Nutritional Quality of Various Edible Oils from Indian Oil Extraction Industry

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Abstract: The nutritional quality of some vegetable oils and fats was investigated in terms of their fatty acid profile. The oils and fats were analyzed by gas chromatography using flame ionization detector (GC-FID). Palmitic acid constituted the major saturated fatty acid component for all the oils while lauric acid was the main saturated fatty acid component for palm kernel and coconut oils. Palmitic acid was nearly 50% of the total fatty acids present in palm oil. Similarly the percentage of lauric acid in palm kernel and coconut oil was approximately 50% of the total fatty acid content. The saturated fatty acid content of all other oils was less than25%.The unsaturated fatty acid content of canola oil was the highest of oil samples . It analyzed 88-90% unsaturated fatty acids with a very small percentage of saturated fatty acid . Thus it may be regarded best choice in terms of its nutritional value for consumption in diet. Mustard oil also presented very high unsaturated fatty acid content (89%) but its high content of 46% erucic acid which is a heart risk limits its uses in diet. The unsaturated fatty acid content of the soybean oil, sunflower oil, ground nut oil and corn oil, was in the range 79-85%. Their saturated fatty acid content was found in the range 9-17%. Thus these oils are good for use as salad oil and for short term cooking processes . The olive oil presented highest mono unsaturated fatty acid content 71% .The rice bran oil with unsaturated fatty acids in the range 73-74% and a relatively richer saturated fatty acid content in the range 22-23% along with the presence of antioxidants is becoming an attractive choice for consumption . The sesame oil is very high in omega 6 acid 43% and unsaturated fatty acid content making 80% of total fatty acid content but presence of natural oxidants make it less prone to oxidation .

Keywords: Edible Oils, Saturated, Unsaturated Fatty Acids, Omega 6 Acid.

Introduction:

Vegetable oils and fats are one of the major components of human diet comprising as much as 25% of average calorie intake. The fats provide a concentrated source of energy and serve as vehicle to fat soluble vitamins (A, D,E and K), nutrients and antioxidants in the body [Emmanuel O. A., and Mudiakeoghene O. (2008)].The vegetable oils are the source of essential fatty acids like linoleic and linolenic acid not synthesized in the body and need to be supplied through diet for growth and the health of an organism [Assiesa J., et al (2004) and Ristic V., and Ristic G. (2003)]. Edible oils and fats of plant origin consist of esters derived from glycerol with chain of fatty acids containing sixteen to eighteen carbon atoms[Nesma E., Hany A. A., Mohammed H. A. E. and Mohammed M. Y. (2010)]. The vegetable oils and fats contain 95-98% saturated and unsaturated fatty acids, triglycerols and 2-5% other components [CHRISTIE, W.W. (1992), ZAMBIAZI, R.Z; ZAMBIAZI, M.W. (2000) and DANIEWSKI, M. (2003)]. The oils and fats of plant origin contain a high percentage of unsaturated fatty acids in the triacylglycerols. The high content of unsaturated fatty acids is desirable but their greater susceptibility to oxidation degrades the organoleptic quality of food, reduces its nutritional value and also produces undesirable flavours[A. Ascherio, (1998) and L.E. Johnson and W.M. Cort (1985)]. While high levels of saturated fatty acids impart stability but they affect the ratio of LDL to HDL (high density lipoproteins), promoting clotting and vascular smooth muscle proliferation [PACIFICI,E, H.K (1994), DZISIAK, D (2004).and PRZYBYLSKI, R.; MCDONALD, B.E (1995)]. As such the nutritional and health implications of oils and fats is gaining importance[Sahena F., et al (2009)]. Therefore, it is essential to know the composition of fatty acids of an oil or fat, to identify their physico-chemical characteristics, to determine their oxidative stability ,any possible adulteration and hence assess their nutritional value.

Gas chromatography is a convenient and precise method for qualitative and quantitative analysis of fatty acid methyl esters. Many workers have reported the studies on oils and fats using gas chromatography[Christie W.W.(1989), Cert A, Moreda W, Perez C (2000), Kostik, V., et.al (2015), ZAMBIAZI R.C. et al(2004)].In this manuscript we attempt to discuss the nutritional value of some edible oils and fats available in the Indian market in terms of their fatty acid profile determined by gas chromatography using flame ionization detector.

2. Materials and methods

2.1. Materials:

Vegetable oils and fats were obtained from local market in India. Eleven samples each of soybean oil , palm oil , canola oil , sunflower oil, ground nut oil, mustard oil, coconut oil, rice bran oil,palm kernel oil, palmolein oil, olive oil,corn oil, sesame oil period between May 2015 to April 2016 were collected from market and analyzed for their nutritional value.

2.1.2- Methods:

Preparation of fatty acid methyl ester(FAME):
Oil samples were directly converted to their volatile methyl esters while solids before conversion to methyl esters were cold extracted from petroleum ether. The conversion of samples to their volatile esters was carried according to the International Standard ISO 5509:2000 – boron trifluoride (BF_3) method (EN ISO 5509:2000) in the following way:
200 microlitre of the oils /petroleum ether extractions were treated with 2ml of MTB reagent prepared by mixing methanol, toluene and boron trifluoride in the ratio 1:1:1. Esterification was performed by refluxing for 1 hr at 60-70^{0}C in tightly sealed pyrex tubes. After cooling it at room temperature, 1mL of hexane was added followed by 1mL of deionized water, mixed gently and allowed to settle until the upper hexane layer become clear. The clear upper layer of methyl esters in petroleum ether was separated carefully in a capped vial and used for analysis. All solvents and standards were of analytical grade (Merck, Fluka).

Chromatography:

HP model 5890 series II (plus) gas chromatograph equipped with an HP automatic liquid sampler and a flame-ionization detector (FID) was used. Separation was performed on a non polar fused silica capillary column (length30 m x 0.32 mm id. x 1 µm film thickness) coated with 100% poly(dimethylsiloxane). The sample volume injected was 1 µl in split less mode with Nitrogen as a carrier gas at a flow rate 1.2 mL min^{-1} .The injection port was maintained at 250^{0}C and Oven temperature was set at 140 ^{0}C for 1minute increasing for 4^{0}C min^{-1}. The final oven temperature was maintained at 240^{0}C with final time set at 20 minutes. The detector temperature was set at 260^{0}C. Total analysis time was 25 minutes. Fatty

acids were separated according to carbon atoms and number of double bonds and were identified by comparing their retention times to standards.

Table -1: Saturated fatty acid composition of different types of vegetable oils and fats (% w/w)

Oil	$C_{6:0}$	$C_{8:0}$	$C_{10:0}$	$C_{12:0}$	$C_{14:0}$	$C_{16:0}$	$C_{18:0}$	$C_{20:0}$	$C_{22:0}$
Soya					0.13±0.02	11.91±0.10	3.2 ±1.12	0.48±0.20	0.26±0.10
Can					0.11±0.06	5.80±2.25	1.66±0.20	1.89±0.11	0.34±0.30
Palm				0.23±0.05	0.92±0.05	45.60±1.47	3.75±1.12	0.14±0.09	
Sun					0.11±0.04	10.53±1.11	3.65±0.02	0.34±0.09	0.60±0.09
Grou					0.08±0.01	12.20±0.65	2.85±0.30	1.00±0.01	2.09±0.03
Mus					-	3.12±0.21	1.34±0.16	0.84±0.14	1.04±0.02
Coco	0.71±0.02	9.24±0.01	5.87±0.01	47.62±0.15	19.48±0.07	7.73±0.10	2.37±0.06	.04±0.01	
Rice					0.39±0.09	20.53±0.17	2.10±0.22	0.45±0.06	0.10±0.10
Palm K kernel	0.21±0.02	4.38±0.21	3.83±0.40	51.13±2.62	15.36±1.22	7.87±1.52	1.82±3.02	0.05±0.02	
Palmo				0.13±0.02	0.87±0.11	40.40±1.55	3.37±2.21	0.20±0.32	
Olive					0.03±0.01	11.35±2.72	2.54±1.12	0.33±0.10	0.15±0.09
Corn					0.07±0.05	14.69±1.12	1.98±0.65	0.39±0.20	0.14±0.09
Ses						10.95±2.05	5.95±0.05	0.60±0.03	

Table- 2: Unsaturated fatty acid composition of different types of vegetable oils and fats (% w/w)

Oil	C18:1)	C18:2)	C18:3
Soya	21.42±0.36	56.48.±1.07	7.40±1.15
Can	63.08.±0.65	21.15±0.60	4.90±1.32
Palm	37.82±0.56	11.80±0.58	0.19±0.10
Sun	22.70.±1.12	59.20±0.93	3.04±2.92
Grou	53.82±0.24	26.70±0.41	0.79±0.15
Mus	62.10±0.17(E)	16.20±0.70	10.66±0.11
Coco	5.53±0.04	1.27±0.02	-
Rice	42.24±0.32	32.49±1.07	1.05±0.30
Palm K kernel	13.63±1.23	2.17±0.21	0.05±0.03
Palm o	43. 70±0.82	11.08±0.67	.20±0.10
Olive	72.93±0.10	11.05±0.50	0.91±0.25
Corn	32. 70±0.82	48.76±1.05	0.76±.22
Ses	38. 75±0.80	42.67±1.68	0.25.±0.05

Table-3:The content of SFA, MUFA, PUFA (% w/w) and the values of P/S indexes in different types of vegetable oil

Oil	SFA	MUFA	PUFA
Soya	15.98±0.36	21.42±0.36	63.88±1.15
Can	9.80.±0.65	63.08.±0.65	26.05±1.32
Palm	49.64±0.56	37.82±0.56	11.99±0.84
Sun	15.63±0.06	22.70.±1.12	62.24±1.02
Grou	18.22±0.24	53.82±0.24	27.69±0.15
Mus	6.40±0.17	62.10±0.17 (E)	26.86±0.41
Coco	93.18±0.05	5.53±0.04	1.27±0.02
Rice	23.50±0.14	42.24±0.32	33.54±1.00
Palm K kernel	84.63±1.23	13.63±1.23	2.22±0.40
Palm o	44. 97±084	43. 70±0.82	11.10±1.10
Olive	14..25±0.10	72.93±0.10	11.96±0.25
Corn	17..27±0.14	32. 70±0.82	49.52±2.22
Ses	17.50±0.10	38.75±0.82	42.92.±0.05

Results and Discussion

All the oils except palm kernel and coconut oils had palmitic acid (C16:0) as the major component of saturated fatty acid content. It was followed by stearic acid(C18:0). in agreement with literature[ZAMBIAZI R.C.et.el.(2000)]. The palm kernel and coconut oil presented lauric acid (C12:0) as the major component of their saturated fatty acid content. The samples of mustard oil and sesame oil did not show the presence of myristic acid, but it was found to be in the range 0.03% - 0.92% for other oils .The presence of behenic acid (C22:0) was found in the samples of soybean oil, sunflower oil, canola oil, corn oil, olive oil, rice bran oil, mustard oil and groundnut oil in the range 0.13%-2.09 % . It was not found in the samples of palm oil, coconut oil, palmolein oil and sesame oil. Arachidic acid (C20:0) was found in minor quantities in all the samples. The fatty acid composition of the oils analyzed is given in Table -1 and Table - 2, respectively. The mean of total saturated fatty acid (SFA), monounsaturated fatty acids (MFA), polyunsaturated fatty acids (PUFA) and the values of polyunsaturated/saturated indexes (P/S) are shown in Table 3.

Soybean, sunflower ,corn and olive oils are analyzed for total saturated fatty acid ranging from 13 to 17%, thus considered useful as salad oils [McKENZIE,S.; TAYLOR, D.C (1996), QUINTEIRO, L.M.C.; VIANNI, R. (1995) and RIZZARDI, M.A. et al (1993)].

The saturated fatty acid content of groundnut and rice bran oils was found in the range 17-23% due to their relatively higher saturated fatty acid content, and consequently due to higher stability, these are good sources for cooking and short term frying processes [McKENZIE,S.; TAYLOR, D.C (1996) and CLARK, W.L.; SERBIA, G.W. (1991)].

The saturated fatty acid make up nearly 50% of the total fatty acids of palm oil and most of it is present as palmitic acid. Stability due to high saturated fatty acid component besides the tendency of β polymorphism structure of the palmitic acid, makes palm oil a good choice for deep frying process, and excellent source for blending oils for achieving specific properties for various uses, as source of margarines and bakery products application [McKENZIE,S.; TAYLOR, D.C (1996) , FREITAS, S.P.; SILVA, F.C.; LAGO, R.C.A. (1998) and VIEIRA, T.M.F.S.; REGITANO-DÀRCE, M.A.B.; OETTERER, M. (1997)].

Saturated fatty acid content of palm kernel and coconut oil was found in the range 84-90%. Lauric acid comprising nearly 50% of the total fatty content in both the oils . Myristic, palmitic and stearic acids , along with short chain fatty acids caprilic and capric were also present in significant amounts. High content of SFA with the presence of low chain fatty acids, make these oils useful in pharmaceutical application, mainly for detergents, soaps and similar products [VIEIRA, T.M.F.S.; REGITANO-DÀRCE, M.A.B.; OETTERER, M. (1997) and PENEDO, P.L.M.; COELHO, G.L.V. (1997)].

The canola oil has a very high content of unsaturated fatty acids 88-90%. The richness of unsaturated fatty acids namely oleic and linolenic acids , the omega-3 fat (4.9%) which reduces the risk of coronary diseases makes it one of the best choice for daily consumption [SHAPIRO, H. (2003), VANSCHOONBEEK, K.; MAAT, M. P. (2003) and WEN, Z. Y.; CHEN, F. (2003)].This choice is further strengthened by nutritional concerns, that presumes lower consumption of saturated fatty acids in the diets .Thus canola oil has got the best composition regarding the saturated fatty acid content making canola oil nutritional for salad and cooking purpose[PRZYBYLSKI, R.; MCDONALD, B.E (1995)]

Analysis results indicate that linoleic acid (C18:2) is the predominant unsaturated fatty acid in the soybean oil making up almost 95% of the PUFA content of the oil. soybean oils also showed linolenic acids, ranging from 6-8% considered adequate for giving ω-3 source. The high PUFA content, relatively low saturated fatty acids and negligible trans fat makes it useful for human diet as salad oil. [McKENZIE,S.; TAYLOR, D.C (1996), QUINTEIRO, L.M.C.; VIANNI, R. (1995) and RIZZARDI, M.A.; SILVA, P.R.F.; GUTKOSKI, L.C.; ROCHA, A.B. (1993)].

Sun flower oil with very high 62% PUFA content ,linoleic acid (C18:2) as the major acid makes this oil as a good source of salad oil [DZISIAK, D (2004). , McKENZIE,S.; TAYLOR, D.C (1996) and VIEIRA, T.M.F.S.; REGITANO-DÀRCE, M.A.B.; OETTERER, M. (1997)]. The linolenic in our sunflower oil samples was also found in the being 0.27% . The reported value lies in the range from 0.12 – 0.45%.[ZAMBIAZI R.C. et al(2007)]

Olive oil presented 73% MUFA content mainly due to the predominant presence of oleic acid (C18:1). It is nutritionally considered one of the best salad vegetable

oil due to the highest MUFA content. [DANIEWSKI, M. et al (2003) and FREITAS, S.P.; SILVA, F.C.; LAGO, R.C.A. (1998)]

The ground nut oil has oleic and linoleic acids making its large unsaturated fatty acid (78-80%) component . Due to its relatively higher saturated fatty acid content (17-18%) and therefore higher stability, groundnut oil is considered a good source for cooking and short term frying process [McKENZIE,S.; TAYLOR, D.C (1996) and CLARK, W.L.; SERBIA, G.W. (1991)].

The mustard oil also contains very large unsaturated fatty acid content. Erucic acid 46% is the major MUFA component . The essential fatty acids linoleic (15.50%) and linolenic(10.78%) are also present as its fatty acid profile reveal. Since erucic acid appears to have toxic effects on the heart at high enough doses[Food Standards Australia New Zealand (June 2003)] In spite of mustard oil containing linoleic and linolenic acids, the high content of erucic acid limits its dietary applications to some specific purposes like pickle making.

Oleic acid and linoleic acid are the major constituents of rice bran oil. The oil with unsaturated fatty acids in the range 73-74% and a relatively richer saturated fatty acid content in the range 22-23% along with the presence of antioxidants is becoming an attractive choice for consumption in diet.[PRZYBYLSKI, R.; MCDONALD, B.E (1995) and McKENZIE,S.; TAYLOR, D.C (1996)].

Palmolein oil has almost similar amounts of monounsaturated (42%)and saturated fatty acids(43%). Its the highly saturated nature renders it solid at room temperature in temperate regions, making it a cheap substitute for butter or trans fats in uses where solid fat is desirable, such as the making of pastry dough and baked goods.

The unsaturated fatty acid content 79% of corn oil is more than its saturated fatty acid content. The oleic and linoleic acid being major components. Presence of essential fatty acids along with its high saturated fatty acid ranging from 13 to 17%, thus considered useful as salad oils [McKENZIE,S.; TAYLOR, D.C (1996), QUINTEIRO, L.M.C.; VIANNI, R. (1995) and RIZZARDI, M.A.; SILVA, P.R.F.; GUTKOSKI, L.C.; ROCHA, A.B. (1993)].

Sesame oil contains oleic(39%) and linoleic acids(43%)which together account for more than 80%% the total fatty acids. Despite sesame oil's high proportion (42%) of polyunsaturated (Omega-6) fatty acids, it is least prone, among cooking oils with high smoke points, to turn rancid when kept in the open[Lee J, Lee Y, Choe E (2008)].[This is due to the natural antioxidants present in the oil. It is used in frying vegetables, making curries and gravies .

CONCLUSIONS:

The canola oil analyzed 88-90% unsaturated fatty acids containing 5-8% of ω-3 fatty acids and a very small percentage of saturated fatty acid .Thus it may be regarded best choice in terms of its nutritional value for consumption in diet. Olive oil with highest MUFA content(71%) and nearly 15% SFA offers best choice as salad oil. The unsaturated fatty acid content of the soybean oil, sunflower oil, ground nut oil and corn oil, was found in the range 79-85%. Their saturated fatty acid content was found in the range 9-17%. Thus these oils are also good for use as salad oil and for short term cooking processes . The rice bran oil with unsaturated fatty acids in the range 73-74% and a relatively richer saturated fatty acid content in the range 22-23% along with the presence of antioxidants is becoming an attractive choice for consumption . Despite very high content of omega 6 acid (43%) sesame oil, natural oxidants make it less prone to oxidation and hence used for frying processes. Both palm oil and palmolein oil find limited dietary applications because of their high SFA content for butter or uses such as the making of pastry dough and baked goods. The mustard oil is very rich in unsaturated fatty acids but its high content of erucic acid(46%) ,a heart risk limits its dietary applications to specific purposes like pickle making.

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