

Yee-Ying Lee · Teck-Kim Tang
Eng-Tong Phuah · Oi-Ming Lai *Editors*

Recent Advances in Edible Fats and Oils Technology

Processing, Health Implications,
Economic and Environmental Impact

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and Environmental Impact

 Springer

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Preface

Fats and oils are used extensively in food and non-food applications. Palm oil, soybean oil, rapeseed oil, and sunflower oil are few of the examples of vegetable oils that are widely traded as commodities. In 2020/2021, global production of fats and oils exceeded 200 million metric tons and is expected to grow at a rate of 4.45% per annum. World production and consumption of fats and oils are mainly dominated by Asia with Indonesia and Malaysia as the prominent countries. The processing method or analysis protocols adopted by the fats and oil industries have been well established in the past few decades. However, over time, discovery of some new findings further propels the fats and oils field. For instance, sustainability and renewable energy are the recent hot topics that have been greatly discussed in recent years, not to mention the occurrence of processing contaminants in edible oils as well as the green approaches utilized to modify the physical and chemical properties of fats and oils.

The book intends to capture a collection of up-to-date scientific advances in fats and oils technology over the past few years. It is contributed by esteemed researchers from academia and industries who are experts in their respective fields. The book covers the existing and recent advanced techniques adopted in the edible fats and oils research that touches on the processing and modification to the traceability and sustainability issues of fats and oils. For ease of reference, the book is structured into three different sections: (a) Chemistry and Processing, (b) Modification and Health Implications, (c) Renewal Energy, Safety, Adulteration, Sustainability, and Traceability. In the first section, the readers are introduced to the various types of edible fats and oils as well as their minor constituents. These chapters cover the sources and properties of vegetable oil, animal fat, seed oil, and minor components. Exotic oil which is a recent topic in the food industry is also revealed. This is then followed through with the modification approaches used to improve the functionality and nutritional value of fats and oils. These chapters touch on the traditional modification techniques like blending, hydrogenation, interesterification, fractionation as well as the current modification method such as oleogelation. A more advanced method using ionic liquid in fats and oils modification is also highlighted in one of the

chapters. Examples of the structured lipid synthesized from the aforementioned approaches and its food application such as diacylglycerols, medium and long-chain triacylglycerol, human milk fat substitute, and cocoa butter substitute are highlighted in the chapters. A chapter on the fats and oils that exist in the form of colloids in a nanosize known as nanoemulsion is also covered. The last part of the book wraps up the safety, adulteration, sustainability, and traceability of fats and oils. It deals with the techniques in the production of renewable energy biodiesel from sludge oil, formation, and detection of processing contaminants such as monochloropropane-diol (MCPD) and glycidyl ester (GE), recent techniques to detect adulteration of fats as well as sustainability and traceability of fats and oils.

To the scientists from academia or industries, we hope that the book will be useful to bring you new insights and keep you abreast with the latest updates of the oils and fats industry. For those who are embarking on their journey to pursue knowledge in the fats and oils area, we hope that the book can spark your interest in this field.

Last but not least, we thank all the authors for spending their precious time despite their busy schedules to contribute to the book chapters. Thank you for your patience given to us in completing the edited book, not to mention the editorial team at Springer Nature for their effort in coordinating the publication of the book.

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Yee-Ying Lee received her Ph.D. degree in Food Biotechnology and B.Sc. degree in Biotechnology from University Putra Malaysia. She is currently a lecturer with School of Science, Monash University Malaysia. She is a committee member of Monash-Industry Palm Oil Education and Research Platform. Her research interest is on lipid modification using lipase in which she has managed to co-author 7 book chapters and published 18 research articles. She has received numerous national and international professional awards for her Ph.D. work on structured lipid medium and long-chain triacylglycerol including 2016 Best Ph.D. award from the Institute of Bioscience, University Putra Malaysia, and 2015 Best Young Researcher Award from Asian Congress on Biotechnology. She and her team were awarded the second position in Developing Solutions for Developing Countries Competition organized by the Institute of Food Technologists in 2014.

Teck-Kim Tang earned his Master's Degree in Biotechnology from University Putra Malaysia in 2013, working on the production of diacylglycerol oil. He is currently pursuing his Ph.D. degree at Universiti Putra Malaysia focusing on the synthesis of emulsion stabilized by microfibrillated cellulose. He has published 17 peer-reviewed articles and co-authored 3 book chapters in the area of lipid technology. He demonstrated a great passion in lipid science and technology research and has an immense knowledge in the area of structured lipid and emulsion technology. He and his team had won a second position in Developing Solutions for Developing Countries Competition organized by the Institute of Food Technologists in 2014.

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Chapter 1

Vegetable Oils and Animal Fats: Sources, Properties and Recovery



Eng-Tong Phuah, Jeremy Wee-Lek Yap, Chei-Wei Lau, Yee-Ying Lee, and Teck-Kim Tang

Abstract Fats and oils can be found naturally in a wide range of animal and plant-based sources. They serve an important part of a balanced and healthy diet as they provide energy, support growth and development, provide the essential fatty acids and boost the immune system. Fats and oils are also high in fat-soluble vitamins especially vitamin E (tocopherols) which is well known for its antioxidant properties. Besides, these ingredients also help to enhance the sensory characteristics of various food products. Some fats and oils may even be used for medicinal purposes and biodiesel production. Obviously, fats and oils are essential components for both food applications and industrial uses. Based on the previous literatures, each fat and oil has its own unique fatty acid profile and physicochemical properties. Therefore, the present chapter reviews and focuses on the nutritional values and physicochemical properties of some common edible fats and oils extracted from both plant and animal sources.

Keywords Animal fats · Vegetable oils · Poultry fat · Lard · Tallow · Fish oil · Palm oil · Soybean oil · Sunflower oil · Coconut oil

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1.1 History, Production and Utilisation of Animal Fats

Animal fat has a long history of use in the Eastern region since Roman times for soap making. Tallow from cattle and sheep is utilised in candle making because of its high saturated fat content. Utilisation of animal fat further extended to food applications. In the 1940s, the consumption of lard among Americans was higher than the vegetable oil. Animal fat enhances the taste, flavour and texture of food. Lard and tallow blended with cottonseed oil provide an excellent source to be used as shortening for baking purposes. Animal fat has also been utilised widely as the frying medium for French fries attributed to their high thermal and oxidative stability. The industrial revolution switches the way animal fats being used in food applications. Public demand for vegetable oil increases over the concern of cholesterol-raising effect of animal fats in the 1990s.

Animal's fat is fat rendered from the fatty tissue or milk of animals such as beef (tallow), sheep (butter), swine (lard) and poultry (chicken, duck, goose fat) and others such as grease (yellow or white). The amount of fat rendered for the animal tissue or milk duct varies from 0 to 60% depending on the age, animal, sex and diet. It accounts for approximately 10% of the global fats and oils market and is valued at USD 227.9 billion in 2020. The major producers of tallow and lard are the United States of America and China, respectively. Table 1.1 shows the animal fats and oils production, consumption and stock in the United States in 2019. Poultry fat contributed to the majority of the animal fats market in the United States followed by tallow and lard. It should be noted that the animal fat is not produced for the edible purpose but is considered as by-products generated that is meant to produce meat, wool, dairy and skin. Today, the majority of the animal fat was utilised for biodiesel, animal feed, oleochemical and food applications. According to EFPRA, animal fat is

Table 1.1 United States: animal fats and oils production, consumption and stocks in 2019

	Jan 2019	Dec 2019	Total (Jan–Dec) ('000 pounds)
<i>Lard</i>			
(a) Production	27,411	30,755	384,396
(b) Removed for use in processing	26,208	31,377	345,524
(c) Stock on hand end of month	(D)	5938	
<i>Poultry fats</i>			
(a) Production	207,154	189,183	2,499,783
(b) Removed for use in processing	210,203	182,201	2,493,935
(c) Stock on hand end of month	23,720	31,499	
<i>Tallow, edible</i>			
(a) Production	67,184	87,347	996,693
(b) Removed for use in processing	68,894	81,301	1,030,983
(c) Stock on hand end of month	31,498	17,847	

Modified from USDA, National Agricultural Statistics Service. Fats and Oils: Oilseed Crushing, Production, Consumption and Stocks 2019 Summary (March 2020).

D: withhold to avoid disclosing data for individual operations

Table 1.2 Utilisation of animal fat in Europe

Table	Amount ('000 tonnes)
Edible fats	186
Oleochemicals	575
Animal fed and pet food	950
Solid fuel	1000

Modified from: EFPRA (Rendering in Numbers)

used mainly for biodiesel followed by animal feed and pet food, oleochemical and edible purposes in Europe. It was surprising to find that the demand for lard in Germany is growing due to its excellent properties to be used as a replacer for butter in the bakery sector. Lard-made pastries have a flakier texture. Goose fat and lard are also a popular spread used in Germany and France. Animal fat not only contributes to excellent solid like texture to bakery products but also it contains no unnatural trans fatty acid. Increasing demand for animal fat used for food application was believed to be due to the new regulation set up to ban the use of trans fatty acid in food products. The growth of the tallow market is also increasing because of the high demand for biodiesel (EMR Report) (Table 1.2).

1.2 Poultry Fat

Poultry fat is fat rendered from the fatty tissue of chicken, duck, goose and by-products of the poultry processing. For example, studies showed that chicken feather contains around 2–12% of the fat. Content of the fat increases with age. Young chicken has more fats depot than the hen. The predominant fatty acid composition of the poultry fat is oleic acid (43.3%), palmitic acid (21.3%) and linoleic acid (19.1%) followed by stearic acid (7.4%) (Table 1.3). However, the fatty acid composition of poultry fat can be manipulated by introducing different feeding diets as indicated in the previous literatures (Hargis and Van Elswyk 1993; Khatun et al. 2018). For example, Hargis and van Elswyk (1993) reported that the ω -3 fatty acids could be increased by the inclusion of marine oil in the diet. Under normal circumstances, poultry fat contains more unsaturated fatty acids than saturated fatty acids with a minute amount of vitamin D and vitamin E.

1.3 Lard Fat

Lard is the fresh clean and healthy fatty tissue from the skin rendered from swine where a certain amount is contributed by bones, ears and tails, internal organs. It appears to have a semi-solid like property and is whitish in colour. It was used as a substitute for butter in the nineteenth century but its usage started to decline because of its high saturated fat and cholesterol content. However, lard was reintroduced

Table 1.3 Fatty acid composition and nutrient composition in poultry fat

Fatty acid	Percentage (%)
C14	1
C16	21.3
C16:1	4.7
C18	7.4
C18:1	43.3
C18:2	19.1
C18:3	1.5
C18:4	1.1
C20	1.1
C20:1	0.4
<i>Nutrient composition</i>	
Vitamin D	1.91000 IU/kg
Vitamin E	27 mg/kg
Choline	1224 mg/kg

Modified from INRAE-CIRAD-AFZ Feed Tables, Thomas et al. (2000)

back following the trans fatty acid issue as a fat substitute to replace the partially hydrogenated fat. It is used widely as bakery and frying application. Table 1.4 shows the fatty acid composition of lard. The main fatty acid of lard is oleic acid (43.4%), palmitic acid (24.9%), stearic acid (15.5%) followed by linoleic acid (9.5%). Lard has a unique acylglycerol configuration whereby the *sn*-2 position is occupied with saturated fatty acid particularly palmitic. Lard is the only fat that are distinctly different from other edible fat and oils where most of the *sn*-2 position of vegetable oil is occupied by unsaturated fatty acid. The triacylglycerol composition in such configuration is similar to the human breast milk fat. The performance of lard for used as shortening in creaming and cake making can be improved through the interesterification process.

1.4 Tallow Fat

Tallow fat is the product rendered from the fatty tissue, muscles and bones of clean and sound bovine animals or sheep at the time of slaughter. Table 1.5 shows that tallow contains 38.5% oleic acid, 26.3% palmitic acid and 21.2% of stearic acid. Vitamin A, D, E, K are present in minute amounts in tallow. Fat derived from beef and sheep tend to have the saturated fatty acid located in the *sn*-1 and *sn*-3 position that resembles vegetable oil. Tallow contains natural trans fatty acid which is the conjugated linoleic acid that was produced through biohydrogenation process in the lumen of the ruminant species. The presence of natural trans fatty acid distinguishes it from other vegetable oil.

Table 1.4 Fatty acid composition, nutrient composition and physicochemical properties in lard fat

Fatty acid	Percentage (%)
C12	0.2
C14	1.7
C16	24.9
C16:1	2.8
C18	15.5
C18:1	43.4
C18:2	9.5
C18:3	0.8
C20	1.3
C20:1	0.7
C22:1	0.2
<i>Nutrient composition</i>	
Vitamin A	0.31000 IU/kg
Vitamin D	11,000 IU/kg
Vitamin E	5 mg/kg
Vitamin B ₆ pyridoxine	0.2 mg/kg
Choline	497 mg/kg
<i>Physicochemical properties</i>	
Melting point	30–40 °C
Saponification value	193–202
Non saponifiable matter	0.1–1.0%

Modified from INRAE-CIRAD-AFZ Feed Tables, Thomas et al. (2000)

1.5 Fish Oil and Krill Oil

Fish oil is derived from the fatty tissue of fatty fish such as salmon, mackerel, anchovies and sardine. Fish oil is more valued than other animal fats. It has anti-inflammatory property that is essential to manage heart and brain health where it is sold as dietary supplements encapsulated in the form of pills or tablets. Fish oil differs from the animal fat derived from the land whereby the fatty acid derived from fish oil is made from the very long carbon atom and they are highly unsaturated. It is made predominantly from the ω -3 polyunsaturated fatty acid (PUFA) particularly C20, C22 and C24 known as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The fatty acid composition of the seawater fish is different from the freshwater fish where the former contains more C20 and C22 with a lesser oleic and linoleic content. Fish oil can also be obtained from many different organs. Cod, halibut and shark stored most of their fat in the liver. Unlike other fish oil, cod liver oil is valued for its vitamin A (15,000–50,000 IU/g) and vitamin D (40–200 IU/g). Sperm oil from whales is prized for their cosmeceutical application. Sperm oil is composed mainly of wax ester and a small amount of triacylglycerol mainly made from oleic acid. Recently, krill oil obtained from the tiny crustacean species that live in the Antarctic Ocean called the Antarctic krill is well sought after. It is also

Table 1.5 Fatty acid composition, vitamin and mineral content in tallow fat

Fatty acid	Percentage (%)
C12	0.2
C14	3.2
C16	26.3
C16:1	3.8
C18	21.2
C18:1	38.5
C18:2	2.8
C18:3	0.7
C20	1.1
C20:1	0.3
C22	0.1
<i>Nutrient composition</i>	
Vitamin A	18.31000 IU/kg
Vitamin D	0.31000 IU/kg
Vitamin E	27 mg/kg
Vitamin K	1.5 mg/kg
Choline	798 mg/kg
<i>Physicochemical properties</i>	
Melting point	44–55 °C
Saponification value	192–198
Non saponifiable matter	0.1–0.6%

Modified from INRAE-CIRAD-AFZ Feed Tables, Thomas et al. (2000)

composed mainly of phospholipid-derived fatty acid such as phosphatidylcholine of around 30–65% and the remaining is composed of triacylglycerol made from EPA and DHA. Contradictorily, fish oil is made mainly from triacylglycerol. The majority of the fatty acids attached to the phosphatidylcholine of krill oil are EPA and DHA which increases the bio-absorption of the essential fatty acid. Unlike other marine oil, krill oil contains an appreciable amount of astaxanthin which is a powerful antioxidant that is responsible for its red colour. Astaxanthin is a more potent antioxidant than Coenzyme Q10 and fish oil (Table 1.6).

1.6 History, Production and Utilisation of Vegetable Oils

Vegetable oils are a group of fats extracted from the plant sources such as seeds, nuts, cereal grains and fruits (Hammond 2003). The use of vegetable oils has been practised by the Ancients thousands of years ago. They collect the oil exuded from the plant by slowly heating up the oily plant products. For instance, archaeological evidence suggested the existence of olive tree dating back to 43,980 B.C. The applications of olive oil as cooking oil, perfume, anointment for the dead, soap and lights in ancient times are well described (Kiritsakis and Markakis 1988;

Table 1.6 Fatty acid composition and nutrient composition in fish oil and krill oil

Fatty acid (%)	Cod liver oil	Salmon oil	Sardine oil	Krill Oil
C12	n.d.	n.d.	0.1	n.d.
C14	3.7	3.7	7.6	15.1
C16	13	10.2	16.2	23.5
C16:1	8.9	8.7	9.2	5.73
C18	2.4	4.7	3.5	1.13
C18:1	24.3	18.6	11.4	19.7
C18:2	1.3	1.2	1.3	2.33
C18:3	0.5	0.6	0.9	0.12
C18:4	0.9	2.1	2	1.04
C20	n.d.	n.d.	0.4	n.d.
C20:1	11.3	8.4	3.2	0.06
C20:2	n.d.	n.d.	n.d.	0.06
C20:4	1.1	0.9	1.6	0.35
C20:5 (EPA)	11	12	16.9	19.92
C22:1	4.6	5.5	0.2	n.d.
C22:5 (DPA)	1.4	2.9	3.8	0.43
C22:6 (DHA)	10.8	13.8	2.5	10.6
<i>Nutrient composition</i>				
Vitamin A	10,001,000 IU/kg	n.d.	n.d.	n.d.
Vitamin D	1,001,000 IU/kg	n.d.	3.31000 IU/kg	n.d.
Vitamin E	219 mg/kg	219 mg/kg	219 mg/kg	n.d.
Vitamin K	1.5 mg/kg	1.5 mg/kg	1.5 mg/kg	n.d.

n.d. not detected. Modified from Ahn et al. (2018)

Clodoveo et al. 2014). Indeed, vegetable oils can be applied in various food, pharmaceutical and cosmetical products. Besides, vegetable oils also exhibit the potential to replace petroleum-based fuels in recent years because vegetable oil-based biofuels have renewable characteristics (Mekhilef et al. 2011; Issariyakul and Dalai 2014). In contrast to animal fats, vegetable oils are more preferable owing to its healthier fatty acid profiles. The vegetable oils contain predominantly unsaturated fatty acids such as oleic, linoleic and linolenic acids, depending on the oil sources. These unsaturated fatty acids are reported to exert beneficial health effects including suppressing coronary heart diseases and cardiovascular diseases as well as providing antioxidative effects (Orsavova et al. 2015). Even though more than 350 oil-bearing crops have been identified, soybean, palm, rapeseed, sunflower and coconut oils remain to be the major vegetable oils. Table 1.7 shows the global vegetable oil consumption (million metric tonnes). A steady increase in the global oil consumption with a compound annual growth rate (CAGR) of 2.2% is observed in tandem with the increasing world population. Worldwide consumption of palm oil is the highest, followed by soybean oil, rapeseed oil and sunflower oil. Others include palm kernel oil, coconut oil and etc. Palm oil offers several advantages such as being the most efficient and highest oil yielding vegetable crops, relatively inexpensive

Table 1.7 Global vegetable oil consumption from 2016/2017 to 2019/2020 (million metric tonnes)

Vegetable oils	2016/2017	2017/2018	2018/2019	2019/2020
Palm oil	61.6	66.99	73.06	71.48
Soybean oil	53.29	54.56	54.92	55.46
Sunflower oil	16.33	17.42	18.2	19.33
Palm kernel oil	7.42	8.09	8.65	8.56
Rapeseed oil	28.9	28.86	28.16	27.62
Coconut oil	3.09	3.4	3.54	3.65
Total	170.63	179.32	186.53	186.1

Modified from Statista (2020)

and it has a variety of uses from baking products and spreads to frying (Norhaizan et al. 2013; Lai et al. 2015). Palm oils are mostly exported to China, European Union, India, Pakistan and other countries. Soybean oil and rapeseed oil are also widely consumed throughout the world owing to their high PUFA content, low crystallisation temperature and reasonable cost.

1.7 Palm Oil

Palm oil is obtained from the mesocarp of the fruit of the oil palm tree, *Elaeis guineensis*. It is grown in several countries in the world where the five leading producing countries are Indonesia (43.5 million tonnes per year), Malaysia (19.3 million tonnes per year), Thailand (3.1 million tonnes per year), Colombia (1.7 million tonnes per year) and Nigeria (1.0 million tonnes per year). Oil palm is a perennial crop which has two crops per year. Two different types of oils can be produced from palm fruit which are crude palm oil from the mesocarp and palm kernel oil from the inside kernel. One hectare of land can produce around 4–5 tonnes of crude palm oil per year and an additional yield of about 1 tonne of palm kernel oil can be obtained from the same fruit bunch (MPOC 2020). Palm oil is considered as one of the highest oil yielding crops among other oil crops.

Palm oil exists in semi-solid form at ambient temperature. It is by far known as the most fractionated oil in the world. The semi-solid palm oil comprises of low- and high-melting triacylglycerol that can be physically refined and fractionated into a liquid fraction and a solid fraction namely palm olein and palm stearin, respectively (Omar et al. 2005). Palm olein is commonly used in cooking and frying oil whereas palm stearin is as solid fat in margarine and shortening blends (Law and Thiagarajan 1990).

Palm oil is well-known with its superior frying performance due to its good oxidative stability. Most importantly, there is a high percentage of symmetrical monounsaturated triacyl group present in palm oil with palmitic-oleic-palmitic (POP) predominating (Duns 1985). Because palm oil contains relatively high levels of carotene, which performs as pro-oxidant even in the presence of high tocopherol

Table 1.8 Fatty acid composition in palm oil

Fatty acid	Percentage (%)
C8	n.d.
C10	n.d.
C12	0.1–1.0
C14	0.9–1.5
C16	41.8–46.8
C16:1	0.1–0.3
C18	4.5–5.1
C18:1	37.3–40.8
C18:2	9.1–11.0
C18:3	0.4–0.6
C20	0.2–0.7
C20:1	n.d.
C20:5 (EPA)	n.d.
C22	n.d.

n.d. not detected. Modified from Koushki et al. (2015), Tan and Nehdi (2012), Noor Lida et al. (2002)

and tocotrienol concentrations, it has a high resistance to oxidation. In addition, it is not mandatory to undergo hydrogenation and the occurrence of trans-fat could be avoided owing to its semi-solid texture at ambient temperature (Koushki et al. 2015). This characteristic brings into the replacement of palm oil for hydrogenated oil in food application as it provides a healthy alternative to trans-fatty acids (May and Nesaretnam 2014). These distinctive physicochemical characteristics of palm oil and its derivatives have brought interest to this oil towards the confectionery and plastic fat products with health benefits (Saber et al. 2010; Goh 2002).

Palm oil differs from other commodity oils as it consists of almost even proportion of saturated and unsaturated fatty acids. Generally, palm oil comprised of nearly 50% of saturated fatty acids, 40% of monounsaturated fatty acids (MUFAs) and 10% of PUFAs (Tan and Nehdi 2012). As shown in Table 1.8, palm oil is predominated by ~44% of palmitic acid, ~39% oleic acid, linoleic acid (~10%) and a small amount of myristic acid and stearic acid. Due to the high saturated fatty acid content, palm oil has a high oxidative stability which is excellent in frying.

The physicochemical properties of palm oil are tabulated in Table 1.9. The high level of palmitic acid (41.8–46.8%) contributes to the low iodine value (IV) in palm oil and its derivatives. Palm oil has a good oxidative and frying stability, not only due to the presence of the unique fatty acid composition, but also having a high smoke point and presence of phytonutrients. Crude palm oil has a reddish-orange colour due to its high carotene content and a characteristic “nutty” flavour. It is also rich in several phytonutrients such as tocopherols, tocotrienols and phytosterols. However, palm oil is always undergoing physical refining such as degumming, bleaching and deodorizing which almost reduces these natural antioxidants by half (Gee 2007).

Table 1.9 Physiochemical properties of palm oil

Characteristics	Range
Specific gravity (4 °C)	0.888–0.889
Iodine value (g I ₂ /100 g fat)	46.0–56.0
Saponification number (mg KOH/g oil)	190.0–202.0
<i>Bioactive compounds (mg/kg oil)</i>	
α-Tocopherol	129.0–215.0
α-Tocotrienol	44.0–73.0
β-Tocopherol	22.0–37.0
β-Tocotrienol	44.0–73.0
γ-Tocopherol	19.0–32.0

n.d. not detected. Almeida et al. (2019), Uddin et al. (2020), O'Brien(2009)

1.8 Soybean Oil

Modern soybean (*Glycine max* (L.) Merr) is an agricultural crop of significant economic importance. It belongs to the order of *Fabales* and the family of *Fabaceae*. The common belief is that modern soybean was first domesticated in China from its wild relative (*G. soja*) dated back to around 6000–9000 years ago (Carter et al. 2004). However, it was also suggested that modern soybean was domesticated from the complex of *G. soja*/*G. max* which diverged from a common ancestor of these two species of *Glycine* (Kim et al. 2010).

Soybean is currently one of the most important crops grown for its protein and oil. It has been incorporated into the human diet in many forms including tofu, soy sauce, soy milk, tempeh, texturized soy protein and so on. The by-products of soybean processing like soybean meal and okara can also be used as animal feed. Soybean can be grown worldwide on a large scale because a wide variety of soils, other than those which are very sandy, can support its growth with an optimum soil pH ranges from 6.0 to 6.5 (FAO 2020). Soybean is an excellent source of plant-based protein for both human and animal consumption, although its protein quality is limited by the low concentration of sulphur amino acids which can be improved through traditional breeding and genetic engineering (Krishnan 2005). Consumption of both protein and non-protein (e.g., isoflavones, lecithin, saponins and fibre) components of soybean have been associated with lower risk of cardiovascular disease (Ramdath et al. 2017).

Soybean oil is the second most consumed edible oil in the world after palm oil. It is also the most consumed vegetable oil in both China and the United States. In non-food application, soybean oil has also been used in the production of biodiesel which can probably perform better than the traditional gasoline (Demirbas 2007; Coppo et al. 2014; Vicente et al. 2010). Other than that, soybean oil can also be manufactured into inks, paints, varnishes, resins and plastics (Cahoon 2003). With

Table 1.10 Fatty acid composition in soybean oil

Fatty acid	Percentage (%)
C8	n.d.
C10	n.d.
C12	n.d.–0.1
C14	n.d.–0.5
C16	7.5–17.0
C16:1	n.d.–0.5
C18	1.6–5.5
C18:1	16.0–50.0
C18:2	35.0–60.0
C18:3	2.0–13.0
C20	n.d.–1.4
C20:1	n.d.–1.0
C20:5 (EPA)	n.d.–0.2
C22	n.d.–0.5

n.d. not detected. Modified from Zambiasi et al. (2007), Ivanov et al. (2011), Byun et al. (1996), Chowdhury et al. (2007), Dobarganes et al. (2002), List (2016), Medina-Juárez et al. (1998), Perkins (1995), Rafalowski et al. (2008), Sawada et al. (2014), Tuberoso et al. (2007), Nouredini et al. (1992a)

this, it is expected that soybean oil will remain as one of the most important vegetable oils in the future.

Soybean oil is rich in unsaturated fatty acids, a typical characteristic of vegetable oils. The five most abundant fatty acids in soybean oil are in the order of linoleic, oleic, palmitic, linolenic and stearic acids, as shown in Table 1.10. The wide range in the reported fatty acid compositions of the commercial soybean oil may be ascribed to the commercialisation of modified oils (Fehr 2007). The high content of PUFAs namely linolenic and linoleic acids reduces the oxidative stability of soybean oil which is undesirable for many food products and industrial applications. Conventionally, this can be overcome through chemical hydrogenation which also results in the formation of trans-fatty acids, a highly undesirable component in fats and oils which increases the risk of several health problems. As the alternatives, genetic approaches such as genetic modification and breeding program have been implemented to obtain improved oil yield, reduced linolenic acid as well as increased oleic acid and stearic acid for better oxidative stability of soybean oil, thereby reducing the reliance on hydrogenation (Clemente and Cahoon 2009). Table 1.11 gives some insights into the variation among the fatty acid compositions of the modified soybean oils.

Different temperatures during the seed development were found to affect the fatty acid composition of soybean oil. According to Rennie and Tanner (1989), the contents of stearic acid and oleic acid increased while linoleic acid and linolenic acid decreased when the day and night temperature decreased from 40 to 15 and 30 to 12 °C. This phenomenon could be ascribed to the effect of temperature on gene expression. On the other hand, exposure of soybeans to up to 5 kGy of γ -irradiation

Table 1.11 Fatty acid compositions in modified soybean oils

	Fatty acid composition (%)				
	C16	C18	C18:1	C18:2	C18:3
Unmodified	11.2	3.4	21.5	55.8	8
Low linolenic	10.1	5.3	41.1	41.2	2.2
Low palmitic	5.9	3.7	40.4	43.4	6.6
Low saturates	3	1	31	57	9
High palmitic	26.3	4.5	15	44.4	9.8
High stearic	8.6	28.7	16.2	41.6	4.9
High saturates	23.3	20	10.5	39.7	6.5
High oleic	6.4	3.3	85.6	1.6	2.2

Modified from Dijkstra (2016)

was reported to have no significant effect on the fatty acid composition of the resulting soybean oil (Byun et al. 1996). Still, the oxidative stability (induction period) was improved by more than 100% after γ -irradiation.

The conventional way to extract soybean oil is by solvent-extraction with hexane. However, leakage of hexane to the environment causes pollution while prolonged exposure to hexane residue in oil also results in several health issues (Kumar et al. 2017). Thus, the potential of other solvents such as ethanol and supercritical carbon dioxide (SCO₂) has been studied in the literatures. For ethanol, yield increased (up to 20%) by using a more concentrated ethanol with absolute ethanol showed the most consistent and best performance at a range of extraction temperature. Besides, the fatty acid composition of soybean oil obtained with ethanol extraction resembles that of typical soybean oil (Sawada et al. 2014). The composition of SCO₂-extracted soybean oil was reported to fulfil the FAO limit as well, although the yield appeared to be lower than that obtained with hexane (yield: 16.4–19.9% with SCO₂, 19.9–25.0% with hexane) (Dobarganes et al. 2002).

Consumption of fats and oils which are high in ω -6/ ω -3 ratio can lead to low-grade inflammation, oxidative stress, endothelial dysfunction and atherosclerosis (DiNicolantonio and O’Keefe 2018). Soybean oil is naturally high in ω -6/ ω -3 ratio with a typical reported range of 6–9. Notably, a very high value of this ratio (22.8) was reported by Rafalowski et al. (2008) in unrefined cold-pressed soybean oil.

Soybean oil is rich in tocopherols with γ -tocopherol as the major form which has been reported as high as 1559 mg/kg oil (Dijkstra 2016). Since it is of plant origin, cholesterol is absent in soybean oil. Nevertheless, soybean oil contains phytosterols with the highest total amount reported as 4050 mg/kg oil (Dijkstra 2016). Among them, β -sitosterol, campesterol and stigmasterol are the three dominant phytosterols being detected in soybean oil. Phytosterols possess therapeutic potential for obesity and diabetes by playing the role as nutritional modulators in regulating the immune response, oxidative stress, adipose tissue metabolism, hypercholesterolemia and gut dysbiosis (Vezza et al. 2020). Particularly, phytosterols can interfere with the solubilisation of cholesterol, thereby blocking its absorption in the small intestine (Quílez et al. 2003). Temperature during the development of soybean was reported

to affect the total phytosterols and tocopherols contents in soybean oil. As reported by Vlahakis and Hazebroek (2000), total phytosterols increased while total tocopherols decreased as the day/night temperature during the soybean development increased from 20/10 to 35/25 °C. This was accompanied by changes in the composition of the phytosterols with proportionally more campesterol at elevated temperature at the expense of stigmasterol and β -sitosterol.

Soybean oil was reported to be susceptible to oxidation, as reflected by its low induction period (4.84–5.24 h). The low oxidative stability of soybean oil is because of the high content of PUFA, particularly linoleic acid and linolenic acid. The shelf life of oil is estimated to be 37.8 weeks based on the accelerated shelf-life model (Alemayhu et al. 2019). As mentioned previously, oxidative stability of soybean oil can be improved when the soybean is subjected to γ -irradiation (Byun et al. 1996). Soybean oil, along with essential oils, has also been used in the making of antibacterial edible films to enhance the microbiological food safety (Zhang et al. 2015) (Table 1.12).

1.9 Rapeseed Oil

Rapeseed (*Brassica napus*), which contains more than 40% of oil, is an important crop grown for its oil which fulfils approximately 13% of world's demand for vegetable oil (Hajduch et al. 2006). It belongs to the order of *Brassicales* and the family of *Brassicaceae*. Rapeseed was domesticated around 400 years ago in Europe where its oil was used in lamps for lighting, soap making and as an edible oil (Gómez-Campo and Prakash 1999). It has been suggested that rapeseed ($2n = 38$) originated from the spontaneous hybridisation of *B. rapa* ($2n = 20$) and *B. oleracea* ($2n = 18$) (Hasan et al. 2008). Rapeseed has been the most important oilseed crop in the EU for more than a decade (Hasan et al. 2008; Krautgartner et al. 2018). Based on the latest data, Canada, EU, China and India are the top 4 countries and/or regions in the production of rapeseed and the world's production of rapeseed achieves 68.19 million metric tons in the year 2019/20.

Rapeseed can be grown on a wide variation of well-drained soils with optimum pH ranging between 5.5 and 8.3 (Ag Marketing Resource Center 2020). After the oil being extracted, rapeseed meal is produced as the by-product which can be used as animal feed. Typically, rapeseed meal contains around 40% of protein and 12% of crude fibre, but it is mostly used to feed ruminant because of its content of antinutrient glucosinolates (Rutkowski 1971). Glucosinolates are sulphur-containing compounds which can be harmful for the thyroid gland of monogastric animals. Through breeding programs, cultivars that are low in glucosinolates has been cultivated (Mailer 2016).

Rapeseed oil has a typical yellowish look and is the third most consumed edible oil in the world after palm and soybean oils. China, Germany, India, the United States are among the four largest rapeseed oil-consuming countries (Grain Central 2019). Other than food application in mayonnaise, salad dressing and others,

Table 1.12 Physicochemical properties of soybean oil

Characteristics	Range
Specific gravity (25 °C)	0.914–0.918
Iodine value (g I ₂ /100 g oil)	126–138
Saponification number (mg KOH/g oil)	189–195
Oxidative stability index (110 °C) (h)	4.84–5.24
Dynamic viscosity (cP)	48.1–57.1
<i>Bioactive compounds (mg/kg oil)</i>	
α-Tocopherol	44–282
β-Tocopherol	n.d.–69.6
γ-Tocopherol	332–1559
σ-Tocopherol	110–477
<i>Phytosterol composition (mg/kg oil)</i>	
β-Sitosterol	650–2360
Brassicasterol	n.d.–128
Campestanol	59.1
Campesterol	248–1310
Cycloartanol	27.2
Cycloartenol	47.1
Egosterol	19.8
Stigmasterol	219–872
24-methylene-Cycloartanol	43.4
Δ5-Avenasterol	n.d.–135
Δ5-Stigmasterol	n.d.–150
Δ7-Avenasterol	n.d.–40
Squalene (mg/kg oil)	n.d.–181

n.d. not detected. Modified from Anwar et al. (2003), Bart et al. (2010), Byun et al. (1996), Dijkstra (2016), Dobarganes et al. (2002), Fang et al. (2016), Kania et al. (2004), List (2016), Medina-Juárez et al. (1998), Nergiz and Celikkale (2011), Nouredini et al. (1992a), Perkins (1995), Rafalowski et al. (2008), Sahasrabudhe et al. (2017), Sawada et al. (2014), Tran et al. (2018), Tuberoso et al. (2007), Yang et al. (2019), Vlahakis and Hazebroek (2000), Nouredini et al. (1992b), Siger et al. (2008)

rapeseed oil can also be utilized as the raw material to produce biodiesel and plastic (Mailer 2016; Encinar et al. 2018; Vicente et al. 2010).

Similar to most vegetable oils, rapeseed oil is rich in unsaturated fatty acid (>80%). This makes rapeseed oil to remain as clear liquid in the refrigerator and fractionation is usually not required to remove any solidified fat (List 2016). The five most abundant fatty acids in rapeseed oil are oleic, linoleic, linolenic, palmitic and stearic acids, as tabulated in Table 1.13. A huge range in the MUFA and PUFA contents, particularly those of oleic, linoleic and linolenic acids has been observed in the literatures. Rapeseed oil was originally rich in erucic acid which makes it suitable as lubricating oil in engines (Eskin 2016). However, long-term oral intake to erucic acid can induce myocardial lipidosis in both human and animals and a tolerable daily

Table 1.13 Fatty acid composition in rapeseed oil

Fatty acid	Percentage (%)
C8	n.d.
C10	n.d.
C12	n.d.
C14	n.d.–0.3
C16	2.5–10.5
C16:1	0.1–0.4
C18	0.9–6.9
C18:1	23.2–66.0
C18:2	15.2–30.0
C18:3	1.2–44.0
C20	n.d.–0.7
C20:1	0.6–9.1
C22	n.d.–0.4
C22:1	n.d.–1.5
C24	n.d.–0.3

n.d. not detected. Modified from Biljana et al. (2015), Dymińska et al. (2017), Kmiecik et al. (2009), List (2016), Matthaus et al. (2016), Nouredini et al. (1992a), Orsavova et al. (2015), Rafalowski et al. (2008), Sagan et al. (2019), Tuberoso et al. (2007), Zambiasi et al. (2007)

intake of erucic acid has been set at 7 mg/kg body weight (EFSA Panel on Contaminants in the Food Chain et al. 2016). Therefore, conventional breeding and genetic engineering have been applied for the past few decades to select and cultivate cultivars of rapeseed with altered fatty acid composition that suite certain functions which include those with low erucic acid content for human consumption (Sakhno 2010; Matthaus et al. 2016). Consequently, cultivars with relatively diverse MUFA and PUFA contents are available nowadays, as reported in the work of Biljana et al. (2015).

Rapeseed oil also contains a good balance of ω -6 and ω -3 fatty acids with ω -6/ ω -3 ratio typically ranges between 1 and 3. A low ω -6/ ω -3 ratio approaching the value of 1 which is believed to be the original value in human's history is associated with reduced risk of cardiovascular disease, cancer, and inflammatory and autoimmune diseases (Simopoulos 2002). However, an abnormally high ω -6/ ω -3 ratio of 16.3 has been reported in a cold-pressed rapeseed oil by Orsavova et al. (2015) which can be attributed to the difference between cultivars. To further improve the ω -6/ ω -3 ratio in rapeseed oil, Sagan et al. (2019) have suggested blending rapeseed oil with the ω -3-rich sage and cress oils in 70:10:20 ratio which was found to decrease the ω -6/ ω -3 ratio by about 50%, but the oxidative stability was compromised due to the higher content of PUFA.

Oil is typically extracted from rapeseed by pressing followed by solvent extraction with hexane which could also cause harm to both the environment and human health (Kumar et al. 2017). As an alternative, extraction with hot pressurised ethanol has been proposed by Citeau et al. (2018). Briefly, the process consists of extraction

of rapeseed flakes with 95.6% ethanol at 95 °C and pressure of 340–360 kPa. The extraction mixture is then subjected to cooling separation at −20 to +13 °C which results in practically complete extraction of high-quality crude rapeseed oil that is free from free fatty acids, phospholipids and non-lipid components and the separated solvent can also be reused for subsequent extraction without the need for complete solvent distillation.

Rapeseed oil contains good amounts of tocopherols. These tocopherols were mainly in γ - and α -forms whereas β - and σ -tocopherols were either not detected or detected in a very low percentage. Similar to other vegetable oils, rapeseed oil is free from cholesterol which is of animal origin. In contrast, diverse phytosterols have been detected in rapeseed oil. Among them, brassicasterol, campesterol and β -sitosterol are the three dominant phytosterols in rapeseed oil which have been detected in levels above 1000 mg/kg oil.

Rapeseed oil is also susceptible to oxidation, as reflected by the short induction period which ranged from 5.1 to 7.4 h as previously reported. Nevertheless, rapeseed oil is more oxidation-resistant than soybean oil due to the higher amount of MUFA particularly oleic acid in rapeseed oil (Table 1.14).

1.10 Sunflower Oil

Sunflower oil is the lipid extract obtained from the sunflower seed of the plant, *Helianthus annuus* L. Sunflower oil is another important edible oil besides palm, soybean and rapeseed oils because the sunflower seed contains approximately 44% of oil and 16% protein, making it an excellent edible oil source (Pilorgé 2020). Sunflower oil is comparable to soybean and corn oils due to their similar fatty acid profile. Sunflower oil is particularly high in unsaturated fatty acids such as linoleic and oleic acids, making it a valuable healthy oil. The sunflower genotype can be categorised according to its oleic content namely (1) regular (14–39%), (2) mid-oleic (43–72%) and (3) high-oleic (75–91%) (FAO 1999; Grompone 2005). The fatty acid composition of the sunflower oil may be affected by some environmental factors namely temperature, sunlight and precipitation that affects the growth of sunflowers, leading to different seed development (Akkaya et al. 2019). Table 1.15 shows the fatty acid composition of a typical sunflower oil.

The main triacylglycerols in sunflower oil are OLL, LLL, OLO and PLO (where L = linoleic; O = oleic and P = palmitic acids), which these triacylglycerols contribute to almost 80% of the total triacylglycerol composition (Noor Lida et al. 2002). Owing to the high degree of unsaturation, sunflower oil appears as light yellowish oil at ambient temperature. Previous study showed that sunflower oil is rich in α -tocopherol contents (403–935 mg/kg oil) (Schmidt and Pokorny 2018). Also, sunflower oil has a relatively high concentration of phytosterols (2850 mg/kg oil) which is higher than the recommended value of 1000 mg/kg to exert beneficial health effects (Yang et al. 2019). The main phytosterols are β -sitosterol, campesterol and stigmasterol. Besides, sunflower oil has a high oxidative stability. Therefore, it

Table 1.14 Physiochemical properties of rapeseed oil

Characteristics	Range
Specific gravity (25 °C)	0.903–0.907
Iodine value (g I ₂ /100 g oil)	109–113
Saponification number (mg KOH/g oil)	170–190
Oxidative stability index (110 °C) (h)	5.1–7.4
Dynamic viscosity (cP)	63.5–78.8
<i>Bioactive compounds (mg/kg oil)</i>	
α-Tocopherol	13–362
β-Tocopherol	n.d.–0.6
γ-Tocopherol	18–536
σ-Tocopherol	n.d.–6
<i>Phytosterol composition (mg/kg oil)</i>	
β-Sitosterol	2310–3941
Brassicasterol	530–1366
Campestanol	28.3
Campesterol	1500–3080
Cycloartanol	11
Cycloartenol	173
Egrosterol	25.4
Stigmasterol	n.d.–257
24-methylene-Cycloartanol	52.8
Δ5-Avenasterol	409
Squalene (mg/kg oil)	211.0–437.4

n.d. not detected. Modified from Anwar et al. (2003), Bart et al. (2010), Dymińska et al. (2017), Fang et al. (2016), Kmiecik et al. (2009), Matthaus et al. (2016), Nergiz and Celikkale (2011), Nouredini et al. (1992a, b), Rafalowski et al. (2008), Rudzińska et al. (2005), Sagan et al. (2019), Sahasrabudhe et al. (2017), Siger et al. (2008), Tran et al. (2018), Tuberoso et al. (2007), Vlahakis and Hazebroek (2000), Yang et al. (2019)

Table 1.15 Fatty acid composition in typical sunflower oil

Fatty acid	Percentage (%)
C12	n.d.
C14	0.1–0.2
C16	5.0–7.6
C16:1	0.1–0.3
C18	2.7–6.5
C18:1	14.0–39.4
C18:2	48.3–74.0
C18:3	0.1–0.3
C20:0	0.1–0.5
C20:1	n.d.–0.3
C22	n.d.–1.5

n.d. not detected. Modified from Panda et al. (2016), Rosa et al. (2009), CODEX (2001)

Table 1.16 Physiochemical properties of sunflower oil

Characteristics	Range
Specific gravity (25 °C)	0.915–0.919
Iodine value (g I ₂ /100 g oil)	120–140
Saponification number (mg KOH/g oil)	188–202
Oxidative stability index (98 °C) (h)	12.8–13.7
Dynamic viscosity (cP)	43–49
<i>Bioactive compounds (mg/kg oil)</i>	
α-Tocopherol	403–935
β-Tocopherol	6–41
γ-Tocopherol	1–27
σ-Tocopherol	n.d.
<i>Phytosterol composition (mg/kg oil)</i>	
β-Sitosterol	1400–2214
Brassicasterol	n.d.–18
Campestanol	3–48
Campesterol	272–296
Cycloartanol	n.d.–7
Cycloartenol	47–130
Egosterol	n.d.–7
Stigmasterol	110–270
Sitostanol	40–45
Δ5-Avenasterol	70–178
24-methylene-cycloartanol	76–14.9
Squalene (mg/kg oil)	134–142

n.d. not detected. Modified from Vafakish et al. (2017), Chiplunkar and Pratap (2016), Crapiste et al. (1999), Tasan and Demirci (2005), Schmidt and Pokorny (2018), Hassanien (2013), CODEX (2001)

can be used for various applications including frying oil, salad oil and etc. (Grompone 2005) (Table 1.16).

1.11 Coconut Oil

Coconut oil is an edible oil extracted from the fresh and mature kernel of the coconut (*Cocos nucifera* L.). Coconut oil can be classified into either virgin coconut oil or refined coconut oil in which the former has not been exposed to any refining steps such as bleaching, degumming and deodorisation after extraction (Agarwal 2017; Soo et al. 2020; Satheesh and Prasad 2012). Therefore, virgin coconut oil was reported to retain most of the polyphenolic compounds. The fatty acid composition and nutritional content of the coconut oil are presented in Tables 1.17 and 1.18, respectively. Coconut oil consists predominantly of short and medium chain fatty acids particularly in lauric acid (46–48%) and followed by myristic acid (16–21%).

Table 1.17 Fatty acid composition in coconut oil

Fatty acid	Percentage (%)
C6	n.d.–0.7
C8	4.6–10.0
C10	4.5–8.0
C12	43.0–53.2
C14	16.0–21.0
C16	7.2–10.2
C16:1	n.d.
C18	2.0–4.0
C18:1	4.5–10.0
C18:2	1.0–2.5
C18:3	n.d.–0.2
C20:0	n.d.–0.2
C20:1	n.d.–0.2
C22	n.d.

n.d. not detected. Modified from Satheesh and Prasad (2012), Soo et al. (2020), Mansor et al. (2012), Prapun et al. (2016), Dayrit et al. (2007), APCC (2005), CODEX (2001), Bhatnagar et al. (2009)

Previous studies suggested that free lauric acids could exert potent antimicrobial activity on Gram-positive bacteria such as *Clostridium difficile*, *Staphylococcus aureus* and *Candida species* (Ogbolu et al. 2007; Abbas et al. 2017; Silalahi et al. 2014). Besides, a diet enriched with coconut oil could possibly suppress the low-density lipoprotein while improving the high-density lipoprotein which is associated with enhanced cardio-protective effect (Chinwong et al. 2017). An analysis on the triacylglycerol composition of coconut oil revealed 22–25% of LaLaLa, 14–16% of CCLa, 19–21% of CLaLa, 13–15% of LaLaM and 7–9% of LaMM (where La = lauric; C = capric and M = myristic acids) as the major triacylglycerol. Due to its substantial amount of medium-chain triacylglycerol, coconut oil has a relatively low melting temperature range (Marina et al. 2009). The physicochemical properties of coconut oil are similar to palm kernel oil in that they exhibit sharp melting points and excellent oxidative stability in addition to high lauric and myristic fatty acids. Coconut oil is also found to contain trace amount of α -tocopherol (17–60 mg/kg), depending on the extraction technique (Prapun et al. 2016; Desai et al. 1988; Arlee et al. 2013). Fermentation technique tends to produce coconut oil with high phenolic compounds. Qualitative analysis of the phenolic compositions of coconut oil revealed the presence of caffeic, catechin, ferulic and p-coumaric acids as the predominant phenolic compounds (Seneviratne and Sudarshana 2008).

Table 1.18 Physicochemical properties of coconut oil

Characteristics	Range
Specific gravity (25 °C)	0.915–0.920
Iodine value (g I ₂ /100 g oil)	4.1–11.0
Saponification number (mg KOH/g oil)	248–280
Oxidative stability index (110 °C) (h)	11.3
Dynamic viscosity (cP)	40
<i>Bioactive compounds (mg/kg oil)</i>	
α-Tocopherol	17–60
β-Tocopherol	n.d.
γ-Tocopherol	n.d.
σ-Tocopherol	n.d.
<i>Phytosterol composition (mg/kg oil)</i>	
β-Sitosterol	27.1
Brassicasterol	n.d.
Campestanol	n.d.
Campesterol	4.1
Cycloartanol	n.d.
Cycloartenol	n.d.
Egrosterol	n.d.
Stigmasterol	8.5
Sitostanol	n.d.
Δ5-Avenasterol	n.d.
Squalene (mg/kg oil)	20

n.d. not detected. Modified from CODEX (2001), APCC (2005), Dayrit et al. (2007), Soo et al. (2020), Prapun et al. (2016), Arlee et al. (2013), Rajan et al. (2010), Bhatnagar et al. (2009), Koh and Long (2012), Pazzoti et al. (2018), Gopakumar and Thankappan (1986), Tan et al. (2002)

1.12 Conclusion

Dietary lipids can be derived from both animal and vegetable sources. They are essential nutrients required to regulate and maintain healthy body functions. In contrast to animal fats, vegetable oils are composed primarily of unsaturated fatty acids (oleic and linoleic acids) with some exceptions. On the other hand, animal fats are high in saturated fatty acids (palmitic and stearic acids) with a considerable amount of MUFAs. However, the fatty acid profile of animal fats can be modified through feeding diet to meet the recommended nutrient requirement. Vegetable oils are also rich in tocopherols and phytosterols which are powerful antioxidants and capable of reducing low-density lipoprotein, thereby lowering the risk of coronary heart diseases. Animal fats also contain some important nutrients including vitamin D and K. In short, both animal fats and vegetable oils can be used for various food applications, depending on their distinctive physicochemical properties.