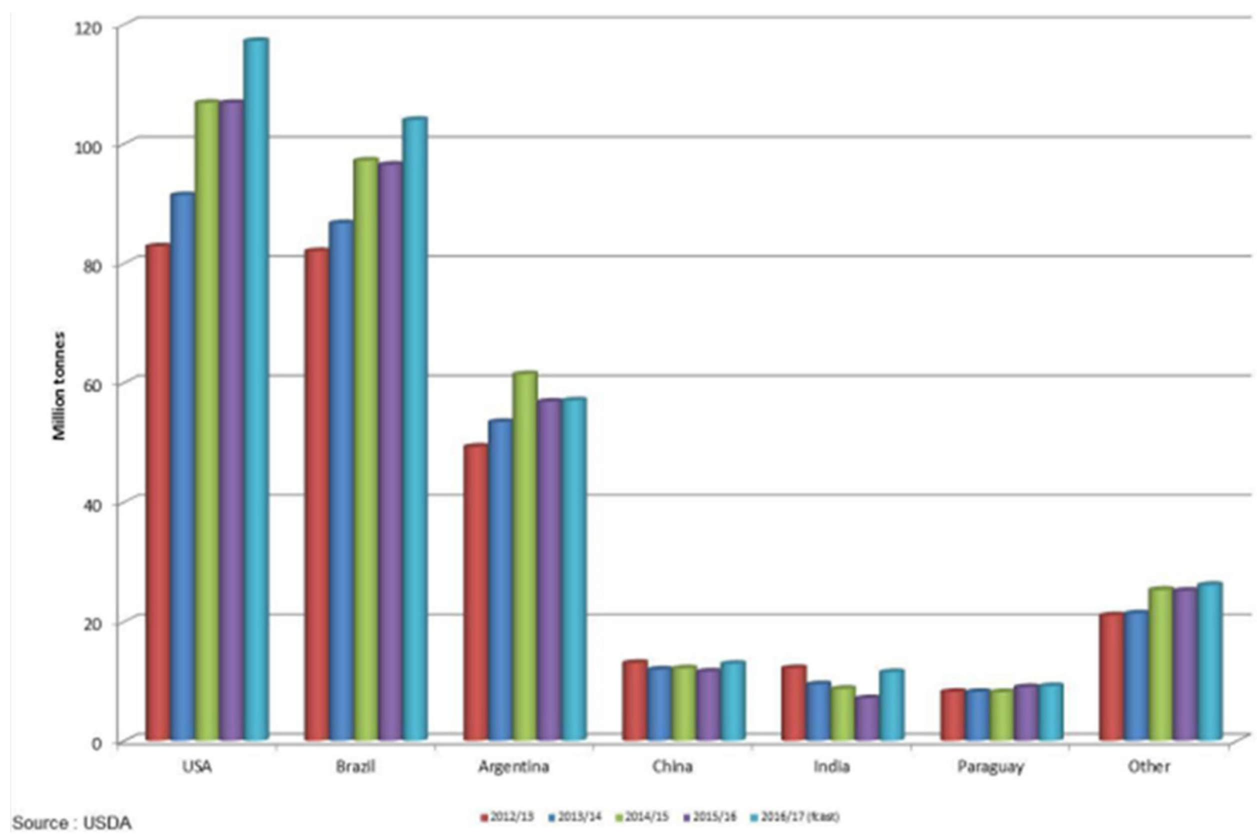

Fig. 3 Production of soybean per country over the years from 2012 to 2016. [Source: USDA (European Commission, 2017)]

Classification of oilseed types commonly available in the world

Oilseed types produced all over the world include two main classes according to their oils whether suitable for human consumption or unsuitable.

Oilseed that can yield oils suitable for human consumption

This includes oilseed that yields oils for every day edible purposes which are conventional oilseed as well as oil-seed that yields non-conventional oil of specific

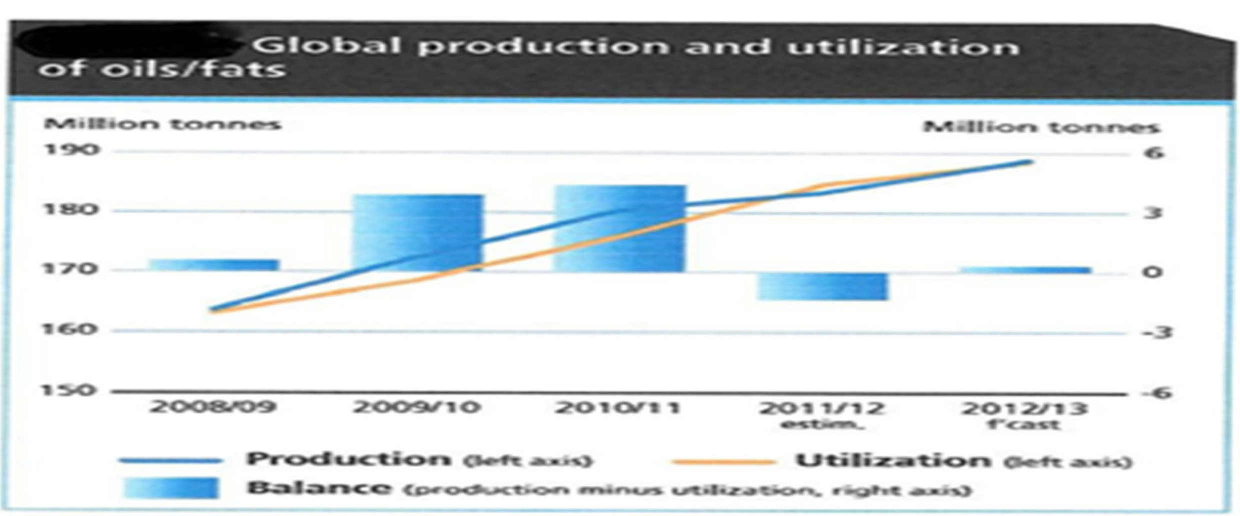

Fig. 4 Global production and utilization of oils/fats. [Source: FAO (FAO-Trade and Markets Division, 2013)]

beneficial and functional properties. It should be notified that some edible oils have been also used in some industrial applications in countries where there is enough surplus of edible oils such as the USA. For example, sunflower oil, either regular, or high oleic may be used in biofuel in the form of methyl esters. In view of the higher oxidative stability of high-oleic sunflower oil, it is used as diesel and gasoline engine lubricant.

Oilseed that yields oils suitable for human consumption for every day edible purposes

Several types of oilseed can yield oil suitable for every day edible purposes. The most common of these oilseeds are sunflower, canola, soybean, and cottonseed.

Sunflower oilseeds

The fatty acid (FA) composition of sunflower seed oil (*Helianthum annuus* L.) depends on the climatic conditions. Cooler climates produce higher amounts of the essential omega-6 PUFA linoleic acid, while in warmer climates, the MUFA oleic acid is predominant. High concentration of linoleic acid is the characteristic of sunflower oil, followed by oleic acid. Saturated fatty acids consist mainly of palmitic acid and stearic acid and their amount not more than 15% of the fatty acid content (Morrison et al., 1995). Percentage of sterols in sunflower oil ranges between 0.24 and 0.26% (Grompone, 2005). It should be notified that sunflower oil which is mainly used for edible purposes can be also used for some industrial applications especially in countries which are self-sufficient of edible oils.

Canola oilseeds

China is among the large producers of canola, representing 27.5% of the world production. Canola (*Brassica napus* and *Brassica campestris* L.) is the major edible canola crop. It is grown in more than 120 countries around the world. The oil was added to the Generally Recognized as Safe (GRAS) list of food products in the USA (Przybylski et al., 2005).

Triacylglycerol of canola oils constitute from 94.4 to 99.1% of the total lipid (Przybylski et al., 2005). Canola oils contain oleic acid of 61.6% (C18:1) which is the major part of the fatty acid followed by linoleic acid (C18:2) and α-linolenic acid (C18:3). Saturated fatty acids, such as palmitic and stearic acids, occur at a percentage of about 6%. Sterols in canola oils range between 0.7 and 1.0%, and the major ones of these sterols are tocopherols which are natural antioxidants (Przybylski et al., 2005).

Soybean oilseeds

Soybean cultivation is high in the USA, Brazil, Argentina, and China. Production in these countries alone accounts for almost 90% of the world's output. Countries in Asia excluding China and Africa together account for only 5% of the total production of soybean. Soybean has the maximum global production (53%) followed by rapeseed mustard (15%), cottonseed (10%), and peanut (9%) (Pratap et al., 2012; Pratap et al., 2016). The USA grows soybean over the largest area and holds a share of about 32% of the world's soybean production, followed by Brazil (31%), Argentina (19%), China (6%), and India (4%) (Yadava et al., 2012).

Linoleic fatty acid is the major fatty acid in soybean oil which ranges between 38 and 60%, followed by oleic in the range of 20–50%. Unsaponifiable matter of soybean oil is about 1.45% of the oil constituting of 16% sterols, 8.5% tocopherols, and 26% hydrocarbons. These minor constituents of soybean oil are valuable commercial products. They include lecithin, phytosterols, and tocopherols (Pratap et al., 2012). Lecithin is produced by degumming of soybean, and it is the predominant source of food emulsifiers (Hammond et al., 2005). It should be emphasized that soybean oil is also associated with several uses in industries as it is used in pharmaceuticals production, productions of plastics, papers, inks, paints, varnishes, cosmetics, and pesticides (Pratap et al., 2012).

Cottonseed

Cottonseed (genus *Gossypium*) is a by-product of cotton ginning, and 16–17% of its weight is cottonseed oil (Bruinsma, 2003; Sharma et al., 2012; Gupta, 2016). Cotton is cultivated in 70 countries around the world. More than a quarter of the world cotton is cultivated in India, followed by the USA (16%), China (14%), and Pakistan (8%). The remaining production comes from Turkey, Australia, Greece, Brazil, and Egypt. Producing of cotton is a dual-purpose crop for both seed and fiber, and this gives valuable primary products for agriculture.

Linoleic acid is the major fatty acid (54.4%), followed by palmitic (21.6%), oleic (18.6%), and other small quantities of other fatty acids. The minor components in the unsaponifiable fraction consist of phospholipids, tocopherols, sterols, resins, carbohydrates, pesticides, gossypol, and other pigments.

Cottonseed oil is used as liquid oil and in the manufacturing of shortening and margarine (USDA, 2002). It can be also used in the manufacture of soap, lubricant sulfonated oil, pharmaceuticals, rubber, as a carrier for nickel catalysts, and, to a lesser degree, in the manufacture of leather, textiles, printing ink, polishes, synthetic plastics, and resins (O'Brien et al., 2005). Recently, cottonseed oil is being used in the synthesis of sucrose polyesters as a zero-calorie fat substitute that has a trade name of Oleans or a common name of Olestra which is suitable for human consumption.

Oilseed that yields non-conventional oil of specific beneficial and functional properties and suitable for human consumption

Groundnut/peanut seed

Groundnut (*Arachis hypogaea* L.) is popularly known as peanut. It is a herbaceous annual legume belongs to the family Fabaceae (Leguminosae), and it is the third most important oilseed crop in the world and cultivated in tropical and subtropical regions. It is a good source of edible oil and protein. Kernel of groundnut contains 40–54% oil, 22–36% protein, and 10–20% carbohydrate. It is also a good source of B vitamins and tocopherol but is weak in fat-soluble vitamins A and D and almost lower in vitamin C. The shells of groundnut are used as a fuel or a filler in fertilizers and in the feed industry (Alagirisamy, 2016). Groundnut is the major oilseed crop in Asian and African countries, and together, they contribute 80% of the total production area of groundnut. Other countries which are producing groundnut include China, India, the USA, Nigeria, Indonesia, Myanmar, Senegal, Sudan, Argentina, and Vietnam. About 60% of groundnut produced in the world is mainly utilized for oil production (Birthal et al., 2010). Peanut oil is rich in mono unsaturated oleic acid followed by diunsaturated linoleic acid followed by saturated palmitic fatty acid. High levels of polyunsaturated fatty acids in groundnut oil make it highly sensitive to rancidity and off-flavors (Alagirisamy, 2016). Sterols are the minor constituents in groundnut oil, and they range from 0.09 to 0.3%. Natural antioxidant in peanut oil is tocopherols (vitamin E which ranges from 48 to 373 mg/kg for alpha-tocopherol, 0–140 mg/kg for beta-tocopherol, 88–389 mg/kg for gamma-tocopherol, and 0–22 mg/kg for delta-tocopherol). Total tocopherol content ranges from 130 to 1300 mg/kg (Codex Alimentarius Commission, 2001).

Linseed/flaxseed oil

Linseed (*Linum usitatissimum* L.) belongs to the Linaceae family. India ranks fourth major country after Canada for linseed production followed by China, the USA, and India. Oil content of linseed ranges between 28 and 30% (Yadava et al., 2012; Sabikhi and MHS, 2012). Major fatty acid of linseed oil is linolenic acid (53.21%) followed by oleic acid (18.51%), linoleic acid (17.25%), and palmitic and stearic acids (6.58 and 4.43%, respectively) (Sabikhi and MHS, 2012; Popa et al., 2012). Sterols are present at 4072 mg/kg in flaxseed lipids and the main sterols is β-sitosterol being 35.6%, of the total amounts of sterols in flaxseed lipids (Ciftci et al., 2012). Tocopherol contents of flaxseed lipids are 747 mg/kg, and γ-Tocopherol is the major being 72.7% of the total amount of tocopherols (Ciftci et al., 2012).

Linseed oil has been widely used in many industrial applications such as its use as a drying oil, and it is used also in so many medicinal products. Linseed oil can be used as a supplemental nutritional component because of the presence of omega-3-α-linolenic acid (Ciftci et al., 2012). Due to its content of highly unsaturated fatty acids, it is unsuitable for cooking purposes. More efforts are therefore needed for the development of new varieties with low linolenic acid, so it can be widely used as cooking oil (Yadava et al., 2012).

Sesame seed

Sesame (*Sesamum indicum* L.) belongs to Pedaliaceae family, and it is one of the oldest traditional oilseed crops. During 2013, Burma was the largest producer of sesame seeds, India was the largest exporter, and Japan was the largest importer of sesame seeds in the world (Islam et al., 2016). Asia is covering more than 50% while Africa is covering 43% of world sesame seed production.

Sesame seeds are rich in fat, protein, carbohydrates, fiber, and essential minerals, and for that, its seed is highly valuable in nutritional and medicinal purposes. Sesame seeds consist of oil at 44–57%, protein at 18–25%, and carbohydrates at 13–14% (Islam et al., 2016; Hwang et al., 2005). Linoleic acid and α-linolenic acid are the most important essential fatty acids in sesame oil constituting more than 80% of fatty acids in the oil. They play a role in the metabolic pathway of prostaglandin synthesis which makes sesame oil of high nutritional value. Unsaponifiable matter represents about 2% of sesame oil, and tocopherol content is in the range from 330 to 1010-mg/kg oil (Codex Alimentarius Commission, 2001).

Sesame has many beneficial nutritional characteristics effects on metabolism (presence of polyunsaturated fatty acid), hypocholesterolemic (presence of lignin), antioxidative effect in biological system (presence of vitamin E), and effect on cancer (presence of tocopherols), liver function, and blood pressure (presence of lignin) (Hwang et al., 2005). Sesame seeds are used in sweets such as sesame bars and halva (dessert) and in bakery products or milled to get high-grade edible oil. Sesame oil has many industrial purposes such as food cooking, ointments, medicine, and cosmetic purposes. Sesame contains immunoglobulin E food allergens. The allergy to sesame seed is because of its use in baked and fast food products (Islam et al., 2016). Sesame oil consists of two kinds of lignins: sesamin and sesamolin. After roasting, sesamolin is converted to sesamol and the molecular structure of the later (sesamol) consists of phenolic and benzodioxide groups which are responsible for the activities of antioxidant and anticancer.

Moringa oilseed

Moringa oleifera (*M. oleifera* L.) has been called the "Miracle Tree" because every part of the tree including leaves, oilseed, stem, and roots has a beneficial properties in nutrition or in pharmaceutical purposes (Gopalakrishnan et al., 2016; Aly et al., 2016; Azad et al., 2015). It belongs to the family of Moringaceae, and it is widely cultivated across the world. It was used by the Romans, Greeks, and ancient Egypt. It is grown locally in India, and it is grown in tropical and subtropical regions of the world. It can be easily grown in poor third-world countries. The common name of *M. oleifera* is drumstick and contains 6–10 seeds while mature seeds yield about 38–40% oil.

Aly et al., 2016 evaluated the fatty acids and chemical composition of Egyptian *Moringa oleifera* L. oil seeds. Their survey showed that moringa oil has high level of oleic acid which makes it suitable for edible purposes. Moringa oil is rich in palmitic, stearic, behenic, and oleic acids. Oleic unsaturated omega-9-fatty acid is about 76.29%, and saturated acids were palmitic, stearic acid, and arachidic up to 12.66% (Aly et al., 2016). The seeds of *Moringa oleifera* are used in water treatment as natural coagulant. Extracts of moringa seeds were used to eliminate heavy metals (such as lead, copper, cadmium, chromium, and arsenic) from water. Moringa oil that can be extracted from its seed can be used in cooking in frying process as a substitute to olive oil and equivalent to its fatty acid composition. It can be used in non-edible purposes such as in the manufacture of perfumes, cosmetics, hair care products, some medicinal purposes, production of lubricants, and biodiesel (Gopalakrishnan et al., 2016).

Oilseed that yields oils not suitable for human consumption

Examples of oilseed that yields oils non-suitable for human consumption are high erucic acid rapeseed, Jatropha, Jojoba, and castor oilseed.

Rapeseed

Large-scale planting of rapeseed was first reported in Europe in the thirteenth century (Przybylski et al., 2005). Rapeseed is obtained from several species of the genus Brassica (Cruciferae family). Conventional rapeseed yields about 40% of its weight oil which is rich in MUFA and the ώ-3ALA (alpha Linolenic acid) (Sabikhi and MHS, 2012). Traditional rapeseed oil contains a high-erucic acid (~ 50%) (C22:1). The high levels of erucic acid cause accumulation of fatty acids in the heart and skeletal muscles as well as delaying in growth. New varieties were bred in 1974 with oleic acid replacing erucic acid and were referred to as canola in the USA and Canada (Przybylski et al., 2005). Because of health concerns, traditional rapeseed oil which is rich in erucic acid is currently used in industrial applications and for the production of biofuels rather than in edible purposes (Choudhary and Jambhulkar, 2016).

Jatropha oilseeds

The seeds of jatropha are a good source of oil, which can be used as a diesel fuel substitute. For best oil yields, the seeds should be harvested when the color of the fruits has changed from green to yellow-brown.

Jatropha oil contains oleic acid (18:1) at 47.0%, linoleic acid (18:2) at 31.6%., palmitic acid (16:0) at 14.1%, and stearic acid (18:0) at 6.7%. It is not suitable for edible purposes as it has a very strong purgative effect (List and Horhammer, 1979; Perry, 1980). However, it can be utilized successfully for the production of alternative fuels for diesel engines (Hawash et al., 2009; Zaher and El Kinawy, 2012; Zaher et al., 2012). The importance of jatropha oil as a source for the production of biodiesel fuel in place of regular diesel fuel from petroleum are attributed to the following reasons: crude oil prices are rising every year; petroleum reserves are depleting with time; global warming represents a very serious problem; and petroleum-importing nations are concerned about their security, and the rate of energy consumption is increasing worldwide. The use of esterified jatropha oils as alternatives for diesel fuel has a potential as it is renewable, its heat of combustion is very close to that of regular diesel fuel, and it is environmentally friendly as it is free from sulfur and is biodegradable and does not increase global warming in comparison to fossil fuels (CO_2 neutral system).

Jojoba oilseeds

Jojoba (*Simmondsia chinensis*) belongs to the family Simmondsiaceae. Jojoba is native to California desert, Mexico, and Arizona. Jojoba seed oil content about 40–50% of liquid waxes in the esters form of long chain alcohol and fatty acids (Baud and Lepiniec, 2010; Ashraful et al., 2014). Major fatty acid composition of the seed is oleic, 34.5–66% (Al-Widyan and Mt.A, 2010; Kumar and Sharma, 2011; Shehata and Razek, 2011). Jojoba seed oil is colorless and odorless and is composed mainly of (97%) wax esters of monounsaturated, straight-chain acids, and alcohols with high-molecular weights (C16-C26). Wax esters consist of (83%) of C20 and C22 together of unsaturated fatty acids and alcohols with two double bonds. It is almost free of oil triglycerides which indicate that jojoba oil is different from all known seed oils since it is not a fat but a liquid wax (Zaher et al., 2004). Jojoba oil has potential uses for many industrial applications such as cosmetics, pharmaceuticals, lubricants, heating oils, and protective coatings (DEE, 2002). In addition, it can be used also as antioxidant, antifoaming, and fire retardant agents. Due to its high dielectric constant, the oil is suitable as an insulator and as a transformer oil. It also can be used as a carrier for pesticides and plant hormones, formulations for softening leather, and paints and adhesive products for sizing and water-proofing. Moreover, jojoba oil, which is waxy in nature, may also have promise in the treatment of industrial wastewater and recovery of toxic heavy metals.

Jojoba oil is suitable as component in the oil formulation for two-cycle gasoline engines. It has good potential as an additive in lubricating oil base stocks. The high temperature stability and excellent viscosity index suggest the possibility of jojoba oil's use as an additive in jet engine lubricants. It can be used in several products including shampoos, hair conditioners, hair sprays, facial oil, bath oils, hand lotions, moisturizers, suntans, makeup removers, shaving creams, lipsticks, lip glosses, varnishing creams, cleaning creams, and skin fresheners (DEE, 2002). The physical and chemical properties of jojoba oil constitute a good basis for its prospective use as an antifoam agent in manufacture of antibiotics. However, the oil has been used as an anti-foaming agent in penicillin production.

Castor oilseeds

Castor (*Ricinus communis* L.) belongs to family Euphorbiaceae. The main countries in the world for growing castor are India, China, Brazil, Thailand, and Russia. World production is about 1.14 million ton of castor (Yadava et al., 2012). Castor seeds contain oil ranging from 40 to 55% while the seed kernels contain oil of about 64–71%. Major fatty acid is ricinoleic acid, and its average percentage in the oil is 75%. In addition to ricinoleic acid, castor seed oil contains linoleic acid (9.7%), oleic acid (7.7%), palmitic acid (2.5%), and stearic acid (2.7%) (Harhar et al., 2016). Total amount of sterols in castor oil is 2210 mg/kg while major sterol is β-sitosterol. Total tocopherol content of castor seed oil is 183 mg/kg, and the major one is γ-tocopherol being 52.7 mg/kg oil (Harhar et al., 2016). Castor oil is a non-edible oil, but it is very suitable for use in cosmetics industry (Yadava et al., 2012; Harhar et al., 2016).

Conclusions and recommended further research work in scope of vegetable oil production

In view of the two crises facing the whole world in food and energy, many efforts have been spent recently in the world as to increase the production of oilseed crops, increase the oil content of the oilseed, and improve the quality of the oil that can be extracted from the seed to be more suitable for use either for edible or non-edible purposes. These efforts have been made through crop breeding and genetic engineering (Gupta, 2016; Khatri et al., 2005; Kinney, 1997). It is highly recommended that much more research work should be directed in this scope as to positively contribute to reducing the gap between the production and the consumption needs of vegetable oils.

Acknowledgements

The facilities offered to the authors by the Central Library at the National Research Centre, Cairo, Egypt, to collect the data necessary for the production of this review article are highly appreciated.

Funding

Since the article is a review paper, the authors were not in need of funding for the production of this article.

Availability of data and materials

Not applicable.

Authors' contributions

All authors contributed equally in all parts of this study. Both authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Received: 15 August 2018 Accepted: 15 October 2018
Published online: 03 November 2018

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