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Le coupage des huiles végétales

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- **LLL:** Trilinoleoylglycerol,
- **PLL:** Palmitoyl-dilinoleoylglycerol
- **LOO:** Linoleoyl-Dioleylglcerol
- **PLO:** Palmitoyl-oleyl-linoleoylglycerol
- **LLO:** Dilinoleol-oleylglycerol
- **TAG:** Triacylglycerols
- **TG:** Triglycéride
- **POO:** Palm Olein Oil
- **OO:** Olive Oil
- **SBO:** Soybean Oil
- **SO:** Sesame Oil
- **RBO:** Rice Bran Oil
- **CAO:** Camellia Oil
- **PNO:** Peanut Oil
- **SFA:** Saturated Fatty Acids
- **MUFA:** Monounsaturated Fatty Acids
- **PUFA:** Polyunsaturated Fatty Acids

INTRODUCTION

Vegetable oils constitute an important part of the human diet and are widely used in the food, pharmaceutical, cosmetic and chemical industries but more widely in food products for their richness in major fatty acids which are nutritionally vital. Vegetable oils are the most important edible lipids in the world, but the majority of them do not have good functional and nutritional properties and oxidative stability appropriate to meet consumer requirements in terms of texture, stability and physico-chemical properties, which are very important factors that will help provide accurate stability data. **(Dugo *et al*, 2004; Reyes-Hernandez *et al*., 2007; Ahmad *et al*., 2010).**

The problem of instability of vegetable oils that leads to undesirable aroma and taste, such as oxidation of edible oils during processing and storage that produces bad-tasting compounds, leads to a deterioration of their sensory qualities and nutritional value; rending the oil undesirable to consumers and industry as a food ingredient, also destroys essential fatty acids and produces toxic compounds (**Choe and Min 2006; Anwar *et al*, 2007).**

The ratio of omega-3 and omega-6 fatty acids which is important for the maintenance of cardiovascular health and the number of unsaturations in oils whose high amount of saturated fat, is one of the causes of coronary heart disease such as atherosclerosis, are factors that affect the quality of the oils. Therefore, consumer dissatisfaction is where the mixing of oils comes into play, which is an innovative idea because it avoids the addition of chemicals to the mixtures and also leads to obtain oils of good quality.

The use of a blended vegetable oil is a simple way to assemble the advantage of different properties and characteristics of each oil **(Ahmad *et al*., 2010; Roiaini *et al*., 2015).**

For many years, the modification of oils by direct mixing with other fats, hydrogenation, interesterification and fractionation have been used to improve the functionality of oils and optimize their application in other food products where direct mixing of fats is the technique of choice, because it is a simple, inexpensive and non-destructive technique that has no negative effects on human health **(Nor Hayati., 2009).**

Blends are used to achieve explicit ingredient benefits that provide protection against oxidation, improve degradation stability, improve recyclability of frying, and also to reduce the cost of edible oils and achieve near ideal acid composition **(Tiwari *et al*., 2014).**

Vegetable oils begin to decompose when isolated from their natural environment, resulting in unpleasant taste and odor, harmful compounds and oxidative deterioration which is accelerated by exposure to the high temperature of about 180°C during frying, light, moisture and the presence of traces of transition metals in the oils. Vegetable oils mixed with non-edible oils such as nettle oil, form a new source of edible oils that are more beneficial to health and have more phytochemicals and essential antioxidant characteristics **(Paul and Chinnan 1997; Durmaz and Talpur., 2015).**

The mixing of vegetable oils with different physical and chemical properties and characteristics is the simplest method to have products with specific physical, chemical and nutritional properties and also good oxidation and texture parameters, unlike the use of an unmixed oil which will have poor oxidation stability and may have some disadvantages, for example Palm oil has a high oxidation stability but has a low content of essential fatty acids and high amounts of saturated fatty acids, while soybean oil has a high content of linolenic acid but low oxidation stability, therefore a mixture of oils with high oxidative stability and rich in antioxidants with other oils can improve the shelf life of these resulting edible oils **(MARIOD *et al*., 2005; De Marcoet *et al*., 2007; Hashempour *et al*., 2016).**

Several studies have been carried out on oil blends such as sesame oil, which provides very high levels of lignans with many bioactive properties, such as antioxidant activity. As a result, this oil is stable, and when blended with other oils, it increases the stability of the blend however, this oil has poor sensory qualities when fried, therefore, it is recommended to mix palm olein with sesame oil to obtain healthy crisps with more acceptable physico-chemical characteristics and sensory properties, an increase in the degree of establishment and improvement in the physico-chemical parameters the aroma, flavour, crispness and general acceptability of fried foods and sensory properties have been marked **(Abdulkarim *et al*., 2010; Gulla and Waghray, 2011; Bakhtiary, 2014).**

Blends of soybean oil with other vegetable oils are analyzed to investigate the effects of changes in fatty acid composition on the oxidative stability of the resulting blend, it has been shown that the quality of the blend of soybean oil with sesame oil during storage at 60°C is improved compared to soybean oil alone due to the richness of sesame oil in antioxidants and their synergistic action **(Chu and Kung, 1998).**

The mixture of vegetable oils is used in Algeria in the manufacture of margarines such as Feurial and Matina which are produced by Cevital and in the manufacture of table oils such as Afia.

The main objective of our research work is to establish the state of the art on the effect and the role of the mixture of several vegetable oils, with different physicochemical and organoleptic properties, on the improvement of nutritional, physicochemical, organoleptic and economic proprieties of the resulting oils

The dissertation is organized in three main parts; the first part constitutes the generalities on fats and the methods of extraction of vegetable oils. The second part is devoted to the botanical, biological, chemical and pharmacological aspects specific to oleaginous plants (palm, soybean and sesame). The third part is focused on blending oils.

CHAPTER I:

General informations about fats

I. Generalities about fats

I.1 Fatty acids

Fatty acids are carboxylic acids with a hydrophobic aliphatic chain, with so-called unsaturated double bonds and without so-called saturated double bonds. They differ from each other by the length of the carbon chain, the position and spatial structure (cis, trans) of the double bonds **(Cuvelier *et al*., 2004).**

I. 2 Lipids

Lipids are a set of families of hydrophobic or amphiphilic compounds (glycerides, free fatty acids, glycolipids, phospholipids, tocopherols, alcohols, pigments (carotenoids, chlorophylls), sterolsand complex lipids such as phosphoglycerides, sphingolipids, glycolipids and polycetides), which constitute the fat or fats. At room temperature when they are liquid are called oils, and fat (concrete) when they are solid at a temperature of 15 C° **(Ollivier *et al*., 2015).**

I.3 Vegetable oils

Vegetable oils composed of a wide variety of constituents; triglycerides are overwhelmingly in the majority (95-99%), and (1-5%) other so-called minor constituents present in small quantities such as phospholipids and unsaponifiables mainly represented by carotenoids, phenols, phytosterols, squalenes and tocopherols **(Pages *et al*, 2010).**

They represent a large family of multipurpose fats that have a dual function: nutritive, sources of various fatty acids, vitamins and various molecules and hedonic, which confers palatability to the food and dishes they accompany. Unlike other fats (margarine, fresh cream, tallow, and other fats of animal origin) which contain a variable amount of water, oils do not contain water, but nearly 100% lipids **(Lecerf, 2011).**

The expiry date is often indicated on the label, informing of the date until which the oil will retain its best qualities. It is advisable to store vegetable oils in cool, dark places in tinted glass or metal packaging and to re-seal the bottle after each use, to reassure protection against UV rays and avoid any auto-oxidation reactions that lead to a rancid taste **(Cahuzac-Picaud, 2010).**

II. Extraction methods of vegetable oils

Crude vegetable oils are produced during the oilseed crushing process, which requires several unit operations, starting with a pre-treatment step that includes washing, drying, heating 60◦C and bottling, followed by a processing step using different techniques, alone or in combination, such as pressing with mechanical presses and solvent extraction **(Régis *et al*., 2016).**

In order to avoid deterioration caused by insects or mould and to prevent or delay the oxidation of lipids, which is favored by enzymes, temperature, humidity and oxygen; techniques such as storage in silos under controlled atmosphere with adequate ventilation without oxygen are used (**Ghouila *et al*., 2019).**

II.1 Pre-treatment

The oilseeds are sieved using rotary sieves to remove impurities that could affect the quality of the oils and oilcake and to avoid the complication of the unit operations that follow

Seed preparation: cleaning, hulling, pre-cooking, and flattening.

Cooking: The flakes from the previous stages undergo indirect steam cooking.

Pressure: continuous presses exert pressure on the flakes; the cake thus obtained, called "cake of pressure", and contains 16 to 24% of materials fat according to the nature of the treated seeds **(Kemper, 2005; Régis *et al*., 2016).**

II.2 Solvent extraction

Usually, crude oils are recovered by solvent from the pressure cake. The processed and ground seeds are placed in the extraction machine. The solvent dissolves the oil, while the protein, fiber and carbohydrates remain in the flour. Then the cake undergoes desolvation by desorption and evaporation of hexane and then distillation of the oil to evaporate the solvent. Hexane and hexane-based solvents are widely used and more efficient for oil extraction and the properties of the oil can be affected by the type of solvent used, so the choice of solvent is very important to meet quality standards **(Bulley *et al*., 1984; Fine *et al*., 2013; Ghouila *et al*., 2019).**

II.3 Microwave extraction:

Microwave-assisted extraction is a process that uses microwave energy to heat solvents that are in contact with a sample in order to remove analytes from the matrix in the solvent. The main advantages of microwave-assisted extraction include reduced extraction time, requires only a few minutes, less solvent, higher extraction rate at lower cost**.** The application of microwaves to extract oil from grape seeds has improved oil yields and increased the levels of polyphenols, coenzymes and vitamin E **(Eskilsson and Bjorklund, 2000; Hao *et al*., 2002;Régis *et al*., 2016).**

II.4 Ultrasonic extraction

Ultrasonic assisted extraction can improve the efficiency of oil extraction, thanks to the acoustic cavitation that disturbs the cell walls. When a mixture is subjected to ultrasound, micro-bubbles develop and oscillate rapidly. These violent implosions break at the surface of the solid matrix, which facilitates the penetration of the solvent into the matrix and allowing the release of the intracellular product, and the mechanical effect caused by ultrasound which allows the agitation of the solvent used, which increases the contact between the solvent and the targeted compounds by allowing greater penetration of the solvent into the sample matrix (**Zhang *et al*., 2008; Sicaire *et al*., 2016).**

Therefore, the main advantages of ultrasonic assisted extraction include reduced extraction time and solvent consumption and it can be carried out at a lower temperature, which can avoid thermal damage to extracts and minimize compound loss, the investigation that was carried out to extract hemp oil by ultrasound showed that the resulting oil is a potential method to produce better hemp oil and is not significantly affected and requires a shorter operating time and lower solvent consumption**(Lin *et al*., 2012).**

II.5 Press extraction

In this process, the cell walls are broken by crushing, flaking, rolling or pressing under high pressure to release the oil. Pressing of oilseeds and nuts follows a sequence:

- Removal of all metal pieces stuck in seeds using magnetic separators.
- Removal of shells or hulls, if necessary.

- Conversion of grain to coarse meal by inter-roll grinding.
- Pressing by means of presses with or without heating, depending on the type of seeds/oil fruits and the desired quality.

By using heat during the pressing process, the cake removes more oil colored as cold-pressed oils, but accompanied by non-glyceride impurities such as phospholipids, carotenoids and unsaponifiables **(Ghouila *et al*., 2019).**

The oil expressed without heating contains the least amount of impurities; it does not require refining, these oils are of high quality called cold-drawn, cold-pressed or virgin oils, they are good sources of tocopherols, carotenoids and chlorophylls, polyphenols and other antioxidants with a positive impact on human health **(Veličkovska *et al*., 2015).**

The crude oil extracted by these various known processes is a cloudy, dark-colored liquid with a capturable odor and flavor. This liquid requires further processing to remove impurities, possible contaminants, and to transform it into a bland, stable and nutritious product useful in the manufacture of food products known as refining **(Stropand Perry 1989; Fine *et al*. 2013).**

III. Refining:

Is a very important technology in the edible oils and fats industry which aims to ensure, on the one hand, the optimization and control of organoleptic and nutritional characteristics and stability during subsequent storage and, on the other hand, the elimination of undesirable compounds (gums, waxes, free fatty acids, pigments, metallic traces, volatile odor compounds and the possible residual content of the solvent used for extraction and contaminants such as pesticides, dioxins, aflatoxins and polybrominated flame retardants (polybrominated diphenyl ethers), but all this must be done with minimal damage to acylglycerols and minimal loss of desirable elements **(De Kock *et al*., 2005; Gibon *et al.*, 2005., Pages *et al*, 2010 ; landucci *et al*, 2013)**

IV. Types of refining

There are two types of refining: chemical and physical or neutralizing distillation:

IV.1 Chemical refining

Chemical refining eliminates its undesirable compounds by neutralization with soda in doing so:

- **Water damaging and/or acid conditioning:** removal of phospholipids.
- **Chemical neutralization with soda:** elimination of free fatty acids, neutralization pastes (soaps), phospholipids, H_3PO_4, metals, some pigments, oxidation products, some contaminants.
- **Washing drying:** elimination of the auxiliaries of manufacture**:** acid, base, water and the waters of washing: soaps, phospholipids.
- **Discoloration:** removal of pigments and traces of soaps, residual phospholipids, polar oxidation products, certain contaminants.
- **Decalcification and filtration**: removal of waxes.
- **Deodorization/vapor injection (180-230°C) under vacuum 2-3 mbar:** removal of volatiles and flavors, hydro peroxides and some contaminants **(Pages *et al.*, 2010).**

IV.2 Physical refining:

Neutralizing distillation eliminates undesirable compounds (deacidification) by high vacuum distillation with steam injection:

- **[Degreasing/Water] Acid conditioning:** removal ofphospholipids.
- **Centrifugation Washing (Drying).**
- **Pre-treatment bleaching (on bleaching earths):** removal of pigments, residual phospholipids, polar oxidation products and some contaminants.
- **Decalcification Filtration: removal of waxes.**
- **Distillation/Vapor injection (230-250°C) or "flash" distillation (260°C) High vacuum (1-2 mbar):** removal of free fatty acids, volatiles, scavengers, hydro peroxides and certain contaminants **(Pages *et al.*, 2010).**

CHAPTER II

Palm oil

I. Botanical characteristics

The oil palm resembles the date palm with a large head of pinnate feathery fronds growing from a sturdy trunk. The two most important palm species are *Elaeis guineensis* found in Africa and *Elaeis melanococca* from America. The fruits grow in clusters of 10 to 50 kg and each contains 800 to 2,000 individual fruits. The female bunch produced can weigh as much as 30–40 kg, palm fruit are black in color when young, turning to orange-red when ripe. Each fruit has one seed, consisting of a hard endocarp covered by a thin epicarp, which is approximately 10 to 46% of the fruit. The fruit produces two types of oil; the fleshy mesocarp produces crude palm oil, which is used mainly for its edible properties and fuel, and the other type is the palm kernel which produces from kernel, which has wide application in the oleo chemical industry **(Edem, 2002; Akbari *et al.*, 2012; Enyoh *et al.*, 2017; Ghouila *et al.*, 2019).**

The oil palm tree has an unbranched stem and belongs to the *Palmae* family, which can grow to a height of 20 to 30 meters, has an economic life span of 25 to 30 years. The palm plant grows under specific conditions such as for land, humidity above 80%, a moderate temperature between 22 and 33 ° C. The most widely sold oil palm comes from E. species. Guineensis which has spread to most tropical and subtropical regions of the world, but in particular Malaysia which is currently the world’s largest producer and exporter of palm oil **(Edem, 2002; Sumathi *et al.*, 2008; Ghouila *et al.*, 2019).**

Figure 1: Palm tree **(Yijun, 2019).**

II. Fruit description

The oil palm fruit is a drupe, which forms in a tight bunch. The pericarp comprises three layers, the exocarp (skin), mesocarp (outer pulp containing palm oil) and endocarp (a hard shell enclosing the kernel (the endosperm) which contains oil and carbohydrate reserves for the embryo **(Sambanthamurthi et *al.*, 2000).**

Figure 2: Palm fruit **(Yijun, 2019).**

II.1 Origin

It has supposed existence of one or more than one land bridges between West Africa and South America during Late Cretaceous and Early Eocene times *Elaies guineensis* originating from West Africa was first introduced to Brazil and other tropical countries in the 15th Century by the Portuguese. However, its propagation did not take off until the 19th Century when the Dutch brought seeds from. The palms planted as ornamentals in Deli. From there the oil palm was sent to the Botanical Gardens in Singapore in 1875, and subsequently brought to Malaysia in 1878. The oil palm was initially planted in Malaysia as an ornamental and the first commercial planting was only in 1917 **(Zeven, 1964; Sundram *et al.*, 2003; Ruiz *et al.*, 2013).**

II.2 Types of production

Diets of fleshy fruits with oily pulp from which oil is extracted semi-concrete red: palm oil. Fruit almonds from which light yellow concrete oil is extracted: palm kernel oil. These two oils are edible **(Jacquemard, 2012).**

III. Palm oil

Palm oil is classified in the category of hard oil due to its richness of saturated fatty acids which may be solid or semi-solid at ambient temperature**.** Palm oil is a lipid extracted from the fleshy orange-red mesocarp of the fruits of the oil palm tree (*Elaeis guineensis*) which contain 45% to 55% oil **(Edem, 2002;Naghshineh *et al.*, 2010).**

III.1 Chemical composition of palm oil

Palm oils have saturated and unsaturated fatty acids in approximately equal amounts. The major fatty acids in palm oil are myristic (14:0), palmitic, stearic, oleic and linoleic (18:2). Most fatty acids are present as TGs. Like all oils, TGs are the major constituents of palm oil. Over 95% of palm oil consists of mixtures of TGs. During oil extraction, the hydrophobic TGs attract other fat- or oil-soluble cellular components. Crude palm oil contains about 1% of minor components including carotenoids, tocopherols, sterols, triterpenes, phospholipids, gtycolipids, aliphatic hydrocarbons and other trace impurities. Other components in palm oil are the metabolites in the biosynthesis of TGs and products from lipolytic activity. These include the monoacylglycerols (MGs), diacylglycerols (DGs) and free fatty acids (FFAs) **(Sundram *et al*. 2003; Goh *et al*., 1985; Enyoh *et al*.,2017).**

Table I: Fatty acid composition (%) of Malaysian palm oil **(Tan *et al*., 2009)**.

Fatty acids	Malaysian palm oil %
Myristic acid (C 14:0)	1.1
Palmitic acid (C 16:0)	43.5
Palmitoleic acid (C 16:1)	0.2
Stearic acid (C 18:0)	4.3
Oleic acid (C 18:1)	39.8
Linoleic acid (C 18:2)	10.2
Linolenic acid (C 18:3)	0.3
Others	0.6
Total	100

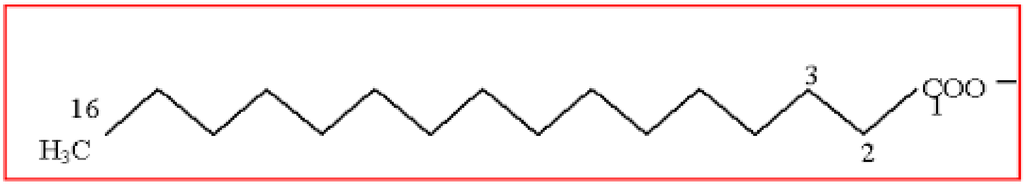

Figure 3: Palmitic acid structure**(www.chups.jussieu.fr)**

III.2 Composition of minor constituents of palm oil

Crude palm oil (CPO) has a deep orange-red color due to the high content of carotenoids. It is also a richsource of vitamin E, representing mainly tocotrienols(70%) and tocopherols (30%). a-Tocopherol and c-tocotrienol account for the majority of the total tocopherols and tocotrienols**.**Both β-carotene and vitamin E are well-known nutritional antioxidants **(Wing, 2002; Naghshineh *et al.*, 2010).**

Table II: Ranges in content for various components in the unsaponifiable fraction from a palm oil **(Sundram *et al.*, 2003; Ogan *et al.*, 2015).**

Component	**%**
Carotenoids	
α- carotene	36.2
β- carotene	54.4
γ- carotene	3.3
Lycopene	3.8
Xanthophylls	2.2
Vitamin E	
α- tocopherol	28
β -tocotrienol	29
γ -tocotrienol	28
δ- tocotrienol	14

Tocotrienols	
α-Tocotrienol	44–73
β-Tocotrienol	44–73
γ-Tocotrienol	262–437
δ-Tocotrienol	70–117
Sterols	
Cholesterol	4
Campesterol	21
Stigmasterols	21
β-sitosterol	63
Total alcohols	
Triterpenic alcohol	80
Alipahtic alcohol	20

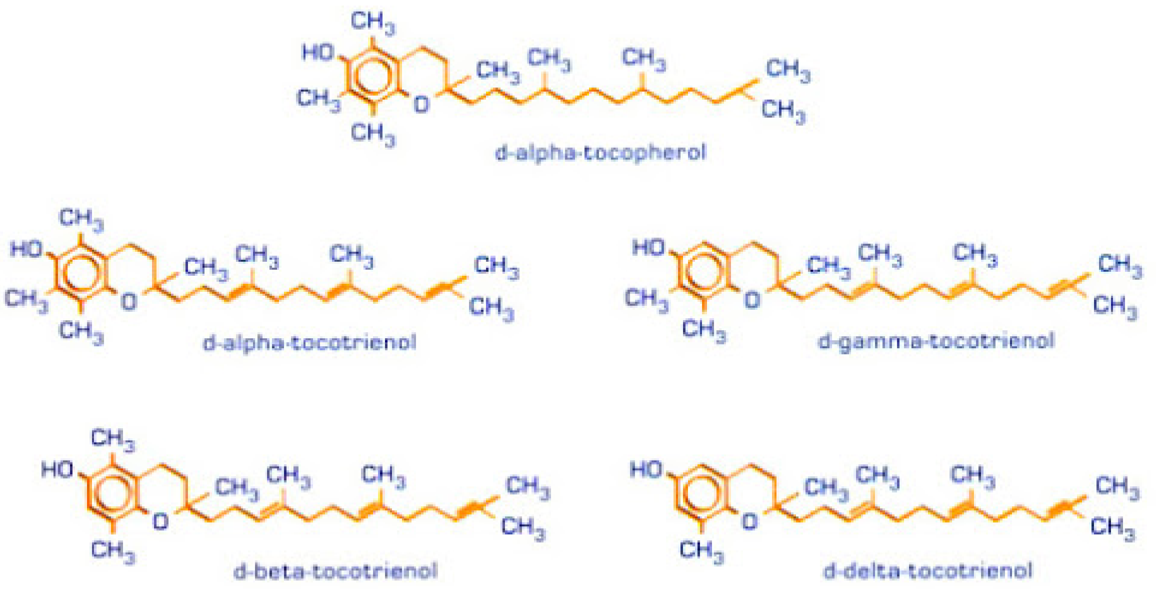

Figure 4: Les Tocotrienols **(www.huiledepalmeetsante.org)**

III.3 Triglycerides composition

Most of the fatty acids of palm oil are present as TAGs. The deferent placement of fatty acids and fatty acid types on the glycerol molecule produces a number of deferent TAGs **(Sambanthamurthi *et al.*, 2000).**

The triglycerides have been grouped in terms of saturated and unsaturated fatty acids**.** There are 7 to 10% of saturated TGs and 6 to 12% unsaturated TGs, more than 85% of the unsaturated fatty acids are located of the glycerol molecule in the sn-2 position. Table III shows the percentage distribution of individual TAGs of palm oil **(Sambanthamurthi *et al.*, 2000; Deffense, 1985).**

Table III: Triglycerides composition of palm oil **(Ogan *et al.*, 2015).**

Triglyceride	Content (%)
Trisaturated (SSS)	9.8
Disaturated (SUS)	48.8
Monosaturated (SUU)	36.5
Triunsaturated (UUU)	4.8
Diglycerides	4.9

IV. Nutritional value of palm oil

Almost 90% of the world's palm oil production is used as food. The nutritional value of balm oil is based on the fatty acid composition. As previously mentioned, palmitic acid is the main saturated fatty acid in palm oil (44%)**,** stearate (5% saturated), oleate (39% monounsaturated), linoleate (10% polyunsaturated) and linolenate (0.3% polyunsaturated). This composition is different from palm kernel oil which is almost 85% saturated. The minor components of interest in palm oil are vitamin E, carotenoids and a complex of phenolic flavonoids rich in antioxidants, the pro-vitamin A activity of red palm oil and palm carotene concentrates and the antioxidant and anti-cancer properties of vitamin E from palm trees, carotenoids and the phenolic-flavonoid complex **(Sundram *et al.*, 2003; Imoisi *et al.*,2015).**

V. Palm oil uses

Palm oil and its refinery products are now consumed worldwide as cooking oil, margarine and shortening, and are also incorporated into fat blends and a wide variety of food products **(Wing, 2002).**

Palm stearin is used mainly in food applications that require higher solid fats content such as shortenings, margarines and Vanaspati (hydrogenated vegetable oils used as substitute for butter in South Asia especially India), palm oil has been used as 100% replacement for traditional hydrogenated seed oils such as soybean oil and canola. Other fractions are used as cocoa butter equivalents in confectioneries while super olein (double fractionated palm olein) is used in mayonnaise and salad dressings. While olive, rapeseed and canola oils contain Z60% of cis-oleic acid, palm olein has ≈ 48% of oleic acid. It has been reported that in healthy normo cholesterolemic humans, palm olein could be substituted for olive oil without adversely affecting serum lipids and lipoprotein levels since it is rich in oleic acid **(Ogan *et al.*, 2015; Sumathi *et al.*, 2008).**

Palm oil is also used as a cosmetic (mainly palm kernel oil), biofuel and energy, animal feed (palm kernel expeller), in pharmaceutical and industrial products and in the food industry **(Book and Claim Ltd, 2006).**

Palm oil was attacked as "saturated" since it contains 44% palmitic acid and 5% stearic acid, and thereby allegedly raises blood cholesterol and increases the risk of cardiovascular disease. However, a sizeable and growing body of scientific evidence indicates that palm oil's effect on blood cholesterol is relatively neutral when compared to other fats and oils, palm oil raises plasma cholesterol only when an excess of dietary cholesterol is presented in the diet. Two main meta-analyses have examined the effect of palmitic acid (found in palm oil) on serum cholesterol. Palm oil stimulates the synthesis of protective HDL cholesterol and removal of harmful LDL cholesterol. Palm oil is rich in vitamins, spatially vitamin E (Tocopherols and tocotrienols are vitamin E isomers and are potent antioxidants that confer oxidative stability to the oil), appear to reduce serum cholesterol concentrations and has potent anti-oxidant effects **(Nagendran *et al.*, 2000; Mukherjee and Mitra, 2009; Imoisi *et al.* 2015).**

VI. Health effects

Crude palm oil is the richest natural plant source of carotenoids. The human body uses carotenoids as Vitamin A. Carotenoids also enhance immune function by a variety of mechanisms, and can improve cardiovascular health. Carotenoids also play an important potential role by acting as biological antioxidants, protecting cells and tissues from the damaging effect of free radicals **(May, 1994; Mukherjee and Mitra, 2009).**

VII. Deforestation:

Industrial agriculture is responsible for 73% of global deforestation, of which 40% for the oil palm alone. The palm tree is no longer responsible for 40% of global deforestation here but "only" for 40% of deforestation due to intensive agriculture. The countries producers, in particular Indonesia and Malaysia immediately reacted with a Council of Palm Oil Producing Countries (CPOPC) press release dated April 11.

CHAPTER III

Soybean oil

I. Botanical characteristics

The soybean, *Glycine max (L)*, is a plant belonging to the genus Glycine from the legume family, *Fabaceae* family, phaseole tribe, cultivated mainly for these oil seeds which provide the main edible oil consumed in the world **(POUZET, 1992; Gallais, 1992).**

The plant has an erect habit and its height varies from 60 to 110cm; the leaves are trifoliate and fall before the full maturity of the plant **(Gallais, 1992).**

Figure 5: Soybean seeds **(Groupe Bonduelle, 2016).**

Table IV: Taxonomical classification of soybean (*Glycine max*)

Kingdom	**Plantae**
Under-kingdom	**Tracheobionta**
Phylum	**Magnoliophyta**
Class	**Magnoliopsida**
Under-class	**Rosidae**
Ordre	**Fabales**
Family	**Fabaceae**
Under-family	**Faboideae**
Tribe	**Phaseoleae**
Under-tribe	**Glycinae**
Genus	**Glycine**
Under-genus	**Soja**
Species	***Glycine max***

II. Soybean oil

Soybean oil is classified in the category of fluid oils by dint of containing a very high percentage of unsaturated fatty acids. The soy oil is remarkably low in color depending on the nature of the seeds and the extraction processes. Fresh, it has a fairly pronounced bean flavor which is gradually attenuates **(Durkee, 1936; Cossut *et al.*, 2002; Naghshineh *et al.*, 2010).**

Soybean oil has a high nutritional value because it is a rich source of unsaturated fatty acids, such as oleic, linoleic, and linolenic acids with one, two, and three double bonds, respectively **(Medic *et al.*, 2014).**

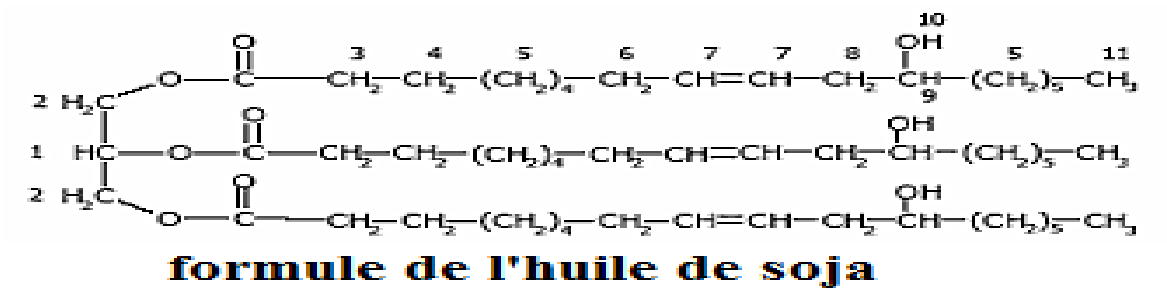

Figure 6: soybean oil formula**(Cerig.efpg.inpg.fr)**

III. Chemical composition of soybean

III.1 Seed composition

Soya is the only legume with a well-balanced protein composition (all essential amino acids are present). It provides useful energy thanks to its complex carbohydrates, and it contains no lactose and cholesterol **(Groupe Bonduelle, 2016).**

Soya bean seeds are the world's most important source of high-quality plant protein and vegetable oil. The value of soya beans is based both on oil and protein. Soya beans normally contain 18.0–22.0% oil and 38.0–43.0% protein. Oil plus protein will range between 58.0% and 62.0% **(Yoshida *et al.*, 2003).**

Table V: Chemical composition of fresh and dry soybean seeds **(Muhlbauer and Muller., 2020).**

Content	Fresh (%)	Dry (%)
Water	25	8
Protein	31. 3	38.4
Fat	15	18.4
Carbohydrates	5.2	6.3
Fiber	18	22.1
Minerals	3.8	4.6

III.2 Oil composition

III.2.1 Fatty acids composition

Oil concentration in soybean seeds ranges from 8.3 to 28%, with a mean of 19.5%. Soybean oil contains five major fatty acids, two saturated fatty acids (palmitic, C16:0; stearic, C18: 0) and three unsaturated fatty acids (oleic, C18:1; linoleic, C18: 2; linolenic C18:3). The concentration of saturated fatty acids in soybean oil ranges from 10–12% for palmitic acid and 3–5% for stearic acid. The concentration of unsaturated fatty acids in oil is about 24% for oleic acid, 54% for linoleic acid, and 8.0% for linolenic acid **(Bellaloui *et al.*, 2015).**

Table VI: Fatty acids composition of soybean oil **(Muhlbauer and Muller., 2020).**

Fatty acids	**Contents** (mg/100 g)	
	Fresh	Dry
Palmitic acid	1416	1738
Stearic acid	475	583
Oleic acid	2956	3626
Linoleic acid	8024	9843
Linolenic acid	761	934

III.2.2 Minor contents composition

Soybean is a source of many vitamins (A, B6, B12, C, and K). These chemical compounds cannot be synthesized in sufficient quantities by an organism and must be obtained from the diet **(Chen *et al.*, 2012).**

Table VII: Some vitamins contained in soybean seeds **(Muhlbauer and Muller., 2020).**

Vitamins	**Contents** (µg/100 g)	
	Fresh	Dry
Vitamin A	52	63
Carotenoids	311	382
Vitamin E	12.3	15.1
Vitamin B1	843	1034
Vitamin B2	377	462

Soy is also:

Source of vitamin B9 (cell renewal, very interesting for pregnant women for the development of the fetus, and in growing children, as well as for convalescent people). It also contains: Vitamin C, minerals such as iron, zinc and calcium. Soybean contains another type of antioxidant which is isoflavones, isoflavoness is an antioxidant compounds currently widely studied in the fight against cancer, cardiovascular disease, osteoporosis and the symptoms of menopause **(Groupe Bonduelle, 2016).**

IV. World soybean production

Soybean is a major source of vegetable oil in the world, and soybean oil represents 56% of world production **(Bellaloui *et al*., 2015).**

- Annually in the United States, soybeans are produced 70 to75 million acres, resulting in nearly 3 billion bushels (>300 million tons) in total, and soybean trade generates nearly 15 billion US dollars every year. The other two nations that produce almost as much soybeans as the United States are Brazil and Argentina. According to a report by, global soybean production has increased by at least 100 million metric tons over the last decade **(Gaonkar and Rosentrater, 2019).**

Table VIII: Main soybean producer and exporter in 1988 **(Gallais, 1992).**

Country	Production (10^6 tons)	Exportation(% of changes)
United state	41.7	59,2
Brazil	22.0	15.2
Argentina	9.5	15,5
China	8.0	/
World production	94.8	

V. Different use of soybean

Soy is used as:

- Oil for human food preparation (cooking oil and margarine)
- High protein meals (soybean meal, soy protein concentrate, soy protein isolate) which are used as ingredients in animal feed.
- Other uses also exist, including various human foods produced directly from soybeans**,** Asian cultures use soybeans to produce traditional foods such as products from the fermentation of soybeans(soy sauce, tempeh, miso, and natto) and also Unfermented products such as tofu, soy paste and soy milk**(Medic *et al*., 2014; Gaonkar and Rosentrater, 2019).**
- Industrial applications such as biodiesel, ink, biocomposites and bioplastics, adhesives, waxes, candles, foams, and hydraulic fluids **(Gaonkar and Rosentrater, 2019).**

VI. Nutritional value of soybean

The nutritional value of soya bean is determined by quality and quantity of its oil and protein. One quality factor is the fatty acid composition of soybean oil. There is increasing evidence for a relationship between consumption of saturated fat and elevated serum cholesterol level, and a relationship between linolenic acid content and the oxidative stability and loss of flavor in a food system **(Yoshida *et al.*, 2003).**

Like other edible oils, soy oil provides us with calories, essential fatty acids, and fat-soluble vitamins (especially vitamin E: “tocopherols”). Since unhydrogenated soy oil contains about 53% linoleic acid and 8% linolenic acid, whereas partially hydrogenated soy oil still contains about 23% linoleic and 3% linolenic acid, soybean oil is an excellent source of essential fatty acids. It is also healthy oil, comparing favorably with canola oil and other highly unsaturated oils. However, the fatty acid composition of soya bean oil is not often considered ideal in terms of oil functionality and oxidative stability **(Liu, 1997; Yoshida *et al.*, 2003).**

VII. Therapeutic effect

Soybean is a good source of plant protein, which also contributes to a wide range of health benefits. Apart from proteins, soybean is rich on basic nutritive constituents, such as lipids, minerals, vitamins, free sugar and contains isoflavones, flavanoids, saponins and peptides that are of therapeutic value **(Sanjukta and Rai, 2016).**

Regular consumption of soy foods can provide health benefits. Epidemiological data have shown lower incidences of heart disease (by improving arterial compliance (elasticity), Kidney disease, certain forms of cancer (especially breast and prostate cancer) and menopause symptoms in China and Japan. Also soybean products have a role in prevention and treatment of several metabolic diseases. Soybean lecithin valuable of brain cells, it improves memory impairment **(Bourre and Dumont, 2002; Rotimi, 2012; Sanjukta and Rai, 2016).**

CHAPTER IV

Sesame oil

I. Characteristic of the species

I.1 Description of the plant *Sesamum indicum* L.

Sesamum indicum L. is a plant of the pedaliaceae family, it is widely cultivated in many parts of the world, primarily in tropical and subtropical areas of the world, including India, China, Sudan, Burma, Tunisia, Egypt, Thailand, Mexico, Gutemala, El Salvador, Afghanistan, Pakistan, Bangladesh, Indonesia, Sri Lanka, Saudi Arabia and Turkey, and has recently been adapted to semi-arid regions **(Dézfoulian *et al*., 2003).**

With regard to the richness of its composition, in oil, mineral elements, proteins, and antioxidants, it is considered the queen of oilseeds.

Sesame **(***Sesamum indicum*, L.**)** comes from the Arabic word "semsim"**.** Is one of the oldest oilseed crops known to mankind It is the oldest oilseed plant in the world at least 4000 years ago**.**There are 4 species: *sesamum indicum*, radiatum, schum and thoron. Whose plant can reach up to 1 m in height. Its seeds are flat and oval, about 3 mm long and 1 mm thick, black, brown, white or red in color **(Gunstone, 2002; Dézfoulian *et al*., 2003; Ross, 2007; Akbar *et al*., 2011; Sene *et al*., 2018).**

Figure 7 : *sesamum indicum L.* **(www.summagallicana.it)**

I.1.1 Stems

Are obtuse square with grooves on the face, yellow-green but often splashed with amounts of aubergine violet. The plants are often highly branched, with up to 26 stems, depending on the variety **(Dorothea, 2004).**

Figure 8: Sesame stems (**www.missouriplants.com).**

I.1.2 Leaves

Are more or less lobed, notched or whole, and vary in shape and size depending on variety and age **(Schilling and Cattan, 1991).**

I.1.3 Flowers

The flowers appear 1, 2 or 3 in the axils of the leaves. It has a generally hairy floral tube on the outer part has four stamens producing pollen viable for a day. The superior ovary has two fused carpals subdivided into 4 chambers. The stigma of the ovary is receptive one day before flower opening **(Schilling and Cattan, 1991).**

Figure 9: sesame leaves and flowers **(www.healthbenefitstimes.com).**

I.1.4 Fruits

After fertilization, the flowers turn into small, smooth or reticulated, white, yellow, brown or black, oblong, deeply fluted capsules. The fruit contains about 50% oil and 25% protein, the oil content varying according to varieties and growing conditions **(Schilling and Cattan, 1991).**

Figure 10: Sesame fruits **(https://fr.depositphotos.com).**

II. Sesame seeds

Sesame seeds are considered important because of its high oil (35-60%) and protein (20-25%) content and 15% carbohydrates, and also a good source of vitamins and minerals, including calcium, potassium, phosphorus, sodium and magnesium. Sesame seeds are also an excellent source of magnesium, manganese, copper, zinc, vitamin B1 and iron rich in sulfur-containing amino acids and contains significant amounts of phytic (5%) and oxalic acids (2.5%) (Table…)**,** Ancient Chinese books say that sesame seeds increase energy and prevent aging, they are increasingly used in the food, cosmetic and pharmaceutical industries **(Gunstone, 2002; Kapadia *et al*., 2002; Sene *et al*., 2018).**

Table IX: Nutritional composition of sesame seeds (**Namiki, 1995 and Anilakumar, 2010).**

Nutrients	Amount of nutrients
Humidity	04.0-05.3(%)
Protein	18.3-25.4(%)
Oil	43.3-44.3(%)
Ashes	05.2-06.2(%)
Glucose	03.2(%)
Fructose	02.6(%)
Sucrose	0.2(%)
Phytosterols	0.4(%)
Energy (calories)/100g	578
Fiber (g)/100g	3.1
Ca (mg)/100g	5,2
P(mg)/100g	1200
K(mg)/100g	540

III. Global seed production

Global production of sesame (Sesamurn indicum L.) is about three billion tons, 75% of which is produced by India, Sudan and Mexico, Uganda and China **(son *et al*., 2011).**

In 2017 the average global production of sesame was 5.53 million tonnes, harvested from 9.98 million hectares; the main producers in sesame-producing countries are Chad, Burma (Myanmar), India, Nigeria, Sudan, China, Ethiopia, Burkina Faso and the United Republic of Tanzania. According to FAO 2018, the production of sesame seeds was as follows: in Africa 2.19 million (56.9%), in Asia 3.14 million (39.7%) and in the Americas 0.189 million (3.4%) and in Europe (0%).Among all oilseed crops, sesame is considered as one of the major oilseed crops, it is ranked 8th for world oil production **(Mehmood *et al*., 2018; Mujtaba *et al*., 2020).**

IV. Sesame oil

Sesame is a high-energy food containing about 50% oil; this content varies according to the species and growing conditions: the lowest is between 34% and 35%, and the highest between 63% and 64%. The average oil content of white seeds is 55%; and 47.8% for black seeds **(Namiki, 1995).**

Sesame oil is rich in polyunsaturated fatty acids and antioxidants such as lignins, which increase the shelf life of foods and improve their taste and texture. It is used in several areas such as medicine, food, cosmetics and biodiesel production **(Anilakumar *et al*., 2010).**

Figure11: sesame oil **(healthfoodxdrinks.com).**

V. Composition of sesame oil

V.1 Fatty acids composition

The main fatty acids in the oil are unsaturated fatty acids (80 - 82%), the predominant ones being oleic acid (18:1, 35 - 50%) and linoleic acid (18:2, 35.5 - 41.2%), as well as a small amount of saturated acids (14 - 15%) such as, palmitic acid (16:0, 7 - 12%) and stearic acid (18:0, 3.5 - 6%) as shown in the following table **(Yasothai, 2014).**

Table X: Percentage of total GA in sesame oil **(Yasothai, 2014).**

Fatty acids	Total (%) Fatty acids content in oil
➢ **Saturated fatty acids**	
Palmitic acid	**7 à 12**
Stearic acid	**3,5 – 6**
➢ **Mono-unsaturated fatty acids**	
Oleic acid	**35-50**
➢ **Polyunsaturated fatty acids**	
Linoleic acid	**35.5 - 41.2**

V.2 Triacylglycerol composition

The main constituents in TAG of sesame oil are polyunsaturated (90.8%) and unsaturated (7.7%) according to the following table:

Table XI: Percentage of total TG in sesame oil **(Gunstone, 2002).**

TAG	total of TG
LLO	25,4%,
LLL	19,6%
LOO	15,1%
PLL	1,8%
PLO	8,1%

V.3 Composition of unsaponifiable matter

The unsaponifiable fraction is between 1.4 and 1.8 %; it consists mainly of sterols, tocopherols and sesame lignans **(Gunstone, 2002).**

V.4 Sterols

Sesame oil contains 0.51-0.76% of total sterols including β-Sitosterol (62-67%), campesterol (15-20%), stigmasterol (5-8%) and Δ5- Avenasterol (7-10%). Monomethyl sterols, namely gramisterol, citrostadienol and obtusifoliol sterol were present mainly as esters **(Gunstone, 2002).**

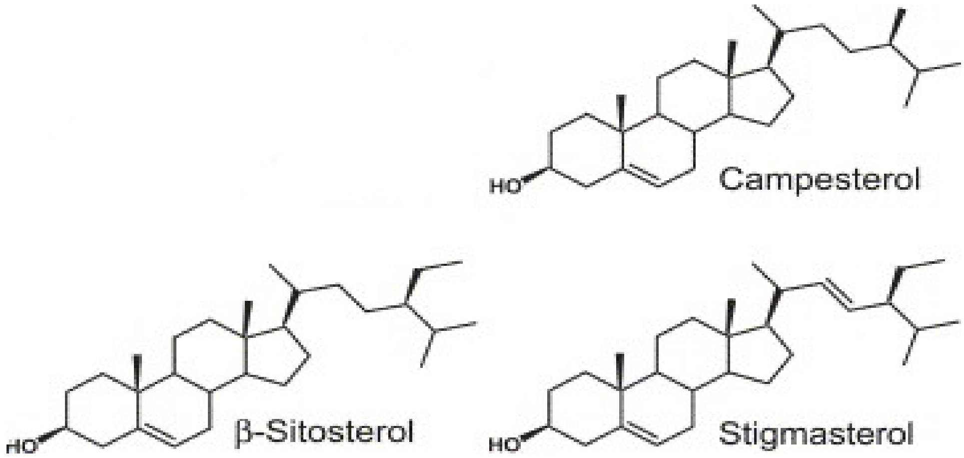

Figure 12: Chemical structure of main sterols **(Vaquero *et al.*, 2010).**

V.5 Tocopherols

Tocopherols are natural antioxidants that are believed to be responsible for the health benefits of this oil, which are found in four isomeric forms α, β, γ and δ. Knowing that in sesame oil γ-tocopherol is predominant (96-98%) with a small portion of δ-tocopherol (2-3%) **(Hwang *et al.*, 2005; Dhifi *et al.*, 2013; Yogranjan *et al.*, 2014).**

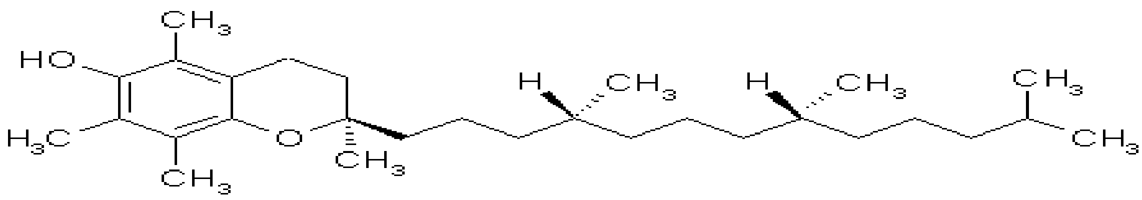

Figure 13: the structure of γ-tocopherols **(Rangkadilok *et al.*, 2010).**

V.6 Lignans

Are also antioxidants responsible for the stability of the oil to oxidation, Sesame seeds and their oil contain significant amounts of lignans, sesamine (0.07 to 0.61%) and sesamoline (0.02 to 0.48%) are the two major lignans found in this oil **(Hwang *et al.*, 2005; Yogranjan *et al.*, 2014).**

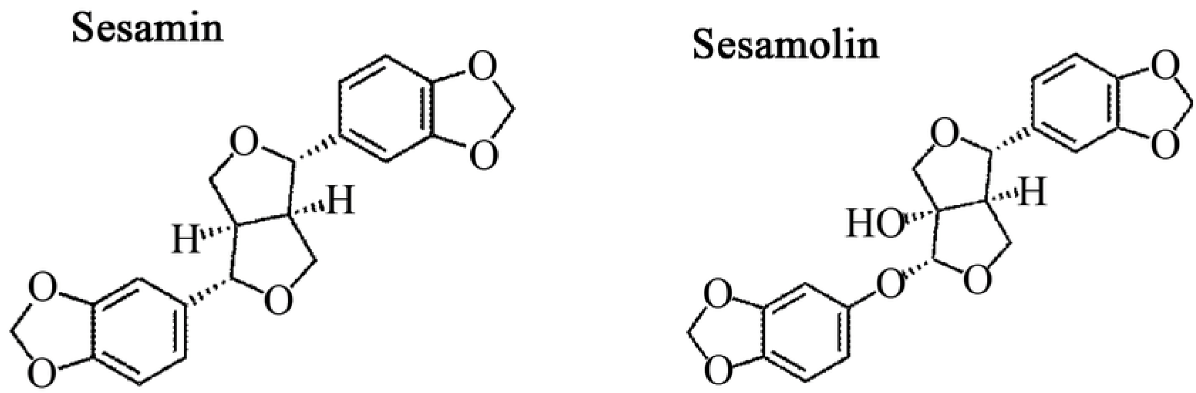

Figure 14: chemical structure of sesamin and sesamolin **(Rangkadilok *et al.*, 2010).**

VI. Characteristics of sesame oil

There are a number of additional parameters that characterize sesame oil, including the monkfish test, specific gravity, smoke point, saponification number and other parameters that are listed in the following table:

Table XII: Characteristics of sesame oil **(Gunstone, 2002).**

Parameter	Seegeler (1983)	Weiss (1983)
Refractive index(n50D)	1.463-1.474(25◦C)	1.458 (60◦C)
Specific gravity(25◦/25◦C)	0.916-0.921	0.922-924
Smoke point (◦C)	166	-
Flashpoint (◦C)	375	-
Solidification point (◦C)	-3 to -4	-3 to -4
Title (◦C)	20-25	22-24
Free fatty acids(% oleic)	1 - 3	1 – 3
Hydroxyl Index	1-10	1-10
Saponification index	186-199	188-193
Unsaponifiable materials	0.9-2.3	0.9-2.3
Baudouin test is positive	/	/

VII. Uses of sesame and its oil

VII.1 Culinary uses

Because of their characteristic flavor and sweetness, peeled sesame seeds are widely used in bakery products as a topping of hamburger buns and some cookies and also used in the preparation of "tahini" and in confectionery such as sweets (halwa turc) and pastry. Sesame oil is used for salads, margarine, cooking and iodized oil, it is a complement to other vegetable oils which improves the oxidative stability of mixture **(Anilakumar *et al*., 2010;Yogranjan *et al*., 2014).**

VII.2 Pharmaceutical uses

Ground sesame seeds are used as a dietary supplement against child malnutrition; used as active ingredients in antiseptics, bactericides, virucides, disinfectants, mites repellents, antituberculosis agents and considerable source of calcium, tryptophan, methionine and many minerals as they use for tuberculosis, used as galactagogue, emmenagogue, as purgative. A diuretic and an aphrodisiac to promote hair growth; for ulcers, hematomas, in cosmetics, ointments, liniments and paints as a solvent for the agents. And also widely used in soap and as a substitute for olive oil to fight bacterial infection on the umbilical cord of newborns **(Ross, 2007; Yogranjan *et al*., 2014; Sene *et al*., 2018).**

CHAPTER V

Blended oils

I. Blending of vegetable oils

Blending of vegetable oil has been a common acceptable practice in many countries in the world. It has been permissible to blend common edible oil with unconventional oils to achieve different aims: to reduce the cost and meet industry demands and using one vegetable oil unalloyed can have low physical, chemical and nutritional properties and also poor oxidative stability **(Hashempour *et al.*, 2016).**

Oils have different compounds, which are present in low concentrations. Some of these trace materials, including tocopherols, phospholids, carotenoids and sterols increase oil stability during frying. Several different oils are usually blended to obtain a healthy oil blend, it is well known that the food value of edible oils depends on the physical and chemical properties **(Alireza *et al.*, 2010; Chaudhary and Grover, 2013; Bakhtiary *et al.*, 2014).**

Blending of vegetable fats/oils has been recognized as one of the most potent solution in producing vegetable oils with good storage stabilities and optimum fatty acids compositions, Oil adulteration of edible oils is generally blended cheaper or lower quality oil to premium oil for example extra-virgin olive oil **(Lizhi *et al.*, 2009; Roiaini *et al.*,2015).**

II. Blend oils uses

Hydrolysis, oxidation and polymerization during storage and heat treatment, leading to a deterioration of the nutritional and sensory quality of vegetable oils, is where the blending of oils with a high content of unsaturated acids such as monounsaturated that are resistant to oxidation at high temperatures and have high nutritional value and important health benefits comes into play **(Jiang and Lu, 2015).**

The quality of an oil is determined by the ratio of saturated / monounsaturated / polyunsaturated fatty acids, the ratio of essential fatty acids (Omega 3 / Omega 6) and the presence of natural antioxidants **(White, 2000).**

This technique optimizes the levels of fatty acids and also leads to the reduction of the melting point of the oils and preserves the quality of the oil; it also seeks instauration in the oils to reduce the risk of coronary heart disease. For example, the addition of 20% palm olein with sweet oils has shown the desired clarity during shelf storage and reduces the risk of crystallization and also sesame oil which provides high amounts of antioxidants and lignin; when blended with other oils increases the stability of the blend **(Gulla and Waghray, 2011; Roiaini *et al*., 2015).**

III. Effect of blending on physical properties

Blending different fats/oils with various properties gives new oil with improved functional characteristics; it is an interesting alternative for broadening industrial applications **(Pereira *et al*., 2019).**

Some oils tend to crystallize and change their clarity when cooled. Studies show that mixing these oils with higher and more unsaturated oils gives a more stable and clear mixture which remains stable during storage. Blending fats/oils leads to changes in triacylglycerol profile, and therefore, to changes in the physical properties of oils **(**such as reduce the risk of cloudy and partial crystallization, sensory quality, solid fat contents, smoke point,viscosity... **(Bakhtiary *et al*., 2014; Roiaini *et al*., 2015; Hashempour *et al*., 2016).**

III.1 Sensory quality

Oil blending has an important role in the sensory attributes, which occur by chemical reaction in oils and fats during deep-frying(frying can involve all of the components to participate in a series of physical and chemical alterations),thermal decomposition, oxidative, cyclization or isomerization and hydrolytic reactions, this physical and chemical reactions changes in the oil or fat are expected to occur as a consequence of the formation of new compounds and also can have an adverse influence on oils at an increasing rate during frying**(Dobarganes *et al*., 2000; Zhang *et al*., 2012).**

The blending of different oils can reduce these undesirable reactions and improve the nutritional and sensory quality of the new products obtained**;** in addition, blending oils can also make changes in odour profiles, moderate their color and textural proprieties (example: blending oils with sesame oil) **(Hashempour *et al*., 2016).**

III.2 Smoke point

The smoke point is the temperature at which oil begins to smoke when heated. The smoke point of oils used for cooking must not be lower than 170 °C and also must not change by more than 50 °C after repeated use. The smoke point of oil is generally related to the concentration of accumulated decomposition products such as fatty acids and partial glycerides **(Yen*et al.*, 1997; Choudhary and Grover, 2013).**

The effect of deep frying on blends of different oils (olive, groundnut, soybean, sunflower, mustard and palm olein oils) with rice bran oil found that all of the mixtures had improved nutritional properties as well as an increased smoke point **(Choudhary and Grover, 2013).**

III.3 Viscosity

Viscosity defined as the resistance to flow of a fluid. It changes generally in deep-frying; it has been well established that temperature has influence on the viscosity of fluid products, with viscosity generally decreasing with increase in temperature **(Fasina *et al.*, 2006; Alptekin and Canakci, 2008).**

Resistance of fluid moving during heating related to unsaturation and the chain length of the fatty acids in the triacylglycerol. Large amounts of polyunsaturated fatty acids lead to low viscosity oils which are sometimes not suitable for certain food processes. And saturated fatty acids in the oil influences the viscosities of vegetable oils (increases viscosity) **(Fasina *et al.*, 2006; Hashempour *et al.*, 2016).**

During deep-frying, blending oils with high stability and good nutritional properties is a good choice to decrease the rate of oxidation and viscosity (produce an oil with good stability at frying temperatures without hydrogenation and formation of Trans fatty acids **(Hashempour *et al.*, 2016).**

III.3.1 Examples in changing of viscosity in blending oils

- The mixture of palm oil, which contains high levels of saturated fatty acids, with sesame oil, which contains large amounts of natural antioxidants sesamin and sesamol, can give stable frying oil that can survive many frying cycles with only a slow increase in viscosity **(Hashempour *et al.*, 2016).**

- Changes of viscosity in blending oils with Canola oil causes a moderation of the increase in viscosity of the oil during frying compared to Canola oil alone and finally that the best stability against an increase in viscosity during frying was detected in blended oils **(Serjouie *et al*., 2010).**

IV. Effect of blending on chemical properties

Blending of oils modifies fatty acid composition without any chemical or biological process like hydrogenation, and gives higher levels of natural antioxidants and bioactive lipids in the blends and, therefore, can improve the nutritional and the Oxidative stability of oil by modification of fatty acid composition. **(Gulla and Waghray, 2011; Hashempour *et al*., 2016).**

Blending different kinds of vegetable oils can change fatty acids profile, oleic acid, the most abundant monounsaturated fatty acid in some edible oils, is more resistant toward oxidation at high temperatures, blending of saturated fats with unsaturated oils has become an alternative approach to give an oil with balanced fatty acids **(Li *et al*., 2014; Jiang and Lu, 2015).**

Vegetable oil blends enhance the oxidative stability of some edible oil; resistance to thermal oxidation of oil mixtures is significantly influenced by the relative percentages of the blended oil types. Example in the case of olive oil, if more than 20% of a mixture, it can have a negative effect on the stability of the blended oil. Furthermore, oxidative stability of oils has an effective role in its shelf-life (practice for altering their physicochemical properties) **(Chandrashekar *et al*., 2010; Hashempour *et al*., 2016).**

Table XIII: Physiochemical evaluation of palm, soybean and sesame oil blended with other oils

Blended oil	Physiochemical evaluation	Reference
Soybean oil + sesame oil/peanut oil	Measuring oxidation stability by determination of peroxide and anisidine values, assessment of radical scavenging activity.	

Soybean oil + camellia oil	Thermal stability and slowing deterioration during deep frying of French fries, increased monounsaturated fatty acid and phenolic compounds, reduction in free fatty acid, peroxide value, panisidine value, total polar components, and color.	
Palm olein + Soybean oil/ Sunflower oil/Canola oil	Create economic cooking oil with high nutritional and physicochemical properties, determination of viscosity, density, melting behavior, peroxide value, saponification value and iodine value.	**Hashempour *et al.*, (2016)**
Palm olein + sunflower oil/canola oil/cottonseed oil	Higher resistance to hydrolytic and oxidative behaviors, enhancement in quality parameters including tocols, p-anisidine value, polar compounds, polymer compounds, induction period, free fatty acid, color and smoke point during frying.	
Palm oil + canola oil	Improved taste, flavor and texture in frying temperature, fatty acid composition, peroxide value, acid value, viscosity, antioxidant activity, color, smoke point and sensory evaluation.	
Palm oil + soybean oil/sunflower oil/canola oil	Determination of chemical and rheological properties by FTIR.	
Palm olein oil + olive oil	improvement of chemical stability against oxidative rancidity and higher chemical stability compared to the other formulated oil blends	
Palm oil: sesame oil	Resulted in ideal fatty acid composition. stable to oxidative deterioration enhanced nutritional qualities	

Sesame oil+ rice bran oil	Sesame oil has considerable antioxidant activity. The antioxidants, sesamin and sesamolin, can resist oxidative deterioration and rancidity thus extend the shelf life of tahin. About 90% of the original antioxidant, sesamin, can be retained after roasting	**Ogan *et al.*,(2015)**
Sesame oil+ soybean oil	oxidation stability and richness in fatty acid and triglycerides composition	**Park *et al.*,(2010)**

V. Effect of blending on nutritional properties

Nutrition is one of the major environmental factors that affect health and disease, the World Health Organization (WHO) introduced three important factors for the nutritional evaluation of oils:

1) Presence of antioxidants,
2) Ratio of saturated, mono- and polyunsaturated fatty acids essential fatty acid ratio, the desirable ratio of polyunsaturated to saturated fat in the diet is 1: 1 (50: 50) **(Hashempour *et al.*, 2016).**

Blending of oil combines the potency of two or more edible oils and offers a balance of fatty acids, fatty acids are considered very important for human nutrition **(Mourente and Bell, 2006; Upadya *et al*., 2015).**

Blending oils can change essential fatty acids status, amount of tocopherol and cholesterol levels, also can increase antioxidant enzyme activities, reduce hepatic lipid peroxidation and oxidation of LDL. Overall, effective combination of oils can develop mixtures, which have many beneficial properties (have the potency to lead to various lifestyle diseases caused by oxidative stress, saturated fatty acid-rich Oils) **(Upadya *et al*., 2015).**

Overall, blending of vegetable oils gives more flexibility to provide functional properties or desired nutritional requirements in food industry **(Chen *et al,* 2007).**

For example, research has shown that blend of safflower oil and rice bran oil exerts significant reduction in plasma cholesterol and concluded that blending rice bran oil with safflower oil magnify the hypocholesterolemic efficacy compared with the effect of each oil alone **(Upadya *et al*., 2015).**

VI. Industrial applications

Oil blending is a technological method that is used to produce specific products:

- Bakery: good texture of bakery products and All-purpose shortening and icing shortening. Shortenings defined as a fat product used in foods, by mixtures including animal fats and vegetable oils (Example: Short dough cookie structure, characterized by its aerated and tender texture, depends on the presence of solid fat during kneading)**.** Besides, mixing olive oil, palm stearin and palm mid-fraction can give shortening and cocoa butter substitute with lower calories **(Ribeiro *et al.*, 2009; Ramli *et al*, 2014; Mert and demirkesen, 2016).**
- Use of vegetable oils as a biomass energy source, in fabrication of oil-diesel and biodiesel by blending two or more vegetable oils **(Ozaktas, 2000).**
- Soft margarine: or zero-trans margarines can be produced by blending different oils including pine nut oil and palm stearin or palm oil, palm kernel oil and sunflower oil **(Ribeiro *et al*., 2009; Adhikari *et al*., 2010).**

VI. 1 Examples of industrial application in Algeria:

- **Matina** (margarine produced by Cevital) contains a combination of three rigorously selected vegetable oils (sunflower oil, coconut oil, and palm oil) which makes it a valuable source of essential fatty acids for the metabolism and these oils are not hydrogenated.
- **Fleurial Margarine:** Fleurial margarine is a 100% vegetable table margarine that does not contain cholesterol, made from a mixture of different oils; it contains 82% fat.Itcomes from a mixture of oils, which are rigorously deserved, which are: Sunflower, Soybean, Palm and Copra oil **(Cevital-agro-industrie, 2003).**
- **Afia** oil is the result of over 30 years of expertise in the field of refining and production of edible oils. It is the only oil in Algeria that contains corn inits formula. Afia oil, pure, digestible and 100% vegetable, is composed of corn (5%) and soybean

(95%) oils, rich in vitamin E, thus ensuring essential nutritional intake **(Chekroun, 2013).**

VII. Examples on the changes in fatty acid composition in oil blends

VII.1 Palm olein oil and olive oil blend

The blending of polyunsaturated oil with more saturated or monosaturated oils is to adjust fatty acid levels to an optimal level, such as combining high-oleic sunflower oil with corn oil or hydrogenated soybean oil with soybean oil or combining palm-olein with sunflower oil**(Moulton *et al*., 1975; Frankel and Huang, 1994).**

The results indicated in **table XIII** shows that the concentration level of C18:1, C16:0 increased with increasing the Palm Olein Oil content in the oil blend formulations; while the percentage of C18:3 decreased as the Palm Olein Oil content was increased**(Naghshineh *et al*.,2010).**

Table XIV: Fatty acid composition of Palm olein oil and olive oil blends **(Naghshineh *et al*., 2010).**

Fatty acids (%)	**(POO:OO) 50:50**	**(POO:OO) 75:25**
C12:0	0.29	0.29
C14:0	6.35	3.75
C16:0	21.2	30.43
C16:1	1.1	1.12
C18:0	2.77	2.93
C18:1	59.04	58.57
C18:2	8.96	10.08
C18:3	0.47	0.40

VII.2 Sesame oil and rice bran oil blend

It been found that using antioxidants and unsaturated fatty acids rich blend of 20% cold-pressed un-refined sesame oil and 80% physically refined rice bran oil (**Table XV**) as cooking oil for eight weeks lowered hyperglycemia and improved the lipid profile. The study indicated that the use of the sesame oil blend had an additive effect with anti-diabetic medication for the highest reduction of blood glucose **(Devarajan *et al.*, 2016).**

Table XV: fatty acids concentration in sesame oil and rice bran oil blend **(Devarajan *et al.*, 2016).**

Fatty acids composition (%)	Sesame oil	Rice bran oil	Sesame oil and rice bran oil blend
Palmitic acid	9.31	20.08	17.92
Stearic acid	5.43	2.41	3.01
Arachidonic acid	0.66	0.52	0.52
Oleic acid	42.91	42.98	42.97
Linoleic acid	41.28	33.63	35.56
Linolenic acid	0.44	0.39	0.4

Blending of sesame oil with soybean oil is frequently conducted practices in many areas. Relative contents of selected major fatty acids in blended with sesame oil and soybean oil are shown in **(Table XVI),** Oleic and linoleic acids were the two major fatty acids in both sesame oil and soybean oil. Relative percentage of oleic and linoleic acids in sesame oil were 41.82% and 40.50%, respectively, and 23.40% and 53.40% in soybean oil, respectively. Soybean oil contained about 18.6 times more linolenic acid than sesame oil **(Park *et al.*, 2010).**

Table XVI: Sesame oil and soybean oil blend SO: SBO **(Park *et al.*, 2010).**

Fatty acids composition (%)	SO:SBO 50/50	SO:SBO 100/00
Palmitic acid	0.59 ± 0.33	11.30 ± 0.37
Stearic acid	5.18 ± 0.18	4.30 ± 0.20
Oleic acid	31.72 ± 0.96	23.00 ± 0.54
Linoleic acid	47.47 ± 1.61	53.40 ± 2.41
Linolenic acid	3.39 ± 0.11	5.96 ± 0.24
Arachidonic acid	3.39 ± 0.11	0.41 ± 0.00

VII.3 Soybean oil blend with sesame oil, rice bran oil, camellia oil and peanut oil

Blending of selected oils with SBO non-significantly changed of main fatty acids in the blends. The results are shown in table XVI, major changes were noted in the contents of oleic acid (C18:1) and linoleic acid (C18:2) of blended oils. SBO had the highest percentage of polyunsaturated fatty acids PUFA and the lowest monounsaturated fatty acids MUFA. Blending with selected oil did not lead to significant modification in saturated fatty acids SFA **(Li *et al.*, 2014).**

Table XVII: soybean (SBO) oil blended with four types of vegetable oils **(Li *et al.*, 2014).**

Fatty acid	SBO:SO (**sesame oil**)	SBO:RBO (**rice bran oil)**	SBO:CAO (**camellia oil)**	SBO:PNO**(Peanut oil)**
Myristic acid	0.15 ± 0.13	0.22 ± 0.32	0.16 ± 0.02	0.13 ± 0.04a
Palmitic acid	15.48 ± 0.02	17.41 ± 0.04	17.10 ± 0.58	15.75 ± 0.01c
Palmitoleic acid	0.28 ± 0.08	0.34 ± 0.09	0.27 ± 0.01	0.19 ± 0.02a
Stearic acid	6.83 ± 0.01	5.91 ± 0.01	6.53 ± 0.23	6.45 ± 0.10a
Oleic acid	26.17 ± 0.01	24.47 ± 0.83	30.38 ± 0.75	26.36 ± 0.01d
Linoleic acid	48.36 ± 0.12	46.84 ± 0.11	44.74 ± 1.15	48.99 ± 0.01d
Linolenic acid	0.12 ± 0.02	0.14 ± 0.34	0.14 ± 0.01	0.056 ± 0.32b
Arachidic acid	0.48 ± 0.25	0.55 ± 0.28	0.44 ± 0.01	0.79 ± 0.09e
Total SFA	23.41 ± 0.25	24.19 ± 0.32	24.75 ± 0.13	23.70 ± 0.01b
Total MUFA	26.80 ± 0.30	25.22 ± 0.09	31.19 ± 0.12	23.91 ± 0.02b
Total PUFA	48.56 ± 0.11	47.06 ± 0.83	44.95 ± 0.64	50.53 ± 0.06e

CONCLUSION

Oils and fats have different chemical and physical properties, which makes them rich in certain contents and poor in others. In our study we have concentrated on three types of oil, which are palm, soybean and sesame oil, these three oils have different major and minor composition.

Palm oil is an oil rich on saturated fatty acids especially acid palmitic, plus it contains minor constituents such as carotenoids, tocopherol and sterol, the nutritional value of this oil is based on fatty acid composition, but the minor composition also play an important role because of his richness on antioxidants.

Soybean is unsaturated oil, rich in oleic acid and an important source of protein, which is one of the causes of its nutritional value in addition to its richness in fatty acids and antioxidants (vitamins).

Sesame oil is rich in polyunsaturated fatty acids and antioxidants; it's also a good source of proteins, vitamins and minerals.

When palm is blended with other vegetable oils, mostly the results show that it creates economic cooking oil with high nutritional and physicochemical properties and resulted in ideal fatty acid composition. In the case of Soybean, the blending gives thermal stability and slowing deterioration during deep-frying and increases monounsaturated fatty acids, and also reduces the amount of free fatty acids. Sesame oil generally, in its mixtures, gives an oil with high oxidative stability and rich in terms of fatty acid and triglyceride composition.

Blending oils is the simplest procedure to change fatty acid composition, in order to increase bioactive components and natural antioxidants (oxidative activity is the most sought after trait in edible oils), also changing physical proprieties, for example increasing sensory qualities, amelioration of viscosity and reducing the risk of cloudy and partial crystallization.

In addition, blending oils improve nutritional compositions, which have many beneficial properties (balanced fatty acids composition, natural antioxidants…), and also diversified industrial application by giving news products. Blending among vegetable oils gives the manufacturer greater flexibility to tailor the products to accomplish specific functional properties.

Perspectives :

- Give more importance to oils, which contain a high level of antioxidants and rich in terms of fatty acid composition.
- Deepen the chemical and biological investigation of other plants in order to isolate the molecules responsible for the activities observed.
- Encourage the enhancement of blended oils in various fields.
- Find ratios and extraction methods in which the mixture contains the best composition and good results of the activities studied.

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Abstract:

Oils and fats have many functions in the preparation of food products. Using a mixed vegetable oil is a simple way to bring together the advantages of the different properties and characteristics of each oil.

This paper is a brief review of recent publications on the positive benefits of mixing three vegetable oils with different properties to obtain new oil blends. in our study, we relied on three types of vegetable oils, palm, soybean and sesame oil, different studies have shown the results of blending these oils with other vegetable oils. There is a lot of research on oil blending, and the results show that oil blending is widely used in the food industry to produce blended oils with improved stability and nutritional characteristics.

It has been shown that blending oils give an oil with new physical and chemical characteristics as well, which increases nutritional value.

Palm, soybean and sesame oil mixed with other vegetable oils gives a new oil with high oxidative stability, in particular sesame oil, with a rich composition of fatty acids, and thus reduces the amount of free fatty acids (soybean mixtures).

Key words: blending, oil, chemical characteristics, fatty acids, oxidative stability, palm, soybean, sesame.

Résumé :

Les huiles et les graisses ont de nombreuses fonctions dans la préparation des produits alimentaires. L'utilisation d'une huile végétale mélangée est un moyen simple de rassembler les avantages des différentes propriétés et caractéristiques de chaque huile.

Cet article est une brève revue de publications récentes sur les avantages positifs du mélange de trois huiles végétales aux propriétés différentes pour obtenir de nouveaux mélanges d'huiles. Dans notre étude, nous nous sommes appuyés sur trois types d'huiles végétales, l'huile de palme, de soja et de sésame, différentes études ont montré les résultats du mélange de ces huiles avec d'autres huiles végétales. Il existe de nombreuses recherches sur le mélange d'huile, et les résultats montrent que le coupage d'huile est largement utilisé dans l'industrie alimentaire pour produire des huiles mélangées avec une stabilité et des caractéristiques nutritionnelles améliorées.

Il a été démontré que les huiles de mélange donnent également une huile avec de nouvelles caractéristiques physiques et chimiques, ce qui augmente la valeur nutritionnelle.

L'huile de palme, de soja et de sésame mélangée à d'autres huiles végétales donne une nouvelle huile à haute stabilité oxydative, en particulier l'huile de sésame, avec une composition riche en acides gras, et réduit ainsi la quantité d'acides gras libres (mélanges de soja).

Mots clés: coupage, huile, caractéristiques chimiques, acides gras,stabilité oxydative, palme, soja, sésame.

ملخص:

للزيوت والدهون وظائف عديدة في تحضير المنتجات الغذائية. يعد استخدام الزيت النباتي المختلط طريقة بسيطة للجمع بين مزايا الخصائص والخصائص المختلفة لكل زيت.

هذه الورقة عبارة عن استعراض موجز للمنشورات الحديثة حول الفوائد الإيجابية لخلط ثلاثة زيوت نباتية بخصائص مختلفة للحصول على خلطات زيتية جديدة. اعتمدنا في دراستنا على ثلاثة أنواع من الزيوت النباتية وهي زيت النخيل وفول الصويا وزيت السمسم، وقد أظهرت دراسات مختلفة نتائج مزج هذه الزيوت مع زيوت نباتية أخرى. هناك الكثير من الأبحاث حول مزج الزيت، وأظهرت النتائج أن مزج الزيت يستخدم على نطاق واسع في صناعة المواد الغذائية لإنتاج زيوت مخلوطة مع استقرار محسّن وخصائص غذائية.

لقد ثبت أن مزج الزيوت يعطي زيتًا بخصائص فيزيائية وكيميائية جديدة أيضًا، مما يزيد من القيمة الغذائية.

زيت النخيل وفول الصويا والسمسم الممزوج بزيوت نباتية أخرى يعطي زيتًا جديدًا يتمتع بدرجة عالية من الاستقرار التأكسدي، وخاصة زيت السمسم، مع تركيبة غنية من الأحماض الدهنية، وبالتالي يقلل من كمية الأحماض الدهنية الحرة (خلائط فول الصويا)

الكلمات المفتاحية: المزج،الزيت، الخصائص الكيميائية، الأحماض الدهنية، الثبات التأكسدي،النخيل، فول الصويا، السمسم.