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Characteristics and fatty acid composition of commonly consumed cooking oil marketed locally in Riyadh city

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Abstract

Vegetable oils and fats have wide application in foods and play important sensory and functional roles in food products. The objective of this study was to determine the physicochemical properties and fatty acid composition of commonly consumed cooking oil marketed locally in Riyadh. Four types of vegetable oils, commercially available, were used in this study. All oils were of food grade. In this study physicochemical property such as acid value, peroxide value, saponification and iodine value of palm oil was found to be the best. Similarly, ratio of monounsaturated to saturated fatty acids (M/S), polyunsaturated to saturated fatty acids (P/S) and sum of monounsaturated and polyunsaturated fatty acids to saturated fatty acids (M+P)/S was found to be the best for palm oil. The health benefits of palm oil may be achievable by increasing its consumption.

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Introduction

Fats and oils are considered as essential nutrients in both human and animal diets. Vegetable oils and fats have wide application in foods where they are used in frying, cooking, salad dressing, shortening of pasty etc. Typically, common vegetable oils, including olive, sunflower, mustard, safflower, rice bran, soybean, sesame are low in saturated fats and the double bonds within unsaturated acids are in the cis configuration (Bakker *et al*., 1997). Vegetable oils act as carriers of fat-soluble vitamins (A, D, E, and K) and play important sensory and functional roles in food products. They provide the most concentrated source of energy, supply essential fatty acids linoleic and linolenic acids which are precursors for important hormones, the prostaglandins and responsible for growth (Fasina *et al*., 2006), provide satiety and increases the palatability of food (Johnson and Saikia, 2009).

In natural vegetable oils, the unsaturated acids are present in the cis- form (Tang, 2002). The various structures of fatty acids impart different effects on physical properties on vegetable oils (Bello and Anjorin, 2012). Unsaturated acids will have a lower melting point compared to saturated fatty acids of similar chain length (Chayanoot *et al.,* 2005). As the amount of unsaturation increases, the relative rate of oxidation will also increase (Konthe, 2005). Fatty acid composition and chain length affect properties such freezing points, boiling points cloud and pour points, kinematics viscosity, oxidation, and Nox emissions (Bello and Anjorin, 2012). According to our knowledge there is scarcity of study on the physicochemical properties, fatty acid composition and the ratio of various essential and non essential fatty acids of the commonly consumed cooking oil marketed locally in Riyadh. So, the objective of this study is to determine the physicochemical properties and fatty acid composition of commonly consumed cooking oil marketed locally in Riyadh. This study will help in determining the safety and quality of edible oil commonly consumed in Riyadh.

Materials and methods

Four types of vegetable oils, commercially available, were used in this study. All oils were of food grade. Each sample was filled into glass bottles and then sealed airtight.

Specific gravity

A pre-cleaned 50 ml specific gravity bottle was weighed and filled to the brim with water. A stopper was inserted and any water that spilled out through the capillary opening on the stopper was carefully wiped off and reweighed. After weighing, the bottle was dried and filled with oil samples and weighed (AOAC, 1984).

$$\text{Specific Gravity at 30°C} = \frac{A-B}{C-B}$$

Where,

A= weight in gram of specific gravity bottle with oil at 30°C

B= weight in gram of specific gravity bottle at 30°C

C= weight in gram of specific gravity bottle with water at 30°

Refractive index (RI)

Measurement of refractive index was done with a mean of suitable refractometer. Double prism was opened with the help of the screw head and a drop of oil was placed on the prism. The prism was closed firmly by tightening screw heads. Water was circulated through instruments and instrument was allowed to stand for few minutes before reading so that the temperature of the test samples and instrument remain same. Prism should be cleaned between readings by wiping off oil with cotton pad moistened with ethyl alcohol/toluene/petroleum ether and then dried (AOAC, 1984).

Peroxide value (PV)

Peroxide value (PV) was determined as described by Leonard *et al.* (1987) by dissolving 1 g of oil samples in a 30 ml glacial acetic acid- chloroform solution (60:40, v/v), adding of 1 ml potassium iodide (15%) and titrating the iodine librated with 0.1 N sodium thiosulphate solution until an initial yellow colour disappeared and a faint blue colour appeared and 0.5 ml starch indicator was added quickly with continuous titration until there was a sudden disappearance of the blue color which signifies the end point. The peroxide value was expressed as milli equivalents of peroxide per 1000 g of sample (Leonard *et al*., 1987).

PV= = Volume of titration x Normality x 1000

Weight of the sample

Acid value (AV)

5 g of the oil was weighed and 50 ml of hot neutral alcohol was added with a few drops of phenolphthalein. The mixture was shaken vigorously and titrated with 0.5 N NaOH solutions with constant shaking until the pink colour remains permanent (Pearson, 1970).

AV= Volume of titration x Normality X 40

Weight of sample

Saponification (SV)

Two g oil sample of was weighed into a clean dried conical flask and 25 ml of alcoholic potassium hydroxide was added. The flask was heated for an hour with frequent shaking. One milliliter (1 ml) of 1% phenolphthalein indicator was added and the hot excess alkali titrated with 0.5 M hydrochloric acid (HCl) until it reached the end point where it turned colorless. A blank titration was carried out at the same time and under the same condition (Leonard *et al*., 1987).

SV= (A-B) x N x 56.1
- --------------------------------
Weight of sampleWhere

B= blank titre value

A= test titre value

Iodine value (IV)

One g oil sample was weighed into a dry glass stopper bottle of 250 ml capacity and 10 ml of carbon tetrachloride was added to the oil. About 20 ml of Wijs solution was then added and allowed to stand in the dark for 30 min. After 30 minutes, 15 ml of (10%) potassium iodide and 100 ml of water was added and then titrated with 0.1N thiosulphate solution using starch as indicator just before the end point. A blank was also prepared alongside the oil samples (Pearson, 1970).

IV= (B-A) x N x 12.69

Weight of sample (g)

Where

B= blank titre value

A= test titre value

Methylation and Identification of fatty acids (FA)

The samples under investigation were methylated by diazomethane prepared from methylamine according to the method described by Vogel, 1975.

Identification of the individual FA methyl esters was achieved by using reference standards. Standards of fatty acids were purchased from Sigma Company, USA. The FA composition was analyzed by a gas chromatograph (GC-17A model, Schimadza Co. Japan) equipped with a double FID detector. Gas chromatographic parameters were as follows:

Injector temperature: 240°C

Detector: FID; detector temperature: 280°C; programming temperature: 70°C (4°C/min) upto 140°C isothermal

Flow rate N_2: 30 ml/min; Flow rate H_2: 30 ml/min; Flow rate Air: 30 ml/min

Chart speed: 0.5cm/min

Sensitivity: 32

Results and discussion

Table 1 shows the standard requirement for essential composition and quality of oils and fat as specified by the Codex Alimentarius Commission (CAC) (FAO/WHO, 1994). Graphs 1-3 shows the physicochemical quality and graph 4 represents the ratio of monounsaturated fatty acid (M)/saturated fatty acid (S), polyunsaturated fatty acid (P)/saturated fatty acids (S), (M+P)/S and omega 6 fatty acid/omega 3 fatty acids of commonly consumed cooking oil marketed locally in Riyadh.

A) Physicochemical quality of cooking oils commonly consumed in Riyadh

Specific Gravity

Specific gravity is the ratio of density of substance to that of water at a specific temperature. It is used as a simple means of obtaining information about the concentration of solutions (Rossell *et al.*, 1983). Specific gravity of corn, olive and sunflower oil was found to be almost same while it was slightly less for palm oil.

Table 1. Standard requirement for physicochemical quality of cooking oils as specified by the Codex Alimentarius Commision (CAC) (FAO/WHO 1994).

Physical properties	Corn oil	Olive oil	Sunflower oil	Palm oil
Specific gravity (25°C)	NA	NA	NA	NA
Refractive index (40°C)	1.473-1.476	1.468-1.470	1.467-1.469	1.449-1.455
Acid value (mg KOH /gm oil)	≤ 0.6	≤ 0.6	≤ 0.6	≤ 0.6
Peroxide value (meq/kg)	≤10	≤15	≤10	≤10
Saponification (mg KOH/gm oil)	187-193	184-196	188-194	190-209
Iodine value (gm iodine/100gm oil)	103-128	75-94	110-143	50.6-55.1

Refractive Index

Refractive index of a substance measures how the substance affects light passing through it and to an extent tells its degree of purity. It is a parameter that relates to molecular weight, fatty acid chain length, degree of unsaturation and degree of conjugation (Gunstone, 2002). It was applied in preliminary identification of oil and also has shown purity or fluctuation in oil (Yousefi *et al.*, 2013). The refractive index of light in a vacuum is 1.00 (Inekwe *et al.*, 2012). The oils and fat exhibited different refractive indices. Refractive index of corn, olive, sunflower and palm oil was found to be 1.464, 1.465, 1.468 and 1.451 respectively. These values are in line with the results obtained by Al Abbad and Basuny, 2012. Refractive index of olive, sunflower and palm oil lies between the standard guidelines set by WHO and FAO, while the present study showed slightly less value for corn oil than the standard set by WHO and FAO.

Table 2. Fatty acid composition of cooking oils commonly consumed in Riyadh.

Fatty acids	Form	Corn oil	Olive oil	Sunflower oil	Palm oil
Saturated Fatty Acids					
Myristic acid	C14:0	0.21	---	0.93	---
Palmitic acid	C16:0	12.40	2.60	5.40	38.61
Stearic acid	C18:0	2.39	1.02	4.41	4.46
Arachidic acid	C20:0	0.57	10.60	0.23	0.85
Total saturated fatty acids		15.57	14.22	10.98	43.92
Monounsaturated Fatty Acids					
Oleic acid	C18:1	24.30	72.91	21.52	42.76
Polyunsaturated Fatty Acids					
Linoleic acid	C18:2	59.21	9.52	66.34	13.32
Linolenic acid	C18:3	0.92	3.35	1.17	---
Total polyunsaturated fatty acids		60.13	12.82	67.51	13.32

Acid Value

Acid value is a measure of the extent to which the triacylglycerides in the oil have been decomposed by lipase action (Inekwe *et al.*, 2012). Low level of acidity is referring to suitable quality of oil (Yousefi *et al.*, 2013). It is often used as a general indication of the condition of edibility of the oil. Acid value of oil suitable for edible purposes should not exceed 4 mg/g (Esuoso and Odetokun, 1995). The acid value measured for the cooking oil ranged from 0.24 to 1.4 mg-KOH/g oil. Acid value of corn, olive, sunflower and palm oil was found to be 0.24, 1.4, 0.25 and 0.28 respectively. Salimon and Farhan, 2012 reported 1.4 mg/gm and 2.4 mg/g of acid value in Saudi extra virgin olive oil and Saudi olive oil. The values of corn, sunflower and palm oil are in line with the standard guidelines set by WHO and FAO, while the present study showed higher value for olive oil than the standard set by WHO and FAO.

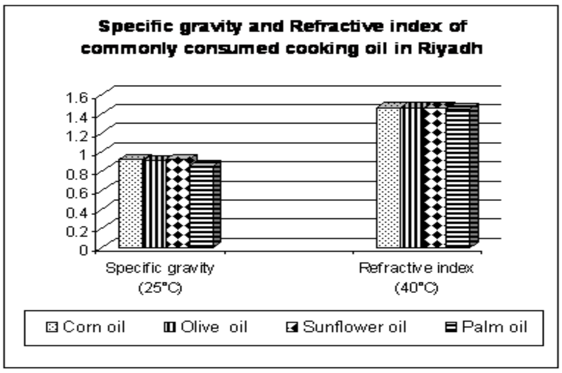

Fig. 1. Specific gravity and Refractive index of commonly consumed cooking oil in Riyadh.

Peroxide value

Peroxide value is an indicator of the deterioration of lipids due to oxidation at the double bond of an unsaturated fatty acid which causes rancidity (Inekwe *et al.*, 2012). It is a quality index for deciding the usability of oils; and hence lower the index will be, higher will be quality of oil (Yousefi *et al.*, 2013). The values in this report ranged from 0.7 to 16.5 meq/kg. Peroxide value of corn, olive, sunflower and palm oil was found to be 16.5, 0.7, 14.2 and 2.16 respectively. The highest value was found in corn oil (16.5 meq/kg-oil) followed by sunflower oil (14.2 meq/kg oil) and the lowest value from olive oil (0.7 meq/kg-oil). Unsaturated (especially polyunsaturated) fatty acids are also more prone to oxidation which might be the reason for high peroxide value of corn and sunflower oil. In this study the values of corn and sunflower oils were higher than the FAO and WHO standards for edible vegetable oils. The rate of peroxidation differed from oil to oil as related to different treatment to which the oils were subjected. International standard specifications no. 210 in 2009 have forced companies and factories producing oils and fats no more than about acid value 2% as oleic acid and peroxide value 10 milligrams peroxides /kg oil (Al Abbad and Basuny, 2012).

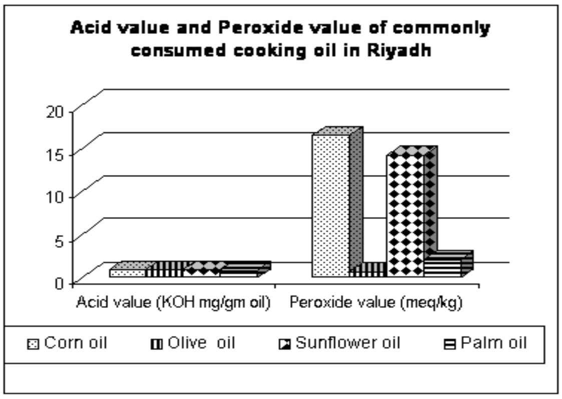

Fig. 2. Acid value and Peroxide value of commonly consumed cooking oil in Riyadh.

Saponification

Saponification value is a measure of the mean molecular weight of the fatty acids present in the lipid as each lipid has within the limits of biological variation, constant fatty acid composition (Ihekoronye and Ngoddy, 1995). Studies show that the high saponification values indicate that the oils are normal triglycerides and will be useful in the production of soap (Akbar *et al.*, 2009). Saponification value is used in checking adulteration. The degree of edibility of a fat is generally considered to be inversely proportional to the total amount of free fatty acids (Duel, 1951). Saponification of corn, olive, sunflower and palm oil was found to be 196,195,194 and 202 respectively. Salimon and Farhan, 2012 reported 189.7 mg/gm saponification value in Saudi olive oil. Saponification of palm oil was found to be highest. This result may be explained by the fact that the lengths of fatty acids of palm oil were lowest. The values of olive, sunflower and palm oil are in line with the standard guidelines set by WHO and FAO, while the present study showed slightly higher value for corn oil than the standard set by WHO and FAO.

Iodine Value

The Iodine value (IV) is a measure of the relative degree of unsaturation in oils. It is defined as the content of iodine in grams that is reacted by 100 grams of oil. The high degree of unsaturation further suggests that the oils can be used as semi drying oils for the manufacture of cosmetics and oil paints (Oladele and Oshodi, 2008) as well as alkyd resin, shoe polish and varnishes (Akintayo, 2004). The greater the iodine value, the more the unsaturation (Yousefi *et al.*, 2013) and the higher the susceptibility to oxidation. Our results show that sunflower oil had the highest value for iodine oil (140) hence the most unsaturated compared to palm oil which had the least value for iodine value (50), thus the most saturated. These values are in line with the results obtained by Al Abbad and Basuny, 2012. Iodine values for all the edible oils and fat studied were within the specification recommended by FAO/WHO.

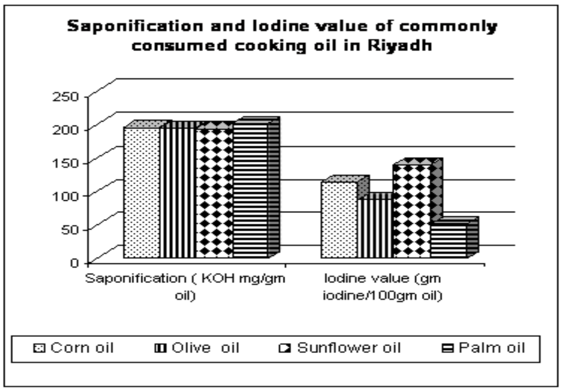

Fig. 3. Saponification and Iodine value of commonly consumed cooking oil in Riyadh.

B) Fatty acid composition of cooking oils commonly consumed in Riyadh

The results of determination of fatty acids composition by gas chromatography in commonly used cooking oils in Riyadh city of Saudi Arabia samples has been presented in table 2. Table 2 indicates clear differences in the fatty acids composition of oils. The fatty acid composition which is the relative proportion of different fatty acids in the mixture of triglycerides is a characteristic to each vegetable oil. The physiological effects of vegetable oil are also based on their fatty acid composition (Tautua *et al.*, 2013). The fatty acid composition alters with the variety, soil, and climatic conditions (Egan *et al.*, 1981). The fatty acid content of these oils shows beneficial mixture of all the kind of fatty acids unsaturated and saturated fatty acids. Nutritional fat is recognized as a key player in cardiovascular disease or factors associated with increased risk, such as triglycerides, plasma cholesterol and obesity (Yousefi *et al.*, 2013).

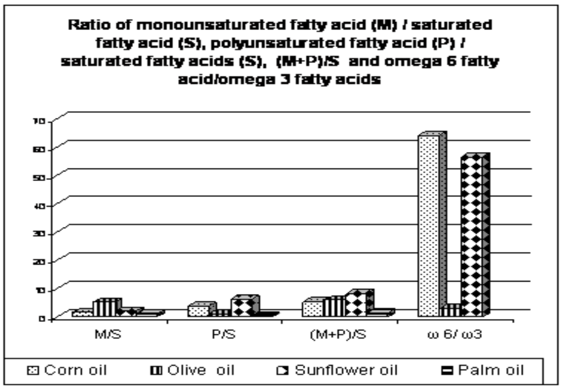

Fig. 4. Ratio of monounsaturated fatty acid/saturated fatty acid, polyunsaturated fatty acid/saturated fatty acids, (M+P)/S and omega 6 fatty acid/omega 3 fatty acids.

Palmitic acid (C16:0) was the most prominent saturated fatty acid identified in corn, sunflower and palm oil, while arachidic acid (C20:0) was the major saturated fatty acid identified in olive oil. Myristic acid (C14:0) was not found in olive and palm oil and was found in very less quantity in corn and sunflower oil. Zock, *et al.* 1994 reported appreciably high level of myristic and palmitic acids which rise blood cholesterol. Total saturated fatty acid was highest in palm oil followed by corn, olive and sunflower oil. In a previous study also palmitic acid was the most prominent saturated fatty acid identified in palm oil (Dauqan *et al.*, 2011). Saturated fatty acids with 12, 14 and 16 carbon atoms are known to be the primary contributors to elevated blood cholesterol and so contribute to cardiovascular diseases, and C14 (myristic acid) is found to be the main culprit (Grundy, 1999; Wardlaw, 2003).

The results showed a higher content of unsaturated fatty acids in the oils as is the case with most vegetable oils which makes them liquid at room temperature. The findings are similar to those of Makkar *et al.*, 2010. Oleic acid (C18:1) was highest in olive oil followed by palm, corn and sunflower oil.

Daunqan *et al.*, 2011 reported oleic acid as the most prominent monounsaturated fatty acid identified in corn oil. The high content of monounsaturated fatty acids (MUFAs) especially oleic acid (18:1) is associated with a low incidence of coronary heart disease (CHD) because it decreases total cholesterol (10%) and low-density lipoprotein cholesterol (Grundy, 1999; Dennys *et al.*, 2006).

Linoleic acid (C18:2) was the major polyunsaturated fatty acids identified in all the samples. Its highest concentration was observed in sunflower oil and least in palm oil. It is reported that linoleic acid is the one of the most significant polyunsaturated fatty acids in human diet as its ability for preventing heart and vascular diseases. Level of linolenic acid (C18:3) was low in corn, olive and sunflower oil and it was undetected in palm oil.

The total unsaturated fatty acid (UFA) was seen to be much higher than the total saturated fatty acids (SFA). This agrees with the report of Wardlaw, 2003 that plant oils contain mostly UFA ranging from 73-94% of total lipids. Corn oil and sunflower oil shows high levels of polyunsaturated (essential) fatty acids and low levels of saturated fatty acids and linolenic acid (Anonymous, 1996). Similar result was obtained in this study. Although dietary intake of certain unsaturated fatty acids, in particular conjugated linoleic and fat-soluble antioxidants has been linked to potential health benefits (Gillian *et al.*, 2008) the unsaturated (especially polyunsaturated) fatty acids are also more prone to oxidation.

C) Ratio of M/S, P/S, P/M and (PUFA + MUFA)/SFA

Ratio of fatty acids has been shown in graph 4. From the graph it has been depicted that M/S ratio was highest for olive oil and least for palm oil, P/S and (M+P)/S ratio was highest for sunflower oil and least for palm oil. In a study the effects of dietary MUFA and (PUFA + MUFA)/SFA ratio on plasma and liver lipid concentrations were studied. It seems that the prerequisites for keeping low plasma and liver C are (i) low MUFA/SFA ratio and (ii) PUFA + MUFA/SFA ratio not to exceed 2 (Chang and Huang, 1998). In this study (M+P)/S ratio of palm oil was found to be less than 2. High (P+M)/S ratio increases plasma VLDL and LDL lipids and reduces the hepatic hypertriglyceridemic effect of dietary cholesterol in rats. These results suggest that the higher (P+M)/S ratio is more cholesterolemic and hepatocholesterolemic than lower (P+M)/S ratio in rats fed with high-cholesterol diet (Chang *et al.*, 2003).

Mattson and Grundy, 1985 suggested that oleic acid is as effective as linoleic acid in lowering LDL-C levels in normo-triglyceridemic patients, and oleic acid seemingly reduces HDL-C levels less frequently than does linoleic acid. Neither type of unsaturated fat had striking effects on lipoprotein levels of hypertriglyceridemic patients. A high PUFA: SFA (P: S) ratio diet enhances oxidative stress because PUFA are highly susceptible to lipid peroxidation (Kang *et al.*, 2005).

D) Ratio of Essential Fatty Acids (ω-6/ω-3)

From the graph 4 it has been depicted that ω-6/ω-3 ratio was highest for corn oil followed by sunflower and olive oil. In this study ω-3 was not found in palm oil. Since olive oil is low in linoleic acid (LA) whereas corn oil and sunflower oils are high respectively, study suggests that the alpha linolenic acid (ALA) incorporation into cell membranes increases in olive oil (Simopoulos, 2009). Similarly, Cleland *et al.*, 1992 have shown that olive oil increases the incorporation of ω-3 fatty acids whereas the LA from corn oil competes. Hansen *et al.*, 1963 for the first time explained that the dietary intake of certain polyunsaturated fatty acids (PUFAs) is required by the humans, which the body is unable to synthesize and these PUFAs were therefore referred to as essential fatty acids (EFAs) and recognized as essential biochemical components of human diet (Gomez *et al.*, 2011). Linoleic acid and ALA are the parent fatty acids of ω--6 and ω-3 groups respectively. All the other members of ω-6 and ω-3 groups are derivatives of LA and ALA respectively. Omega–6 and ω-3 fatty acids 'compete' for the same enzymes, as the enzyme that is involved in these mechanisms have the same functions in the two fatty acid groups (Yehuda,

2003) These fatty acids are vital for and growth and development, they play an important role in the prevention and management of various chronic diseases such as coronary disease (Gebauer *et al.*, 2006), obstructive pulmonary disease (Shahar *et al.*, 1994), brain and retina (Lauritzen *et al.*, 2001), breast cancer (Shannon *et al.*, 2007), physical and mental health status (Silvers and Scott, 2002). As reported earlier ω-3 / ω-6 ratios are considered to be important (Alasalvar *et al.,* 2002). Citil *et al.* 2011 mentioned that a decrease in the ω-6/ ω-3 PUFA ratio increased the availability of ω-3 PUFAs, which are beneficial for human health. The ratio of 4/1 of LA/ALA led to a 70% decrease in total mortality at the end of 2 years (Lorgeril *et al.*, 1994). But the higher the ratio of ω-6/ω-3 fatty acids in platelet phospholipids, the higher is the death rate from cardiovascular disease (Weber *et al.*, 1986). As the ratio of ω-6 PUFAs to ω-3 PUFAs increases, the prevalence of type 2 diabetes also increases (Raheja *et al.*, 1993). Regarding the ω-6/ω-3 ratio in cardiovascular disease, various studies agree that the ratio must be improved, though there are controversial data on its usefulness as a cardiovascular risk marker (Gomez *et al.*, 2011). Increased dietary intake of LA leads to platelet aggregation, oxidation of LDL, and interferes with the incorporation of EPA in cell membrane phospholipids (Simopoulos, 2008).

In industrialized societies, changes have taken place in our diet, particularly in the type and amount of essential fatty acids (EFA) (Simopoulos, 2002).Due to increased amounts of omega-6 fatty acids, the eicosanoids metabolic products from AA are formed in larger quantities which are biologically active even in very small quantities (Simopoulos, 2008). So, the correct ratio between ω-6 and ω-3 fatty acid is very important (Perretti *et al.*, 2007).

Conclusion

The fatty acid profile and other composition of cooking oils commonly consumed in Saudi Arabia were found to be of good quality. Further studies are required to find out the health benefits of these oils. In this study physicochemical property such as acid value, peroxide value, saponification and iodine value of palm oil was found to be the best. Similarly, ratio of monounsaturated to saturated fatty acids (M/S), polyunsaturated to saturated fatty acids (P/S) and sum of monounsaturated and polyunsaturated fatty acids to saturated fatty acids (M+P)/S was found to be the best for palm oil. The health benefits of palm oil may be achievable by increasing the consumption of this healthy oil in daily intake.

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