Journal of Food Chemistry & Nanotechnology

http://dx.doi.org/10.17756/jfcn.2016-013

Short Communication

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Oil, Protein, Chlorophyll, Cadmium and Lead Contents of Seeds in Oil and Fiber Flax (*Linum usitatissimum* L.) Cultivars and in Oil Hemp (*Cannabis sativa* L.) Cultivar Finola Cultivated in South-Western Part of Finland

Marketta Saastamoinen[1*], Merja Eurola[2] and Veli Hietaniemi[3]

[1]*Satafood Development Association, Viialankatu 25, FI-32700 Huittinen, Finland*
[2]*Merja Eurola, Natural Resources Institute Finland, Management and Production of Renewable Resources, FI-31600 Jokioinen, Finland*
[3]*Natural Resources Institute Finland, Bio-based business and industry, FI-31600 Jokioinen, Finland*

[*]Correspondence to:
Marketta Saastamoinen
Satafood Development Association
Viialankatu 25, FI-32700 Huittinen, Finland
E-mail: marke.saastamoinen@gmail.com

Received: February 03, 2016
Accepted: April 06, 2016
Published: April 08, 2016

Citation: Saastamoinen M, Eurola M, Hietaniemi V. 2016. Oil, Protein, Chlorophyll, Cadmium and Lead Contents of Seeds in Oil and Fiber Flax (*Linum usitatissimum* L.) Cultivars and in Oil Hemp (*Cannabis sativa* L.) Cultivar Finola Cultivated in South-Western Part of Finland. *J Food Chem Nanotechnol* 2(2): 73-76.

Published by United Scientific Group

Abstract

Chemical composition of seeds of two minor oil crops, flax (*Linum usitatissimum* L.) and oil hemp (*Cannabis sativa* L.) cultivated in Finland were analyzed and compared to others. Oilseed flax cultivars were Abacus, Aries, Comtess, Heljä, Helmi, Laser, Sunrise, and Taurus, three fiber flax cultivars were Belinka, Martta and Snaigiai. Oil hemp cultivar was Finola, a Finnish cultivar with low cannabinoids content. Oil content was higher in oil flax cultivars (42.2-48.8 mg 100 g^{-1}) than in fiber flax (34.8-42.2 mg 100 g^{-1}) and oil hemp (34.6 mg 100 g^{-1}) cultivars. Protein contents were lower in high oil flax cultivars than in fiber flax cultivars. Very great difference between the species was in chlorophyll content, which was much higher in oil hemp (138.3 mg kg^{-1}) than in oilseed (0-6.8 mg kg^{-1}) or fiber flax (5.9-11.0 mg kg^{-1}) cultivars. Oil hemp is so late in Finland that all seeds do not ripen well. Cadmium contents of oilseed (0.390-0.797 mg kg^{-1}) and fiber flax (0.497-0.600 mg kg^{-1}) cultivars were much higher than those of oil hemp (0.020 mg kg^{-1}). Oil hemp cultivar Finola did not accumulate cadmium from the soil. Lead contents were low.

Keywords

Oil, Protein, Chlorophyll content, Cadmium, Lead, Flax, Oil hemp

Introduction

Flax (*Linum usitatissimum* L.) and hemp (*Cannabis sativa* L.) are very variable plants. Flax and hemp are food and feed plants, which produce both food or feed and fiber. Flax oil can be used as technical purposes, too, e.g. in production of oil colors, and linoleum floors. Both plant species include fiber and oil cultivars, those yield is used as food or feed. *Cannabis sativa* L. includes oil cultivars, which have very low content of cannabinoids. Eighty five different cannabinoids have been found from *Cannabis sativa* [1]. The psychoactive cannabinoid is tetrahydrocannabinol (THC) ((6aR, 10aR)-delta-9-tetrahydrocannabinol) [2, 3]. Its content in yield of hemp must not exceed 0.2% (2 mg kg^{-1}) in EU countries [4]. There are no common limits for different food and feed products in EU countries, but they are differing in different countries.

Oilseed flax and oil hemp are currently cultivated in Finland. Oilseed flax and oil hemp are minor oil crops in Finland. Oilseed flax is cultivated 1000-2000 ha yearly, and oil hemp even less. The average yield of oilseed flax in Finland is about 1000 kg ha^{-1}. The seed yield of oil hemp is about 700-1000 kg ha^{-1} in Finland. There is one oil hemp cultivar, Finola with low THC content in Finland. The production of fiber flax and hemp cultivars is small as the textile industry is uneconomical and fiber production must compete with forest fiber production. Cellulose nanofiber

is prepared by chemical treatments and separation techniques from flax and hemp composites [5].

Oilseed flax and hemp oil are used as food and feed as special purposes for their beneficial effects on health. They contain high linoleic and linolenic acid contents. Linolenic acid content of oilseed flax oil is higher, 53% [6], than that of hempseed oil [7]. Hempseed oil contains also gamma-linolenic acid 4% in the oil [8]. The yield of gamma linolenic acid has been 3-30 kg ha^{-1} for different genotypes of oil hemp being at the same level as in borage (*Borago officinalis* L.) (19-30 kg ha^{-1}) and evening primrose (*Oenothera biennis* L. Scop.) (7-30 kg ha^{-1}) [9], which are cultivated for gamma linolenic acid. Hempseed oil has been as effective as oilseed flax oil in lowering serum cholesterol [10]. It has been found, that conjugated linoleic acid content of cow milk is increased by a diet containing 2.2 and 4.4% flax oil [11]. Protein content and quality of oilseed flax and oil hemp are good. Seed chemical quality of oilseed flax and oil hemp is good, but both species are able to accumulate cadmium from the soil [12, 13].

Material and Methods

Material consisted of farm and trial seed samples of oilseed and fiber flax as described previously [14] added by two flax trials from the year 2011 and farm samples oil hemp from the same area of south-western part of Finland from the years 2005 and 2007-11. Oil hemp samples were Finola cultivar which is the only oil hemp cultivar cultivated in Finland. Oil, protein, cadmium and lead contents were analyzed as described previously [14]. Chlorophyll contents were analyzed according the official methods used in Finland [15]. Dried and cooled seeds (5 g) are weighed to metal tubes and crushed and dissolved in a mixture of gasoline 80/100 (750 mL) and absolute ethanol (250 mL) 50 min by 200 per min, centrifuged 10 min 3000 r per min. Supernatant is measured by spectrophotometer beginning at 655 nm, searching the maximum wave length. If the absorbance (A) at 670 nm is over 0.7, supernatant is diluted to 1.75 mL dilution mixture. Dilution is taken into consideration in calculation. Chlorophyll content in oil (mg kg^{-1}) is calculated by the following equations:

- $A_{diff} = (A_{667\ nm} - (A_{627\ nm} + A_{707\ nm}))/2.$
- Chlorophyll, mg kg^{-1} = (A_{diff} x 0.933 x 15)/(0.1016 x 1 x g),

Statistical analyses were calculated by Statistica program.

Results and Discussion

Oil contents in oilseed flax cultivars (42.2-48.8 g 100 g^{-1}) were higher than those in fiber flax cultivars (34.8-42.2 g 100 g^{-1}) (Table 1) and in oil hemp cultivar Finola (34.6 g 100 g^{-1}) (Table 2). Oilseed and fiber flax cultivars differed significantly in their oil contents. Callaway [8] has reported 35.5% oil content in Finola oil hemp. Bayrak et al. [16] have reported 23.3-40.4% oil content in *Linum usitatissimum* genotypes. Finola hemp seed oil contains palmitic (6.0%), stearic (2.4%), oleic (8.6%), linoleic (54.2%), alpha-linolenic acid (21.7%) and also 3.9% of gamma-linolenic and 1.9% stearidonic acid

Table 1: Oil, protein, chlorophyll, cadmium and lead contents from dry matter of seeds of oil and fiber flax cultivars in 2007-11.

Type of variety	Cultivar	Number of samples	Oil content (g 100 g^{-1})		Protein content (g 100 g^{-1})		Chlorophyll content (mg kg^{-1})		Number of samples	Cadmium content[1] (mg kg^{-1})		Lead content[1] (mg kg^{-1})	
		n	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	n	Mean	Std. Dev.	Mean	Std. Dev.
Oil	Helmi	10	42.2	1.66	23.8	2.15	2.92	2.40	9	0.797	0.42	0.031	0.02
	Heljä	5	44.2	3.16	24.1	2.91	2.06	1.42	3	0.523	0.08	0.012	0.01
	Laser	16	45.6	2.14	21.8	1.85	3.30	1.42	13	0.414	0.11	0.039	0.02
	Taurus	4	44.6	6.81	23.1	1.90	5.05	3.41	2	0.400	0.00	0.013	0.00
	Sunsrise	3	46.1	4.04	22.7	2.69	2.30	2.52	2	0.460	0.11	0.015	0.00
	Abacus	1	48.8		19.4		0.00		1	0.460		0.010	
	Aries	3	44.2	9.19	22.7	3.61	6.00	4.24	1	0.390		0.021	
	Comtess	2	44.3	6.36	24.1	2.33	6.75	4.60	1	0.390		0.021	
Fibre	Martta	3	37.8	4.33	27.0	2.82	6.17	1.26	2	0.600	0.04	0.016	0.01
	Belinka	3	34.8	6.81	26.2	1.06	5.93	5.25	3	0.497	0.12	0.010	0.00
	Snaigiai	1	42.2		27.9		11.00						
F-test between varieties													
F-value			6.272***		2.4855*		1.28			1.66		1.48	
p-value			0.0000		0.0272		0.2761			0.1492		0.2045	
df effect			10		10		10			9		9	
df error			40		29		39			27		27	

Significance: *p<0.05, ***p<0.001

[1] = Results from the years 2007-10 [14]

[7]. *Linum* seed oil contains 7-9% palmitic, 4-6% stearic, 18-44% oleic, 14-28 linoleic and 19-53% alpha-linolenic acid [17-19]. High linoleic and low linolenic acid contents are found only in mutant genotypes of *Linum usitatissimum* [18]. Linoleic and linolenic acids are essential fatty acids for human beings, and gamma-linolenic acid is also an essential fatty acid [20]. Gamma-linolenic acid has many beneficial effects on health, e.g. decreasing the effects of atopic dermatitis [21]. Stearidonic acid has a role in synthesis of prostaglandins [7]. Hemp oil with exceptional and rare fatty acid composition is very beneficial oil for health of humans.

Oil of oil hemp contained high chlorophyll content (138 mg kg^{-1}) (Table 2) compared to oilseed (0-6.75 mg kg^{-1}) and fiber flax varieties (5.9-11.0 mg kg^{-1}) Finland (Table 1). High chlorophyll content is caused by unripe green seeds containing chlorophyll. Chlorophyll content is an indication of maturity of seeds. It is important in areas where summer is short and cool. High chlorophyll content is not liked by food industry, because it colors the oil and limits the usage of oil in food industry. Food industry in Finland uses the value of 20-30 mg kg^{-1} for chlorophyll content of oil, the higher values cause decrease in price. Hemp oil cannot be used as food oil in normal food processes, but it has special uses as healthy product for its beneficial and exceptional fatty acid composition. In rapeseeds (*Brassica napus* L.) chlorophyll content is lower by early sowing, higher seeding rate and lower branching of the crop [22]. Chlorophyll can be precipitated and removed from edible oils e.g. by 2400 mg L^{-1} phosphoric acid at 120 °C [23].

Table 2: Chemical composition from dry matter of seeds of oil hemp cultivated in south-western part of Finland in 2005, 2007-11.

Cultivar		Oil contents (g 100 g^{-1})	Protein contents (g 100 g^{-1})	Chlorophyll contents (mg kg^{-1})	Cadmium contents (mg kg^{-1})	Lead contents (mg kg^{-1})
Finola	Mean	34.6	25.7	138.3	0.020	0.019
	Std. Dev.	1.39	1.4	31.9		
	Number of fields/ samples	6	6	4	2	2

Oilseed and fiber flax cultivars differed significantly in protein contents. Protein contents were higher in fiber flax cultivars (26.2-27.9 g 100 g^{-1}) than in oilseed flax cultivars (19.4-24.1 g 100 g^{-1}) (Table 1). Protein content of oil hemp Finola was at the same level (25.7 g 100 g^{-1}) as those of fiber flax cultivars (Table 2). Malhi et al. [24] have studied N uptake and protein content in 4 flax cultivars in 3 years in Saskatchewan in Canada. It seems that protein content is very much genotype dependent.

Cadmium contents were much lower in oil hemp cultivar Finola compared to oilseed and fiber flax cultivars (Table 1 and 2). Flax seeds accumulate cadmium. It was found that low pH of soil accumulates cadmium to flax seeds [14]. Cadmium contents of oil hemp were at the same level as found by Korkmaz et al. [25] in Western Turkey (5-23 µg kg^{-1}). Many researchers have found that hemp is accumulating cadmium from the soil and hemp is thought to be a possible crop for phytoremediation in heavy metals polluted areas [13, 26-28]. Linger et al. [13] have found that the leaves accumulate more cadmium that seeds or fiber in hemp. Shi et al. [28] have found differences in cadmium accumulation capacity in hemp genotypes. Mihoc et al. [29] have studied cadmium contents of seeds of 5 oil hemp varieties in Romania and found high cadmium contents in them (means 1.9-3.4 mg kg^{-1}), the values being higher than the cadmium contents found in flax and hemp samples in Finland (Table 1 and 2). Lead contents were low in flax and hemp samples (Table 1 and 2). According to the present results Finola hemp cultivar seems to be rather safe as food plant cultivated in Finland.

Conclusions

Oil, protein, chlorophyll, cadmium and lead contents were studied in seed yields of oil and fiber flax cultivars and in oil hemp cultivar Finola in south-western part of Finland. Chlorophyll content of hemp oil was high for the late maturity. Cadmium contents in oil and fiber flax were high, and in oil hemp Finola very low. Finola oil hemp seems to be safe as food plant as cultivated in Finland.

Acknowledgements

This research was financed by the Rural Development Programme for Mainland Finland of EU. We thank Satakunta and Pirkanmaa Centers of Economic Development, Transport and the Environment for their financial support and participating farmers and research units.

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