Lipid Content and Fatty Acid Composition of Some Edible Plants

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(Received 5th September, 2006, revised 27th December, 2006)

Summary: The total lipid contents and the distribution of fatty acids were determined in the leaves, fruits and seeds of eight plant species, collected from different areas of NWFP, Pakistan. Results for total lipid and fatty acid composition are given. The amount of lipid, on fresh weight basis, varied from 0.25 % to 1.14 %. The general order of decreasing lipid potential was seeds > leaves > fruits. Gas chromatographic analysis revealed that principal saturated fatty acid in the species was palmitic (3.14 to 37.71 %). Among the monounsaturated series oleic acid (1.56 to 15.96 %) was highest while linoleic (4.77 to 38.49 %) and alpha-linolenic (5.32 to 44.03 %) acids observed the predominant polyunsaturated fatty acids, but their relative proportions varied. Most of the plant foods discussed in this article contribute significantly to the diets of the populations of NWFP and the nutrient values reported herein represent a contribution to the expanding database of the nutrient contents of the plant foods of this part of Pakistan

Introduction

Food lipid is a red-hot area of research It is considered a key to good and bad blood cholesterol. Its consumption is also connected to the production of mystery cellular agents called prostaglandins and ultimately to averting cancer and heart diseases. There are three types of fats dominant in our food. These are labeled as saturated, monounsaturated and polyunsaturated fats. Given the state of research they could be called good fat, good bad fat and bad fat [1].

Polyunsaturated fatty acids (PUFAs) have been recommended as desirable dietary components since 1950s. The more biologically significant poly-unsaturated fatty acids (PUFAs) include two with 18-carbon chains, linoleic acid (LA; C18: 2 ω6) and alpha-linolenic acid (LNA; C18: 3 ω3), which are considered essential fatty acids (EFAs) [2-3]. There is an increasing interest in ω3 PUFAs because studies have shown that these fatty acids can reduce the risk of heart disease [4-8] and symptoms of arthritis [9-10]. The ω3 PUFAs have also been found to play an important role in the development of brain and retinal tissues in the fetus and infants [11-12]. Actually the ω3 PUFAs force down the level of low-density lipoprotein (LDL) that carry triglycerides and cholesterol into the body tissues and push the level of high-density lipoprotein (HDL), clearing few of the circulatory system, which sweep away fat laden cholesterol or low-density lipoprotein [13-14].

The ensuring wave of awareness of the protective role of omega-3 polyunsaturated fatty acids, (ω3 PUFAs), against the development of cardiovascular diseases has espoused the promotion of fish and other seafood consumption. These ω3 PUFAs may be called as miracle for the people of this modern and mechanized world because they provide a broad range of health benefits, which are not found in any other fat [15]. The beneficial effects attributed to the ω3 fatty acids are believed to be due to their ability to replace arachidonic acid (C20: 4 ω6) in membrane phospholipids (PL), and membranes enriched with eicosapentaenoic acid produce prostaglandin I3, which is equipotent as an antiaggregatory agent as prostacyclin [16]. The amount of arachidonic acid, which replaces eicosapentaenoic acid in the phospholipids (PL) of the membranes, will depend upon the outcome of α-linolenic acid competing with linoleic acid for the enzymes involved in desaturation and elongation. There fore the ratio of dietary α-linolenic to linoleic acid is important [17-18].

Green vegetables consumption has long been considered to have health benefits mainly due to vitamins, minerals and phytonutrients (such as vitamin C, folate, antioxidant etc.) contained in vege-table rich diet. Additionally, green vegetables are known to contain a relatively high proportion of ω3

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polyunsaturated, primarily in the form of α-linolenic acid. The amount of lipids present in the most common vegetables is low, and the fatty acids of these lipids are mainly ω3 and ω6 with 16 and 18 carbons. Consumption of green vegetables thus, could contribute to 18: 3 ω3 and 18: 2 ω6 PUFAs intake, especially for vegetarian population [19]. In view of the cardinal role of dietary fats in human health and diseases, the chemical composition of fats and oils of edible plants have become a research priority of lipid chemistry.

Human populations of the northwestern region of Pakistan depend upon a number of plant foods to satisfy a substantial part of their nutritional requirements. However, the database of the nutrients and chemical composition of these plant foods is incomplete. Further more, as geographical location, climatic conditions and plant cultivars can effect the fatty acid composition, so a study was carried out to evaluate certain edible plants (Table-1) of NWFP, Pakistan with regard to their lipid potential and fatty acid composition.

Results and Discussion

Table-2 shows data on the total lipid and fatty acid composition of plants. The total lipid content in the plants varied from 1.14 % to 0.25 %, the highest value being observed in the *Fagonia cretica* while *Brassica oleracea variety botrytis* (0.25 %) showed the lowest value. The lipid content of the seeds of *Fagonia cretica* (1.14 %) was higher than *Pisum sativum* (0.98 %). Similarly among the green leafy vegetables, *Trigonella foenum-graecum* (0.81 %) was highest in its lipid content. The general order of decreasing lipid content in plants parts was seeds > leaves > fruits. The lipid contents for *Pisum sativum* seeds (0.98 %) and fruit of *Hibiscus esculentus* (0.43 %) were in close agreement to those reported earlier [20-21], where as the lipid content for most of plants in the present study was higher than reported elsewhere [22]. It is remarkable that the total amounts of lipids in these plants studied are higher than most of the edible wild species [23]. The high lipid content of these plants may encourage their use as high fat sources in some food formulations.

The major fatty acids have 16 or 18 carbon atoms with a variable degree of unsaturation. Palmitic (16: 0) acid was the major saturated fatty acid, contributing 18.12 to 37.71 % of the total fatty acids in *Trigonella foenum-graecum* and *Fagonia cretica*, respectively. Leaves of *Mentha longifolia* (18.61 %) and *Trigonella foenum-graecum* (18.12 %)

Table-1: Description of Plants [31-32]

S. No	Botanical Name	Edible parts	Edible/medicinal uses	Parts used for analysis	Area of Collection	Voucher* No
1.	*Brassica oleracea variety botrytis*	Flowers, leaves	Cooked vegetable, salads/ fungicide	Leaves	Peshawar	004321-4
2.	*Fagonia cretica* L.	–	– / Beneficial in the treatment of a number of diseases e.g. liver trouble, opthalmia and toothache, scabies, cooling medicine, fever, snakebite, tumors, etc.	Seeds	Peshawar	004912-5
3.	*Hibiscus esculentus*, L.	Fruit, leaves, roots, seeds	Vegetable, oil, coffee, pectin/antispasmodic, demulcent, diaphoretic, diuretic, emollient, stimulant, vulnerary	Fruits	Kohat	004407-8
4.	*Mentha longifolia* L.	Leaves	Condiment, tea/antiasthmatic, antiseptic, antispasmodic, carminative, stimulant	Leaves	Bannu	004407-7
5.	*Pisum sativum* L.	Leaves, seeds	Vegetable, salads/contraceptive, fungicidal, spermicidal	Seeds	Mansehra	004321-2
6.	*Taraxacum officinale*	Flowers, leaves, roots	Coffee, tea, salad/ aperient, cholagogue, depurative, strongly diuretic, hepatic, laxative, stomachic and tonic	Leaves	Mansehra	004321-1
7.	*Trigonella foenum-graecum* L.	Leaves, seeds, seed pods	Coffee, condiment, tea and as vegetable/ wide range of medicinal applications	Leaves	Mansehra	004321-3
8.	*Vicia faba* L.	Leaves, seeds, unripe pods	Common vegetable/ diuretic and lithontripic	Unripe young pods	Mansehra	004407-6

* Herbarium reference numbers

Table-2: Fatty Acid Composition of Plants

Lipid/ Fatty acids (%)	BOB	FC	HE	ML	PS	TO	TFG	VF
Lipid	0.25	1.14	0.43	0.64	0.98	0.50	0.81	0.37
C10: 0	Nd	Nd	Nd	7.27	Nd	Nd	Nd	Nd
C12: 0	Nd	Nd	0.26	6.42	0.38	0.98	Nd	0.73
C14: 0	0.28	1.60	3.48	Nd	0.47	1.05	Nd	1.67
C16: 0	23.52	37.71	28.02	18.61	18.71	19.60	18.12	25.08
C18: 0	4.28	16.77	6.52	9.98	4.21	12.60	4.99	8.34
C20: 0	1.87	1.21	1.88	Nd	Nd	Nd	1.32	1.40
C22: 0	Nd	0.83	0.59	Nd	Nd	Nd	1.11	Nd
Total saturated acids	30.01	58.12	40.75	42.28	25.75	34.23	25.54	37.22
C16: 1ω9	Nd	Nd	Nd	Nd	Nd	Nd	Nd	2.61
C18: 1ω9	7.61	10.19	3.00	4.99	15.94	1.56	7.79	3.91
C20: 1ω9	Nd	Nd	3.96	3.21	0.32	2.50	0.46	1.72
C22: 1ω13	Nd	Nd	Nd	Nd	1.06	0.91	Nd	0.94
Total monounsaturated acids	7.61	10.19	6.96	8.20	17.32	4.97	8.25	9.18
C18: 2ω6	8.03	21.01	29.50	14.59	38.49	11.23	23.01	7.90
C18: 3ω3	44.03	6.00	8.57	17.61	5.32	26.03	33.88	40.31
Total polyunsaturated acids	52.06	27.01	38.07	32.20	43.81	37.27	56.89	48.21
IFA	89.62	95.32	85.78	82.68	84.90	76.46	90.68	94.61
Moisture (%)	91.65	68.38	88.56	84.65	70.83	87.81	86.98	90.24

BOB = *Brassica oleracea variety botrytis*, FC = *Fagonia cretica* L., HE = *Hibiscus esculentus* L., ML = *Mentha longifolia L.*, PS = *Pisum sativum* L., TFG = *Trigonella foenum-graecum L.*, TO = *Taraxacum officinale*, VF = *Vicia faba* L., IFA = Identified percentage of fatty acids

Nd = Not detected

cretica (16.77 %) and lowest in seeds of *Pisum sativum* (4.21 %). Smaller amounts of long chain eicosanoic (20: 0) and doeicosanoic acids (22: 0), were also detected ranging from an absence to 1.88 and 1.11 % respectively; the highest concentrations of the former were observed in *Hibiscus esculentus* while the latter in *Trigonella foenum-graecum*. The unusually high amounts of short chain fatty acids, Lauric acid (12: 0) and capric acid (10: 0) were observed in *Mentha longifolia* showing values 6.42 % and 7.27 % respectively. Values for most of the fatty acid contents of *Pisum sativum* were by lower orders of magnitude than reported earlier [24] while for *Hibiscus esculentus* higher than reported elsewhere [25]. The percentage of TSFAs was turned out to be the highest in *Fagonia cretica* seeds (58.12 %) while lowest in *Pisum sativum* (25.75 %) and *Trigonella foenum-graecum* (25.54 %).

The distribution of total monounsaturates (MUFAs) ranged from 4.97 % in *Taraxacum officinale* to 17.32 % in *Pisum sativum*. Values for the leaves of *Mentha longifolia* (8.20 %) and *Trigonella foenum-graecum* (8.25 %) were nearly an order of magnitude. The predominant monounsaturated fatty acid was oleic acid. The oleic acid varied between 1.56 % in *Taraxacum officinale* to 15.94 % in *Pisum sativum*. Seeds of both *Fagonia cretica* (10.19 %) and *Pisum sativum* (15.94 %) were higher in oleic acid contents than the leafy vegetables and the fruits of plants. Erucic acid (22:1ω13) was detected only in *Taraxacum officinale* (0.91 %), *Vicia faba* (0.94 %) and *Pisum sativum* (1.06 %). The present data for these plants, however, could not be compared with those in the literature, due to unavailability of literature on leaves [26].

PUFAs having medicinal importance constitute the major fraction of TSFAs. Total PUFAs were found to be highest in *Trigonella foenum-graecum* (56.89 %) while seeds of *Fagonia cretica* (27.01 %) showed the lowest value. Leaves of *Trigonella foenum-graecum* (56.89 %) and *Brassica oleracea variety botrytis* (52.06 %) were also high in PUFAs contents. The amounts of linoleic acid (18: 2ω6) and α-linolenic acid (18: 3ω3) in the plants are noteworthy because both are EFAs to humans and therefore must be obtained through the diet. Significant differences were observed in the EFAs contents of plants. The linoleic acid content ranged from 7.90 % in *Vicia faba* to 38.49 % in the seeds of *Pisum sativum*. With regard to linolenic acid, *Brassica oleracea variety botrytis* had the highest amount (44.03 %) while seeds of *Pisum sativum* (5.32 %) showed the lowest value. Seeds were much low in their linolenic acid contents than the leaves and the fruits of plants. The linoleic and linolenic acid contents determined in *Brassica oleracea variety botrytis* and *Mentha longifolia* were lower than reported in the literature [19]. Low linoleic acid (11.23 %) and high linolenic acid (26.03 %) contents in *Taraxacum officinale* were observed compared to

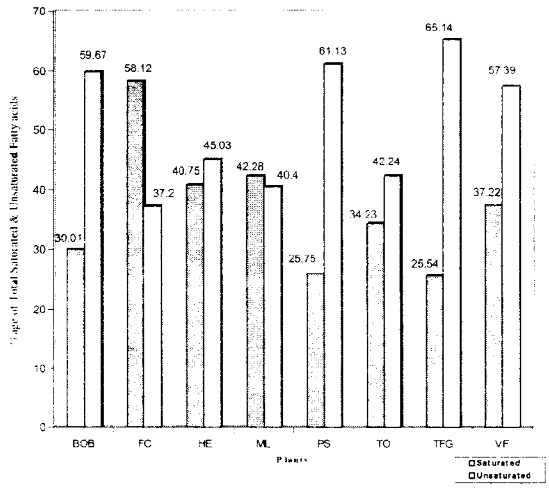

Fig. 1: Comparison of Total Saturated and Unsaturated Fatty Acid Contents of Plants.

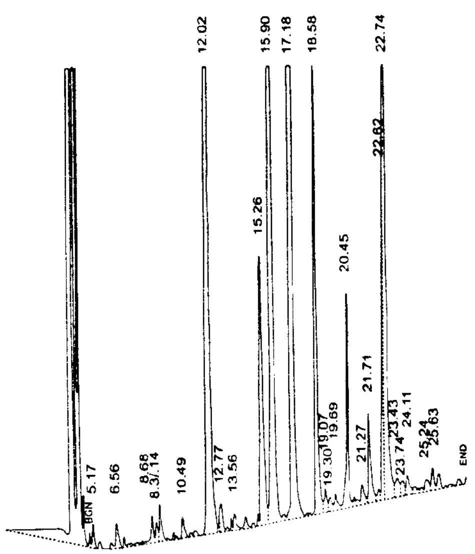

Fig. 2: GC Signature of *Pisum sativum* (seeds).

the previous study [27]. The optimal dietary intake of α-linolenic acid seemed to be about 2g per day or 0.6 to 1 % of total energy intake. The high contents of linoleic and or linolenic acids in most of these plants demonstrated their good nutritional qualities.

The fatty acid profile of all the species, with the exception of *Fagonia* seeds, contains a higher percent-age of unsaturated fatty acids, which is the main characteristic of a good quality vegetable fat. This makes them more suitable for edible purposes. The percentage of lauric acid in the plants except *Mentha longifolia*, is less, thereby minimizing chances of cholesterol rise. In the plants species, the stearic acid is found in such amount, which generates no adverse effect on blood lipids and lipoproteins [28]. Oleic acid is present in good amount in *Pisum sativum, Fagonia cretica, Trigonella foenum-graecum* and *Brassica oleracea variety botrytis,* which lowers LDL while maintaining HDL and is also helpful in the synthesis of EFAs [17-18]. Low level of linoleic acid in most of these, coupled with high level of linolenic acid is sufficient to suppress triglycerides accumulation in skeletal muscles and potentially in cardio myocytes and β-cells [29]. The presence of high amount of erucic acid, present in many plants, possesses the main problem for edible purposes. Various regulations restrict the erucic acid content up to 10 % at the most. High erucic acid content is beneficial for polymer industry, whereas low erucic acid is recommended for the dietary purposes. Therefore, it is important to undertake systematic characterization of the available gene pool for its variable fatty acid profile to be utilized for specific purposes [30]. Results demonstrate that the level of this acid does not make the consumption of these plants risky.

The present work discussed together with literature data verifies that lipid contents and fatty acids distribution, in most of the cases, were different than the previously reported work. Variations in climate, soil, agronomic practices, plant cultivars, rainfall and possibly temperature are the probable causes of differences in nutrient levels and indicate the need of locally prepared food composition tables. The data contained in the present report provides an evidence of the potential nutritional value of the indigenous plants of the NWFP region of Pakistan. The data will be informative and helpful in estimating the total intake of lipid and fatty acids in these species from Pakistan.

Experimental

Collection and Pre-Treatment of Plant Samples

A total of eight plant species, Table-1 [31-32] were collected from different areas of NWFP, Pakistan. Standard botanical field collection methodology was used for the collection of plant samples [33]. Specific samples were obtained with the aid of interpreters and field guides. Multiple specimens of each type were collected. Genus and species were confirmed by comparison with herbarium reference materials deposited at Department of Botany, University of Peshawar, Pakistan. Voucher numbers of plants specimens are given in Table-1. Before analysis, the samples were inspected for non-plant materials and any visible dirt and insect parts were removed. A sample composite of each specimen was analyzed so that all results are expressed on the basis of fresh weight.

Extraction of Lipid

One batch of each sample was extracted with chloroform/ methanol (2: 1, v/ v) and depigmented as described elsewhere [34-35]. The solid, non-lipid material was removed by filtration and after the removal of solvent on rotary evaporator, the total weight of the extracted lipid was determined gravimetrically.

Gas Chromatography of Fatty Acids

The lipid was saponified [36] followed by the hydrolysis with hydrochloric acid, to liberate the fatty acids. The fatty acids were transformed into their methyl esters [37]. The fatty acids methyl esters (FAMEs) were analyzed with a Perkin Elmer gas chromatograph, model 8700, fitted with SP-2340 methyl lignoserate-coated (0.20 μm film thickness), capillary column (60 m x 0.25 mm) and flame ionization detector. Other conditions were as follows: (1) initial oven temperature, 130 °C; (2) ramp rate (increasing temperature rate) 10 °C / min; (3) final temperature, 220 °C; (4) injector temperature, 260 °C; (5) detector temperature, 270 °C; and (6) temperature hold, 5 min before and 10 min after the run. A 1-2 μL-sample volume was injected. The nitrogen with a flow rate of 3.5 mL/ minute was used as a mobile phase. Electronic pressure control was set in the constant flow mode. Fatty acids were identified by comparing their relative and absolute retention times with those of authentic standards for FAMEs obtained from Sigma Chemical Co. Quantification was done by a built-in data-handling program provided by the manufacturer of the gas chromatograph (Perkin Elmer). The data was transferred on an Epson LX-800 printer attached to the instrument through an RS-232-C port. FA composition was reported as a relative percentage of the total peak area. Fatty acid peaks were identified and quantified by comparison of their retention times with those of reference standards.

Acknowledgements

The authors are grateful to Mr. Naveed Akhtar and Mr. Zahir Muhammad, Department of Botany, University of Peshawar, for their valuable help in the collection and identification of plant samples.

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