Mongolian Journal of Chemistry 14 (40), 2013, p2-3

Mongolian Academy of Sciences

Mongolian Journal of Chemistry

The Institute of Chemistry & Chemical Technology

Physical and chemical characteristics and fatty acids composition of seeds oil isolated from *Camelina sativa* (L) cultivated in Mongolia

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ARTICLE INFO: Received 01 November 2013; revised 13 december 2013; accepted 13 December 2013

Abstract: *Camelina sativa* L is a cruciferous oilseed plant. This plant is cultivated as an oilseed crop mainly in Europe and in North America and over the past years the cultivation has arranged in our country. The analyzed oil is obtained from the seeds of *Camelina sativa* L, growing in Bornuur, Tuv province. The goal of this study was to determine the physical and chemical characteristics and fatty acids composition of *Camelina sativa* L seed oil cultivated in Mongolia. According to our analysis total lipid was determined 38.52 %, moisture 4.80 % and total mineral elements 4.02 %, respectively. Mineral elements in *Camelina sativa* L seeds contain calcium (0.56 %), phosphorous (1.22 %), potassium (1.39 %), magnesium (0.53 %) in dominated amounts; iron, zinc, manganese and copper in trace amounts. Eight nonessential amino acids in seeds of this plant with total amount of 75.9 % were identified; phenylalanine was detected in highest amount among the all identified amino acids, while lysine, tryptophan and arginine are followed.

The following characteristics in *Camelina sativa* seeds oil were determined. The refractive index was 1.4774 at 20 ^{0}C, the peroxide value of fresh oil was 0.03 meq H_2O_2 /kg, saponification value 185.8 mg KOH/g, iodine value 143.33 g J_2 and acidic value 6.27 mg KOH /g. Carotenoid was determined as 16.77 mg %, by spectrometry in *Camelina sativa* seeds oil. The analysis of fatty acids composition showed that there are 12.5 % saturated and 87.5 % unsaturated fatty acids. In particular, oleic acid (C18:1) 14.0 %, linoleic acid (C18:2) 9.0 %, α-linolenic acid (C18:3) 10.5 % and gondoic acid (C20:1) 32.8 %, were composed the major part of unsaturated fatty acids.

Keywords: Camelina sativa L, seed oil composition, fatty acids, acidic value, peroxide value, iodine value

INTRODUCTION

There is no doubt that the value of traditional edible oils will increase due to the growth of population all over the world, resulting in an increase in the demand for oil. Nowadays the people are seeking for healthy food. Various species of beneficial plants are being cultivated in our country every year.

Fat is a nutritious component of food and it provides not only calories for the human body but also further helps for a tissue recovery, regulates the metabolism, takes in different biological processes. Fat is 30-35% of the total calorie intake of a person in one day [1].

The source of fat is classified into animal and vegetable oil. Animal fat is rich resource of saturated fatty acids which has negative effects on the human body such as increased cholesterol and high risk for certain diseases. In contrast to that, vegetable oil, which is rich resource of many kinds of unsaturated fatty acids, prevents from heart and vascular diseases, brain and articulation diseases. *Camelina sativa* L is cultivated in Canada, France, Belgium, Holland, Russia, Australia and Poland. This plant is used to obtain raw oil material for the food, cosmetic, medicine and biofuel industries. *Camelina sativa* L with popular names “false flax” or “gold pleasure” is a cruciferous oilseed plant. This plant oil was ever studied in many countries. Seeds contain 38 to 43% oil and 27 to 32% protein, respectively. Over 50% of the fatty acids in cold pressed Camelina oil are polyunsaturated [2]. The vitamin E in Camelina oil is approximately 110 mg/100 g. It is well suited for use as cooking oil [3].

Sunflower, canola, mustard, soybean plant are cultivated in our country. However, oil from these plants cannot be used in industry, due to small cultivation.We have studied a new source of oil from *Camelina sativa* seeds that has cultivated in our country.

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EXPERIMENTAL

Plant materials and oil sample: The camelina oil used in this study was obtained from seeds of *Camelina sativa* L cultivated in Bornuur, Tuv province. The seed sample was collected in September, 2011.

Methods: Moisture and ash was determined by gravimetric method. Moisture was determined by drying at 105^0C for 3 hours and ash content was determined by incinerating in a muffle furnace at 550^0C [4]. Composition of ash was measured by the X-ray fluorescence. The concentration of mineral element was determined by using HORIBA X-ray Fluorescence analyzer MESA-500W (at the Laboratory of Chemical Analysis, school of material and technology, MUST)

Amino acid composition: Amino acids were determined by the quantitative paper chromatographic method with following spectrophotometry using standard amino acids [5].

Extraction of oil from seeds: 100 g of dried seeds, ground to fine powder in a grinder. Then, 15 g of the powder were extracted with organic solvent *n*-hexane using a Soxhlet (capacity of 250 ml) apparatus for 8 h (60^0C) in 3 replications. The oil yield was expressed in percentage of the extracted oil to the sample weight (w/w). The samples were analyzed in triplicate: the standard deviations were calculated. The oil obtained was stored at 4^0C for further investigation [6].

Determination of fatty acids composition: The fatty acid composition was determined according to the method of International Organization of Standards (ISO) draft standard [7]. One drop of the oil was dissolved in 1 ml of *n*-heptane in a tube, 50 µl 2 M sodium methanolate in methanol was added, and the closed tube was agitated vigorously for 1 min. After addition of 100 µl of water, the tube was centrifuged at 4000 rpm for 10 min and the lower aqueous phase was removed. Fifty microliter of 1 M hydrochloric acid was added to the *n*-heptane phase, mixed for a short time. The lower aqueous phase was rejected. About 20 mg of sodium hydro sulfate monohydrate, (extra pure, Merck, Darmstadt, Germany) was added. After centrifugation at 4000 rpm for 10 min *n*-heptane phase at the top transferred to a vial and injected into a Varian 5890 gas chromatography with capillary column, CP- Sil 88, (100 m long, 0.25 mm ID, film thickness 0.2 µm). The temperature program was: from 155^0C heated to 22^0C (1.5 ^{0}C/min), 10 min isotherm: injector 250^0C, detector 250^0C, split ratio 1:50, detector gas 30 ml/min hydrogen: 300 ml/min air and carrier gas: 30 ml/min nitrogen, manual injection, volume less than 1 µl. The integration software computed the peak areas and percentages of fatty acid methyl esters (FAME) were obtained as weight percent by direct internal normalization.

RESULTS AND DISCUSSION

Some biochemical characteristics of *Camelina sativa* L seeds are shown in table 1.

Table 1. Analysis of *Camelina sativa* L seeds

№	Characteristics	Camelina sativa L seeds	
		Content	Anusha S., et al. [8]
1	Moisture, %	4.8	8
2	Mineral elements, %	4.02	6.6
3	Oil yield, %	38.52	30-40

As seen in the table, the results of our analysis are almost similar to Anusha S., *et al*. There are 12 mineral elements in seeds of *Camelina sativa* L (Table 2). The species examined contained appreciable concentrations of potassium, phosphorous, calcium and magnesium suggesting that seeds of *Camelina sativa* L could be used as good sources of minerals.

Table 2. Micro- and macro-elements in *Camelina sativa* L seeds

№	Elements	Camelina sativa L	
		in 100g ash,%	in 100g dry seeds, %
1	Ca	13.83	0.56
2	K	34.62	1.39
3	P	30.31	1.22
4	Mg	13.18	0.53
5	Na	5.09	0.20
6	S	1.06	0.04
7	Al	0.95	0.04
8	Fe	0.55	0.02
9	Zn	0.21	0.008
10	Mn	0.14	0.005
11	Cu	0.03	0.001
12	Si	0.01	0.0004

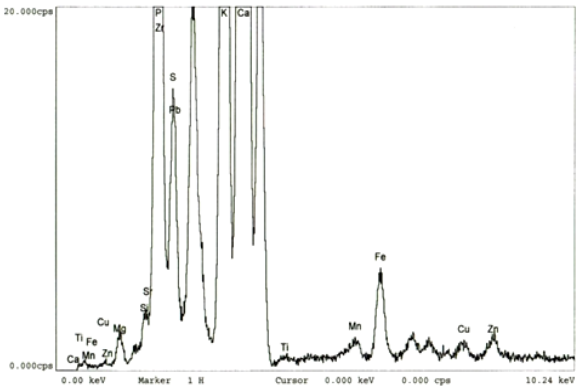

Fig. 1. Seeds oil X-ray fluorescence spectrum of *Camelina sativa* L

Potassium was observed to dominate than others. Whereas zinc, manganese, copper, and silicon were found in trace amounts. Potassium is crucial to heart function and plays a key role in skeletal and smooth muscle contraction, making it important for normal digestive and muscular function [9]. The content of free and protein amino acids were determined by the paper chromatographic method, results are shown in Table 3.

There were determined 6 essential amino acids and 8 nonessential amino acids, which are 24 % and 76 % of total detected amino acids, respectively. Alanine, aspartic acid and glutamic acid were dominated in essential amino acids, whereas phehylalanine, lysine and tryptophan were dominated in nonessential amino acids. Nonessential amino acid content being high is of significance and it is not a common feature in other plants.

Table 3. Amino acids in *Camelina sativa* L seeds

	Amino acids	Estimated in 100 g protein,%
Essential amino acids	Cystine + Cysteine	0.85
	Clycine	2.46
	Alanine	7.04
	Aspartic acid	5.72
	Glutamic acid	5.64
	Serine	2.28
	Total	24.0
Nonessential amino acids	Lysine	23.6
	Leucine	5.73
	Methionine	0.17
	Phenylalanine	25.59
	Tryptophan	8.53
	Valine	0.26
	Arginine	7.69
	Histidine	4.32
	Total	76.0

The quality of oil from seeds of *Camelina sativa* was evaluated by its chemical characteristics, which are shown in Table 4. Our study of acidic value and iodine value was higher than previous study [8]. Usually iodine value is depended on the content of unsaturated fatty acids. The saponification value for *Camelina sativa* seeds oil was 185.18mg KOH/g, which indicates that this oil contains fatty acids with lower average moleculer weight chain lengths. Peroxide value was 0.03 mg-eq H_2O_2/kg, which indicates that this oil is not oxidized. Considering acidic, saponification, peroxide, iodine and esterfication values it can be believed that *Camelina sativa* seeds oil has a good quality and a good source of unsaturated fatty acids.

Table 4. Quantitative characteristics of *Camelina sativa* L seeds oil

Characteristics	Camelina sativa L	
	Our study	Anusha, S, et al. [9]
Refractive index (n_d^{20})	1.4774	1.4773
Acidic value (mg KOH/g)	6.27	2.35
Saponification value (mg KOH/g)	185.18	187.8
Peroxide value (mg-eq H_2O_2/kg)	0.03	-
Esterfication value (mg/g)	178.91	185.45
Iodine value (J_2 %)	143.33	104.7
Carotenoid (mg %)	16.77	-

The gas chromatography results indicated that 18 fatty acids observed in *Camelina sativa* seeds oil. Saturated fatty acids particular, palmitic acid (C16:0), stearic acid (C18:0) and arachidonic acid (C20:0) while, oleic acid (C18:1), linoleic acid (C18:2), gondoic acid (C20:1) and linolenic acid (C18:3) are the major unsaturated fatty acids in oil of *Camelina sativa* L.

Especially, gas chromatography analysis of fatty acids composition showed that gondoic acid is dominated in unsaturated fatty acids.

Table 5. Content of fatty acids in *Camelina sativa* oil

Fatty acids	Camelina sativa L.
Saturated fatty acids, %	
Myristic acid (14:0)	0.10
Palmitic acid (16:0)	5.11
Margaric acid (17:0)	<0.10
Stearic acid (18:0)	2.32
Arachidic acid (20:0)	2.06
Behenic acid (22:0)	0.42
Lignoceric acid (C24:0)	0.17
Monounsaturated fatty acids, %	
Palmitoleic acid (16:1)	0.10
Oleic acid (18:1)	14.0
Gondoic acid (20:1)	32.8
Erucic acid (22:1)	1.31
Nervonic acid (C24:1)	1.04
Polyunsaturated fatty acids,%	
Linoleic acid (18:2n ω6)	19.0
Linolenic acid (18:3)	1.46
α-Linolenic acid C18:3n ω3)	10.5
Eicosadienoic acid (20:2)	1.71
Eicosatrienoic acid (20:3 ω3)	2.41
Docosadienoic acid (C22:2)	0.14
Unsaturated fatty acids	**87.5**
Saturated fatty acids	**12.5**

Gondoic acid is a monounsaturated omega-9 fatty acid found in a variety of plant oils and nuts. It is the main acid component of jojoba oil [10]. The percentage of total polyunsaturated fatty acids in *Camelina sativa* seeds oil was about 87.5%. Thus, it could be concluded that *Camelina sativa* seeds oil is a good source of mono and polyunsaturated fatty acids.

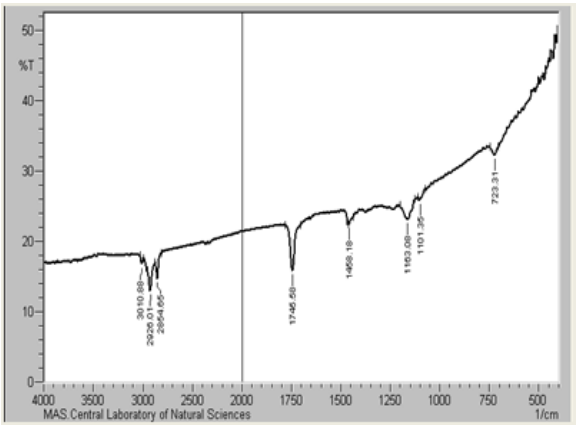

Fig. 2. Infrared spectra of *Camelina sativa* seeds oil

Figure 2 shows the infrared spectrum of the *Camelina sativa* oil. Among the absorption bands common to spectra are the band at 2950-3000 cm^{-1} C-C-H (sp^3) stretching vibration and 1730-1750 cm^{-1} C=O streching vibration of ester group, 1465 cm^{-1} -CH_2- (σ) stretching vibration, 665-730 $^{1-}RCH=CHR^1$ (cis). This explanation of spectrogram shows the at all unsaturated fatty acids situated in cis-stereoisomer in *Camelina sativa* oil.

CONCLUSIONS

Camelina sativa L is a new crop, cultivated in Mongolia, with a variety of uses. This plant species is relatively easy to breed, and easy to grow with low input costs. It flourished and adjusted well to the Mongolian environment and climate. The yield of seed oil and in its high content of nonessential fatty acids indicate that *Camelina sativa* L seeds can be a new source for food oil, and fuel (biodiesel) in a technical field.

The oil is a rich source of α-linolenic acid (19.0%). *Camelina sativa* L oil contains 32.8% of gondoic acid (20:1), which is absent in the most common vegetable oils and 1.31% of erucic acid (22:1), which determines the applicability of oil for human consumption, but in our oil it was well below the permitted value of 5% and also significantly lower than the values reported by others.

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