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Original Research Article

Effect of Roasting on Fatty Acid Profile of Brown and Yellow Varieties of Flaxseed (*Linum usitatissimum* L)

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Abstract

Purpose: *To monitor changes in fatty acid profiles of brown and yellow varieties of flaxseeds in the raw and roasted states using gas chromatography (GC).*
Methods: *Samples of flaxseeds were extracted with n-hexane in a Soxhlet apparatus for 8 h. Methyl-esterification of the samples was performed by methanolic boron trifluoride (BF3-MeOH) method according to American Oil Chemists' Society (AOCS). Fatty acid (FA), analyzed using GC equipped with a split/splitless capillary injector and flame ionization detector (FID).*
Results: *The results indicate that lipid content varied with the type of seed. Seed oil content was 53.31 ± 0.30 and 45.20 ± 0.20 % for roasted and unroasted brown flax, respectively, and 10.25 ± 0.04 % for the yellow type. The yellow and roasted brown type, at 300 ^{o}C, showed the lowest and highest oil content, respectively. The highest calculated oxidizability (COX) value was found for the unroasted brown type (13.19 ± 0.01 %) whilst the lowest amount was observed for the roasted brown seed at 350 ^{o}C (12.79 ± 0.01 %). COX value for yellow type was 5.62 ± 0.01 %.*
Conclusion: *This study shows that the fatty acids content of flaxseeds vary with roasting conditions. This is significant because flax seed fatty acid composition influences the applications of the oil.*

Keywords: *Oil, Flaxseed, Roasting, Fatty acid, Linum usitatissimum, Calculated oxidizability value*

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INTRODUCTION

Linum usitatissimum L is the taxonomic identity of flax. Linum is the great genus within the flax family Linaceae. Flaxseed basically contains mucilage and oil. It is also an excellent source of ω-3 fatty acids (FA), particularly linolenic acid, which is beneficial to both humans and animals [1]. In a previous work [2], there were no significant nutritional or safety-related differences between flaxseeds of different colors. Brown flaxseed is rich in alpha-linolenic acid (ALA). Yellow flaxseed is one of two types. One type, a U.S.-developed variety named Omega, is as rich in ALA as brown flax. The second type is an entirely different flax called Solin, which is low in ALA [3]. Flaxseed content varied from 38 to 45 % oil and FA distribution depending on location, cultivation, and environmental conditions [4].

Dry heat (roasting) is a widely used processing methods for cereal products, fruits, and vegetables [5] and known to improve the availability of nutrients, inactive enzymes which accelerate nutrient damage, destroy undesirable microorganisms and food contaminants. During processing, cooking and preserving of food, the application of roasting has mixed effects on its nutritive value [6]. Roasting of flaxseed has traditionally been used to prevent gastrointestinal complications in Iran. Flax seeds have been roasted in the laboratory in an aluminum frying pan using a 100 W electric stove as a source of heat [7].

No evidence supporting change in lipid profile during the roasting process of this seed has, to the best of our knowledge, been reported. Therefore, the objective of the current study was to monitor the changes of FA profiles in both raw and roasted brown and yellow flaxseeds using gas chromatography (GC).

EXPERIMENTAL

Reagents and standards

All solvents and reagents were used of analytical grade. MeOH, n-Hexane, NaOH, methanolic boron trifluoride (BF3-MeOH) and NaCl, Na_2SO_4 were purchased from Merck, (Darmstadt, Germany).

The certified standard mixture of 37-component FA methyl ester (FAMQ-005) was purchased from Accu-standard, USA. Linoleic and linolenic acids were products of Sigma-Supelco while the ester isomer was purchased from Sigma, USA.

Plant materials and treatment

The brown and yellow flaxseeds were obtained from Jamalzade Medicinal Herb Distribution in Tehran, Iran. The seeds were sealed in a bottle and stored at 4 ˚C until used. The seeds were identified by Dr Gholamreza Amin, a taxonomist and Principal Scientific Officer, Faculty of Pharmacy, Tehran University of Medical Science. Voucher specimens (brown type - no. PMP-734, and yellow type - no. PMP-733) were deposited at the Herbarium of the Department of Pharmacognosy (TEH Herbarium), Faculty of Pharmacy, Tehran University of Medical Science. The roasting procedure was carried out for 10 min at 150, 200, 250, 300 and 350 ˚C in a convention electric oven (R-5550, Sharp, Osaka, Japan).

Oil extraction

Samples weighting 10 g were separately ground (60-mesh size), using a stainless-steel grinder and the oil extracted in a Soxhlet apparatus for 8 h with n-hexane. The hexane extracts were filtered through lipid-free filter and the hexane evaporated under nitrogen. The extracted oils were weighted to determine the oil content of the seed and were kept away from light at 25 ˚C until used.

Preparation of methylester

Methyl-esterification was performed by BF_3-MeOH method according to AOCS [8]. 1 g oil was weighed, then added 10 mL of 0.5 M NaOH in MeOH in 125 mL flask and was heated for 10 min at 100 ˚C. Then 12 mL BF_3-MeOH reagent was added and the mixture was heated at 100 ˚C for two min. Five mL of N-hexane was added to the mixture and heated for one min. After cooling, 15 mL of saturated solution of NaCl in H_2O was added and the solution/mixture was shaken for about 15 s. Then the upper phase was isolated and dried with Na_2SO_4 anhydrous. The dryied sample was filtered through a 0.22 mm membrane polytetrafluoroethylene (PTFE) filter and one microgram of the sample solution was injected into the GC.

GC analysis

The methylester was analyzed using GC series 1200 Agilent, USA equipped with a split (80:20) capillary injector and flame ionization detector (FID). A highly polar capillary column HP-88 (88 % - Cyanopropy) aryl-polysiloxane Length 100 m × film 0.2 µm × ID 0.250 mm (Agilent, USA) was used to separate the cis-trans fatty acid methyl esters (FAMEs). Nitrogen was the carrier and ran at constant flow rate of 0.94 mL/min. The injector and detector temperature were set at 220 and 250 ^oC. Split ratio of 1/100 was used for injector and one microgram of the sample was injected into the GC for analysis. Oven temperature was initiated at 180 ˚C for 30 min, increased by 1.5 ^oC/min to 200 ^oC and then kept constant for 30 min. FAME peaks on the GC were identified by comparison against standard FAME mixture. The peak areas were used to calculate the percentage of FA expressed as the percentage of total FA.

Calculated oxidizability value (COX)

The oxidative stability of the seeds at different roasting temperature based on unsaturated FA (USFAs) content was calculated using equation 1 [9].

COX = {1(18.1%) + 10.3(18.2%) + 21.6(18.3%)} × 100 ..... (1)

where 18:1, 18:2 and 18:3% represent percent contents of oleic, linoleic, linolenic acids, respectively.

Data treatment

All measurements were replicated three times to improve the reliability of the results. Data were expressed as mean ± SD analyzed using Statistical Program for Social Sciences, version 21 (IBM SPSS Inc, Chicago, USA). One-way analysis of variance (ANOVA) was used for determining significant difference which was set at $p < 0.05$. For data that meet the assumption of variance homogeneity, Tukey post-hoc was used. Also, where the data did not meet the homogeneity of variances, Dunnett post-hoc test was applied.

RESULTS

The results in Table 1 show that there are significant differences in the level of each FA between different varieties and roasting conditions but the calculated ratio of FA did not show any changes under different roasting conditions (Table 2).

The FA percentages and COX values in unroasted yellow and brown type of Flax and roasted brown Flax in different conditions are reported in Table 1. COX value of each Flax seed oil are presented in Table 1. The highest COX value was in unroasted brown type cultivar (13.19 ± 0.01 %), whilst the minimum amount was found in roasted brown-350 ˚C (12.79 ± 0.01 %). The COX value of yellow type was also 5.62 ± 0.01 %.

The seed oil contents varied from 53.31 ± 0.30 to 45.20 ± 0.20 for the roasted and unroasted brown Flax and 10.25 ± 0.04 for the yellow type. Yellow type and roasted brown type Flax at 300 ˚C had the lowest and highest oil content respectively (Table 1).

The ratio of SFAs to USFAs is a useful index to measure edible oil quality. In the current study it was found between 0.135 and 0.143 (Table 3). The maximum content of determined FA is linolenic acid in brown type with 54.38 ± 0.04 % while the highest content was related to linoleic acid in yellow type with 46.45 ± 0.21 %. It must be emphasized that the erucic, arachidonic, tricosanoic, methyl cis 13.16-docasadienoic and cis-5.8.11.14.17-eicosapentaenoic acid were marginal in most of the assessed temperatures.

Figures 1 and 2 show the chromatogram of fatty acids found in one randomly selected of brown and yellow type sample respectively by GC. As can be seen in Table 2, the calculated FA, and so oil content was compared with U.S. Department of agriculture, agricultural research service [10], grain research laboratory and commercial laboratory (11). USFAs contents in studied types were dramatically higher than those stated in the references cited above. The major FA compounds were linolenic, oleic and linoleic in brown type and linoleic, oleic and palmitic acid in yellow type, respectively. Furthermore, omega 3 in brown type (54.62 ± 0.03 %) and omega 6 in yellow type (46.75 ± 0.21 %) were the main component. The ratio omega−6 to omega−3 ratio stayed stable during the roasting process for brown type (0.22 ± 0.06 %) while the detected amount of this ratio in yellow was noticeably higher with (20.37 ± 0.32 %).

DISCUSSION

The brown type of the flaxseed has been traditionally used in roasted form in foods and galenical drugs in Iran. Significant positive effects of flaxseed on cardiovascular system and its anti-cancer properties are associated with its oil content and omega FAs. Thus, as mentioned previously, the objectives of this study was to monitor changes in FA profiles with temperature. The result from grain research laboratory, commercial laboratory and United State Department of Agriculture showed that the total oil content of unroasted flax seed was different from that of this study as the amount of oil content of the brown type used in the present study was higher by about 6 % but lower by about 30 % when compared with other studies [10]. A previous report has claimed that the highest oil content in flax seed is at the lowest temperature for the period of seed development [12].

With regard to oil content, the significant differences were found between roasted brown types at different temperatures from the initial temperature of 150 ˚C to the highest temperature of 350 ˚C. Roasted seeds at 300 and 350 ˚C have higher amounts of oil content than the other roasted seeds. It seems that this fact could be due to loss of moisture at higher temperatures. On the other hand, Lawal (1986) showed that the moisture content of *Treculia africana* decrease

Table 1: Percentage fatty acid composition of Flax oil at different roasting temperature

Fatty Acid	Unroasted Brown Flax	Brown Flax roasted at 150˚C	Brown Flax roasted at 200 ˚C	Brown Flax roasted at 250 ˚C	Brown Flax roasted at 300 ˚C	Brown Flax roasted at 350 ˚C	Unroasted Yellow Flax
C14:0	0.05±0.00^{b}	0.05±0.00^{b}	0.05±0.02^{b}	0.05±0.01^{b}	0.05±0.01^{b}	0.05±0.02^{b}	0.16±0.00^{a}
C15:0	0.02±0.00^{a}	0.01±0.00^{c}	0.02±0.00^{a}	0.02±0.00^{a}	0.03±0.00^{a}	0.02±0.00^{a}	0.01±0.00^{c}
C16:0	6.17±0.01^{e}	6.31±0.00^{d}	6.50±0.01^{c}	6.51±0.01^{c}	6.69±0.01^{b}	6.48±0.01^{c}	11.74±0.12^{a}
C16:1c	0.08±0.00^{c}	0.08±0.00^{c}	0.08±0.00^{c}	0.09±0.00^{b}	0.09±0.00^{b}	0.07±0.00^{d}	0.11±0.00^{a}
C17:0	0.04±0.00^{c}	0.04±0.00^{c}	ND	0.05±0.00^{b}	0.06±0.001^{a}	0.05±0.00^{b}	0.06±0.00^{a}
C18:0	5.67±0.01^{b}	5.85±0.00^{a}	5.61±0.00^{b}	5.62±0.01^{b}	5.84±0.01^{a}	5.95±0.02^{a}	1.55±0.02^{c}
C18:1c	20.18±0.01^{e}	20.70±0.02^{c}	20.38±0.02^{d}	20.49±0.03^{d}	20.98±0.08^{b}	21.23±0.05^{b}	35.50±0.30^{a}
C18:2c	12.09±0.00^{c}	12.10±0.01^{c}	12.30±0.01^{b}	12.01±0.01^{d}	12.24±0.04^{b}	12.02±0.21^{d}	46.65±0.21^{a}
C18:3c	54.38±0.04^{a}	53.49±0.04^{b}	53.73±0.02^{b}	53.61±0.06^{b}	52.74±0.22^{c}	52.51±0.31^{c}	2.14±0.04^{d}
C21:0	0.11±0.00^{b}	0.11±0.00^{b}	0.11±0.00^{b}	0.11±0.00^{b}	0.11±0.00^{b}	0.11±0.00^{b}	1.02±0.02^{a}
C22:0	0.02±0.00^{a}	0.01±0.00^{b}	0.02±0.00^{a}	0.02±0.00^{a}	0.02±0.00^{a}	0.01±0.00^{b}	0.02±0.00^{a}
C20:3c	0.19±0.01^{a}	0.19±0.00^{a}	0.18±0.00^{b}	0.20±0.00^{a}	0.20±0.00^{a}	0.21±0.00^{a}	0.07±0.00^{c}
C22:1c	0.19±0.01^{a}	ND	ND	ND	ND	ND	ND
C20:4c	0.3±0.00^{a}	ND	0.03±0.00^{a}	ND	ND	ND	ND
C23:0	0.02±0.00^{c}	ND	0.04±0.00^{b}	ND	ND	ND	0.18±0.00^{a}
C22:2c	0.03±0.01^{b}	0.03±0.01^{b}	0.04±0.01^{a}	0.05±0.02^{a}	0.02±0.00^{b}	0.03±0.01^{b}	0.03±0.00^{b}
C20:5c	ND	ND	ND	ND	ND	ND	0.03±0.00^{a}
C24:1c	0.11±0.00^{a}	0.09±0.00^{b}	0.09±0.00^{b}	0.10±0.01^{a}	0.09±0.01^{b}	0.11±0.01^{a}	0.07±0.00^{c}
C22:6c	0.05±0.00^{b}	0.04±0.00^{c}	0.04±0.01^{c}	0.09±0.00^{a}	0.01±0.00^{c}	0.02±0.00^{d}	0.05±0.00^{b}
∑ P,M,L	6.22±0.01^{e}	6.324±0.01^{d}	6.56±0.10^{c}	6.56±0.01^{c}	6.72±0.01^{b}	6.54±0.01^{c}	11.91±0.03^{a}
SFA	11.89±0.00^{d}	12.11±0.01^{c}	12.17±0.02^{c}	12.19±0.02^{c}	12.56±0.02^{b}	12.44±0.03^{b}	13.47±0.14^{a}
MUFA	20.60±0.02^{d}	20.90±0.01^{c}	20.58±0.02^{d}	20.71±0.03^{d}	21.20±0.08^{b}	21.44±0.05^{b}	35.76±0.31^{a}
PUFA	67.29±0.03^{a}	66.42±0.04^{c}	66.90±0.03^{b}	66.51±0.06^{c}	65.72±0.28^{a}	65.38±0.54^{a}	49.23±0.25^{d}
Omega 3	54.63±0.03^{a}	53.73±0.04^{b}	53.96±0.05^{b}	53.90±0.06^{b}	52.97±0.22^{b}	52.77±0.31^{b}	2.29±0.04^{c}
Omega 6	12.35±0.00^{c}	12.32±0.07^{d}	12.57±0.01^{b}	12.27±0.01^{d}	12.47±0.04^{b}	12.28±0.21^{d}	46.75±0.21^{a}
Omega 9	20.52±0.03^{d}	20.83±0.01^{c}	20.52±0.02^{d}	20.63±0.03^{d}	21.10±0.08^{b}	21.39±0.05^{b}	35.58±0.30^{a}
Omega6/ omega3	0.22±0.03^{b}	0.23±0.06 ^{b}	0.23±0.12^{b}	0.22±0.03^{b}	0.23±0.07^{b}	0.23±0.07^{b}	20.37±0.32^{a}
COX value	13.19±0.01^{a}	13.01±0.01^{b}	13.01±0.01^{b}	13.02±0.01^{b}	12.86±0.01^{c}	12.79±0.01^{c}	5.62±0.01^{d}
Oil content	45.20±0.20^{d}	47.24±0.25^{c}	47.31±0.30^{c}	52.64±0.27^{a}	53.31±0.30^{a}	51.62±0.39^{b}	10.25±0.04^{e}

Values in the same row bearing different superscripts are significantly different (P≤0.05).ND not detected. , Data are expressed as mean ± SD (n = 3). . *∑P, M, L=Sum of Plametic, Myristic, Lauric ; SFA= Saturated Fatty Acid ; PUFA= Poly Unsaturated Fatty Acid ; MUFA= Mono Unsaturated Fatty Acid; COX value= Calculated oxidizability value*

dramatically (16.1 %) during the roasting process ($p < 0.01$) [13].

COX value is an index calculated based on USFA [9]. High PUFA of flax oil is readily oxidized during the roasting process [11]. The calculated COX value for flax seeds decreased at higher temperatures.

PUFA from flax oil are essential for human diet and decrease the risk of cholesterol oxidation diseases. Consumption of oleic, linoleic and linolenic acid decrease the level of LDL in human blood. As a medicinal point of view, the linolenic acid content of 1-10 % reduces blood cholesterol levels. Also, linolenic acid was present in amounts of 54.38 ± 0.42 % for brown and 2.14 ± 0.04 % for yellow type. Flax seed grown in USA gave 45 – 52 % linolenic acid whereas this value content of Western Canadian Flaxseed was 59 % which were quite similar to New Zealand flax seed [14].

Table 2: Unroasted flax fatty acids content %

Parameter	Brown flax	Yellow flax	USDA/ARS	GRL	CL
Butyric	ND	ND			
Caproic	ND	ND			
Caprylic	0.001±0.001	0.01±0.00			
Capric	0.001±0.00	0.004±0.00			
Undecanoic	ND	ND			
Lauric	0.01±0.00	0.01±0.00			
Tridecanoic	ND	ND			
Myristic	0.05±0.00	0.16±0.00	0.02	ND	ND
Myristoleic	ND	ND			
Pentadecanoic	0.02±0.00	0.01±0.00	0.01		
Cis-10-pentadecenoic acid	ND	ND			
Palmitic	6.16± 0.01	11.74±0.12	5.61±0.19	4.89	5.15
Palmitoleic	0.08±0.00	0.11±0.00	0.06±0.01	Trace	
Heptadecanoic	0.04±0.00	0.06±0.00	0.045		
Cis-10-heptadecenoic	0.02±0.00	0.06±0.00			
Stearic	5.67±0.01	1.55±0.020	3.15±0.33	2.81	3.09
Elaidic acid	0.02±0.00	ND			
Oleic	20.18±0.01	35.50±0.30	18.50±1.86	18.67	18.90
Linoeleidate	ND	ND			
T-linoleic acid	0.041±0.00	0.05±0.00			
T-linoleic acid	ND	ND			
Linoleic	12.09±0.00	46.65±0.21	14.44±0.80	13.55	14.08
Arachidic	0.01±0.00	ND	0.13	Trace	Trace
T-linolenic acid	0.03±0.00	0.15±0.00			
T-linolenic acid	0.39±0.00	0.23±0.00			
Linolenic	54.38±0.42	2.14±0.04	57.11±1.68	59.07	58.762
Heneicosanoic	0.11±0.00	1.02±0.20			
Methyl cis11,14-Eicosadienoic	0.005±0.00	ND			
Behenic	0.02±0.00	0.02±0.00	0.13	Trace	ND
Methyl cis8,11,14,eicosatrienoic	0.19±0.01	0.07±0.00		ND	ND
Erucic	0.19±0.01	ND	0.03	ND	ND
Methyl cis11,14,17-Eicosatrienoic acid	0.03±0.00	ND			
Arachidonic	0.03±0.00	ND		ND	ND
Tricosanoic	0.02±0.00	0.18±0.00			
Methyl cis 13.16-docasadienoic	0.02±0.00	0.03±0.00	0.01	ND	ND
Lignoceric	ND	ND	0.07	Trace	ND
Cis-5.8.11.14.17-Eicosapentaenoic	ND	0.28±0.00			
Methyl cis-15-tetracosenoate	0.11±0.00	0.07±0.00	0.16	0.25	ND
Cis,4,7,10,13,16,19-docosahexanoic	0.04±0.00	0.05±0.00			
Omega 3	54.62±0.03	2.29±0.04			
Omega 6	12.35±0.00	46.75±0.21			
Omega 9	20.52±0.03	35.58±0.30			
SFA	11.89±0.00	13.47±0.14	3.66		
MUFA	20.60±0.02	35.76±0.31	7.52		
PUFA	67.29±0.03	49.20±0.25	28.73		
Oil content	45.2±0.20	10.25±0.04	42.89±0.90	41.1	35.7

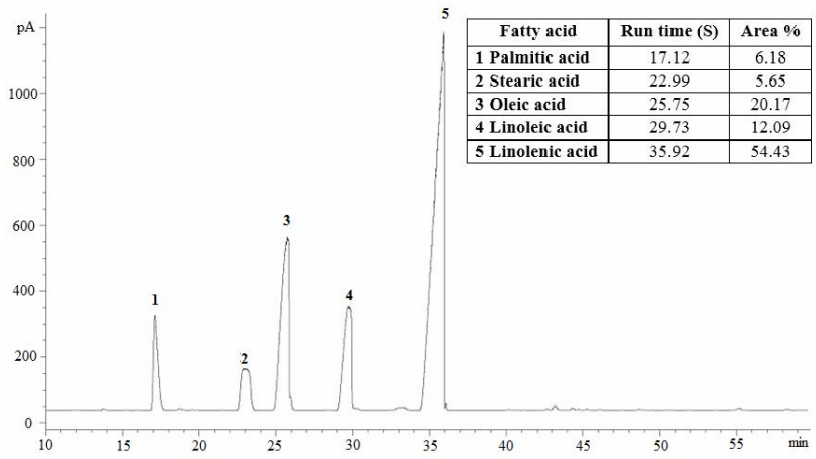
The content of each individual fatty acid ratio is given as a percentage of the corresponding total.
AME=acid methyl ester, USDA=U. S. Department of Agriculture (USDA), ARS= Agricultural Research Service, GRL=Grain Research Laboratory, CL=Commercial Laboratory

Although, previous studies [10,11] did not detect minor FA such as caprilic, lauric, myristic, t-linoleic acid, t-linolenic acid in the Flax seeds, all of them were measurable in this research. It is believed that this depends upon several other factors including air, water, soil, fertilizers used in the farming cultivation, geographic regions altitude, quality of water used for irrigation of flax seed treatment.

The results obtained from this study indicate that reduction in levels of arachidonic and clupanodonic acids resulted in increase of the oleic acid content both in roasted and unroasted and this is in agreement with the findings of Weinberg *et al* [15]. Erucic acid is absorbed in myocardium tissue preferentially but is not metabolized. The levels of erucic acid

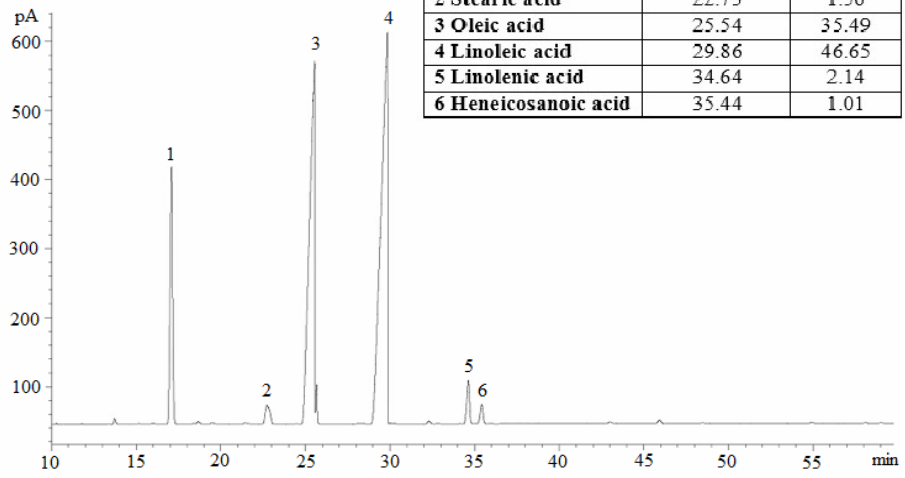
Table 3: The ratio of palmitic, stearic and oleic/linoleic acid, saturated/unsaturated fatty acid in roasted and unroasted Flaxseeds at different temperatures

Fatty Acid ratio	Brown Flax roasted at 150˚C	Brown Flax roasted at 200 ˚C	Brown Flax roasted at 250 ˚C	Brown Flax roasted at 300 ˚C	Brown Flax roasted at 350 ˚C	Unroasted Brown Flax	Unroasted Yellow Flax
P/L	0.52	0.53	0.54	0.55	0.54	0.51	0.25
S/L	0.48	0.45	0.47	0.47	0.50	0.47	0.03
O/L	1.71	1.65	1.70	1.71	1.76	1.67	0.76
SFA/USFA	0.13	0.14	0.14	0.14	0.14	0.13	0.16



Fatty acid	Run time (S)	Area %
1 Palmitic acid	17.12	6.18
2 Stearic acid	22.99	5.65
3 Oleic acid	25.75	20.17
4 Linoleic acid	29.73	12.09
5 Linolenic acid	35.92	54.43

Figure 1: Chromatogram of fatty acids in unroasted brown flaxseed



Fatty acid	Run time (S)	Area %
1 Palmitic acid	17.10	11.74
2 Stearic acid	22.73	1.56
3 Oleic acid	25.54	35.49
4 Linoleic acid	29.86	46.65
5 Linolenic acid	34.64	2.14
6 Heneicosanoic acid	35.44	1.01

Figure 2: Chromatogram of fatty acids in unroasted yellow flaxseed

in foods are limited, in part, over concerns that it may adversely affect heart tissues [16]. The daily intake of erucic acid is restricted (500 mg/day) by Australia Food Standards [16]. It is clear that unroasted flax seed of brown type contains erucic acid (0.19 ± 0.01 %) but this FA is destroyed by upward trends of temperature during the roasting period.

In Choo *et al*'s study, the amount of total USFA in flaxseed was 87 – 91 % while the amount of total SFA ranged from 9 to 12 % [14] which confirms our results (Table 1). Moreover, linolenic is the major FAs in brown type as reported by Daun *et al* [17].

In the present study, the ratio of omega 6 to omega 3 in brown type was 1:5 but for the yellow type, it was 20:1. As has been in some clinical studies [18], omega 6 to omega 3 ratio is critical to maintaining health factors, especially cardiovascular health. However, the necessity of this FA in daily diet has been controversial among researchers, with some recommending a range of 1:1 to 1:4 [19]. In contrast, other researchers believe the ratio of 4:1 is beneficial from the nutritional point of view [20] since metabolites of omega 6 are more inflammatory than those of omega 3. Consequently, results from other studies are similar to those found for brown types of the present study.

CONCLUSION

Flaxseeds are commercially important in production. Consumption of flax (*Linum usitatissimum*) seeds is beneficial to human health. Flaxseeds are one of the richest sources of poly unsaturated fatty acid in human diet and further investigation is required in this regard. The oil content of brown flaxseed is suitable for commercial exploitation for the purpose of optimizing edible oil composition. This is because fatty acid compounds of flaxseed is favorable with low saturated fat content and good USFA/SFA ratios compared to corresponding pulp oils.

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