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ANTIOXIDANT PROPERTIES OF *CAMELINA SATIVA* OIL AND PRESS-CAKES

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Camelina sativa *is well known due to high content of polyunsaturated fatty acids in its oil. Till now this oil has been studied mainly for applications as raw material for synthesis of resins, biodiesel and hydrocarbon fuels. This study examines the oxidative stability of cold-pressed* Camelina sativa *(also known as camelina, false flax or gold-of-pleasure) oil and its extracts of spices. Despite the high content of polyunsaturated fatty acids,* Camelina sativa *oil appeared more rigid against oxidation than rapeseed or flax oil. Extracts of different spices were prepared by maceration in camelina oil at room temperature for 24 h. The stability of extracts was determined under accelerated oxidation conditions and monitored by peroxide values. Most of the tested additives (e.g., bay leaves, allspice, clove, barley sprouts, coriander, ginger) did not influence or even decreased oxidative stability of the oil. However, oil with thyme additive demonstrated remarkably higher stability then* Camelina sativa *oil alone. Press-cakes of camelina seeds were extracted with two polar solvents (ethanol or water) and their mixtures under variable conditions (room temperature or reflux). Prepared polar extracts of press-cakes were characterised by total polyphenol content (Folin–Ciocalteu method) and antiradical activity against 1,1-diphenyl-2-picryl hydrazyl and galvinoxyl.*

Key words: Camelina sativa*, oil, press-cake, total polyphenol content, antiradical activity, antioxidant activity.*

INTRODUCTION

Camelina sativa (in Latvian: sējas idra; in English: gold-of-pleasure; in German: Saat-Leindotter) is historically known as an oil seed crop in Europe and North America countries. However, the renaissance of this oil happened in the last decade, which can be characterised by the huge amount of studies devoted to false flax. Various applications of camelina oil have been demonstrated, e.g., as a fuel for diesel transport engines (Bernardo *et al*., 2003) and raw material used for synthesis of biodiesel (Yang *et al*., 2016), hydrocarbon fuel for jets (Zhao *et al*., 2015) and alkyd resins (Nosal *et al*., 2015). *Camelina sativa* oil is applied for production of potential adhesives containing epoxide (Kim *et al*., 2015) or acrylate and hydroxyl functionalities (Li and Sun, 2015). Besides above mentioned synthetic modifications, transgenic camelina oils have been used for production of acetyl triacylglicerides, which possess lower viscosity and have improved cold temperature properties (Liu *et al*., 2015), and sciadonic acid (Gonzalez-Thuillier *et al*., 2016). In addition, camelina meal (Bullerwell *et al*., 2016) or its extracts (Ye *et al*., 2016), seeds (Bullerwell *et al*., 2016) and oil (Bullerwell *et al*., 2016; Ye *et al*., 2016) have been used in animal feed. Due to high content of polyunsaturated fatty acids, camelina oil is even recommended as an alternative for fish oil (Ye *et al*., 2016).

However, applicability of the oil in food and antiradical properties of the press-cakes are less studied. In order to fill this gap, the aims of the study were to test various methods to improve the oxidative stability of *Camelina sativa* oil with extracts of various spices, and to evaluate the antiradical potential of camelina seed meal.

MATERIALS AND METHODS

***Camelina sativa* oil.** The oil was obtained by cold-pressing method (Täbby Press Type 20) from camelina seeds grown in Latvia at Upeslejas farmstead. Rapeseed and two different flax seed (linolenic-rich (Flaxseed oil I) and linolenic-low (Flaxseed oil II)) oils were obtained similarly from the corresponding seeds (“Iecavnieks”, Ltd., Latvia).

Addition of plant material to *Camelina sativa* seed oil. Known amounts (see Table 1) of cloves (“Latplanta”), bay leaves (“Latplanta”), thyme (“Santa Maria”), allspice (“Lat-

planta"), coriander ("Latplanta"), ginger ("Latplanta"), oat grains (breed 'Lizete'; State Stende Cereals Breeding Institute, Latvia) and/or sprouts of barley (by-product from malt production; "Latraps", Latvia) were added to false flax oil (25 g). The container was capped, darkened, and shaken (Orbital Shaker OS 10) for 24 h, then the mixture was filtered and the extract was used for stability experiments. Each extract at each used concentration was prepared in triplicate. The blank oil was treated similarly, but without the addition of spice.

Addition of conifer needle extract to *Camelina sativa* seed oil. Dense extract of conifer needles ("BF-esse", Ltd., Latvia) (0.13 g) was dissolved in camelina oil (8.18 g) leading to concentrate containing 1.6% of the needle extract. Solutions at different concentration (see Table 1) were prepared by sub sequent dilutions in camelina oil.

Determination of the oxidative stability of the oil extracts. The samples of oil (~20 g) were filled in Petri dishes (diameter 10 cm) and placed in a drying oven at 40 °C. Oxidation was estimated by regular determination of peroxide values. Antioxidant activity (AA) was calculated according to the equation:

$$AA = \frac{t_{extract}}{t_{blank}},$$

where $t_{extract}$ – time, when peroxide value of the camelina oil extract reaches 25 meq. O_2/kg, t_{blank} – time, when peroxide value of the camelina oil without an additive reaches 25 meq. O_2/kg.

Peroxide value. The peroxide value was measured according to standard ISO 3960 (Anonymous, 2007).

Defatting of *Camelina sativa* meal. *Camelina sativa* meal was dried at 105–110 °C till constant weight and then extracted with hexane according to method LVS EN ISO 734.

Preparation of *Camelina sativa* meal extracts. Method A. Camelina meal was stirred with solvent (water, ethanol or mixtures water : ethanol (3 : 7, 1 : 1, 7 : 3, v/v); ratio meal : solvent 1 : 10 (for water) and 1 : 5 (for remaining solvents), g/mL) at room temperature for 24 h, filtered through cellite and the filtrate was used for further analysis. **Method B.** Camelina meal was mixed with solvent (water, ethanol or mixtures water : ethanol (3 : 7, 1 : 1, 7 : 3, v/v); ratio meal : solvent 1 : 10 (for water) and 1 : 5 (for remaining solvents), g/mL) and refluxed for 2 h, filtered through cellite and the filtrate was used for further analysis. Each extract was prepared twice.

Total polyphenol content. Total polyphenol content was determined according by Folin–Ciocalteu assay as described previously (Mierina *et al*., 2013). Absorption at 765 nm was measured with a Camspec M501 single beam scanning UV/Vis spectrometer. Total polyphenol content was expressed as mg of gallic acid equivalents/100 g (mg GAE/100 g) of meal.

Table 1

ANTIOXIDANT ACTIVITY OF PREPARED EXTRACTS OF *CAMELINA SATIVA* SEED OIL

Extract	Additive	Amount, weight, %	Antioxidant activity ±SD*
5C	Clove	5	0.96 ± 0.04[a]
5C5O	Clove	5	0.67 ± 0.02[b]
	Oat	5	
5C2.5O	Clove	5	0.66 ± 0.03[a]
	Oat	2.5	
5C0.5O	Clove	5	0.78 ± 0.02[c]
	Oat	0.5	
5C0.1O	Clove	5	1.00 ± 0.03[b]
	Oat	0.1	
5C5T	Clove	5	2.25 ± 0.05[a]
	Thyme	5	
5C1T	Clove	5	1.98 ± 0.01[a]
	Thyme	1	
5BL	Bay leaves	5	0.64 ± 0.06[d]
5BL5O	Bay leaves	5	0.62 ± 0.02[b]
	Oat	5	
5BL2.5O	Bay leaves	5	0.65 ± 0.06[d]
	Oat	2.5	
5BL0.5O	Bay leaves	5	0.79 ± 0.05[a]
	Oat	0.5	
5BL0.1O	Bay leaves	5	0.74 ± 0.03[a]
	Oat	0.1	
5BL5T	Bay leaves	5	2.25 ± 0.11[a]
	Thyme	5	
5BL1T	Bay leaves	5	1.83 ± 0.10[a]
	Thyme	1	
5O	Oat	5	0.68 ± 0.00[c]
2.5O	Oat	2.5	0.72 ± 0.01[c]
0.5O	Oat	0.5	0.99 ± 0.03[b]
0.1O	Oat	0.1	1.04 ±0.03[b]
1T	Thyme	1	2.48 ± 0.06[c]
5T	Thyme	5	2.80 ± 0.03[c]
1A	Allspice	1	0.89 ± 0.04[a]
5A	Allspice	5	0.85 ± 0.04[a]
5Co	Coriander	5	0.99 ± 0.09[d]
1Co	Coriander	1	1.23 ± 0.07[a]
1G	Ginger	1	1.26 ± 0.04[b]
0.1NE	Extract of needles	0.1	1.04 ± 0.05[a]
0.05NE	Extract of needles	0.05	1.17± 0.01[c]
0.5 SB	Sprouts of barley	0.5	1.16 ± 0.04[b]
0.1SB	Sprouts of barley	0.1	1.06 ± 0.04[a]

*The results are mean ± SD from three experiments. Values marked with the same letter are within the same confidence interval.

1,1-Diphenyl-2-picrylhydrazyl (DPPH) test. Each extract (2 mL) of camelina meal at each concentration was stirred with 200 μM DPPH solution in ethanol (2 mL) and the mix-

ture was kept at room temperature for 30 min; absorbance of the mixture was measured at 515 nm with a Camspec M501 single beam scanning UV/Vis spectrometer. The test was repeated for at least five different concentrations of each extract. DPPH inhibition was expressed as concentration IC_{50} that inhibited 50% of free radicals with a starting concentration 100 μM. In addition, inhibition of DPPH for the extract with concentration 5 μg GAE/mL was expressed as vitamin C equivalents.

Galvinoxyl (GO) test. Camelina meal extract (2 mL) at different concentration was stirred with ~20 μM GO solution in ethanol (2 mL); this mixture was kept at room temperature for 30 min and its absorbance was measured at 428 nm with a Camspec M501 single beam scanning UV/Vis spectrometer. The exact concentration of GO was calculated from a calibration curve with $R^2 = 0.9992$. The test was repeated for at least five different concentrations of each extract. GO inhibition was expressed as concentration IC_{50} that inhibited 50% of free radicals with starting concentration 100 μM.

Statistical analysis. Statistical analysis of data was carried out using the Microsoft Excel software package. The total polyphenol content was calculated from a calibration curve with $R^2 = 0.9999$. Equivalents of vitamin C for DPPH test were calculated from a calibration curve with $R^2 = 0.9987$. The antioxidant activity of the extract is presented as a mean ± standard deviation (SD) from three independent experiments. Total polyphenol content, and values of DPPH and GO tests are presented as a mean ± SD.

RESULTS

Antioxidant activity of the extracts of plant material in camelina oil (Table 1) varied from 0.62 for extract 5BL5O to 2.80 for extract 5T, depending on the species used. Most of the extracts (clove, bay leaf, oats and allspices) decreased the oxidative stability of the camelina seed oil. Some plants (coriander, ginger, and sprouts of barley) and dense extract of needles had negligible impact on the oxidative stability of the false flax oil. In contrast, extract containing thyme additive showed significantly improved oxidative stability in comparison to the camelina oil without any additive.

In order to compare camelina oil with some common edible oils the oxidative stability of the last was determined under the same accelerated oxidation conditions. False flax oil was observed to be more stable than rapeseed and flax seed oil I, but flax seed oil II was two times more resistant to autooxidation than camelina oil (Table 2).

Camelina sativa meal was analysed for total polyphenol content, as well as inhibition of DPPH and GO free radicals (Table 3). The analyses were carried out for both defatted and crude camelina meal. Camelina meal after cold-pressing of the oil contained 8.4 ± 0.5% of oil. Total polyphenol content (TPC) in the meal extracts varied from 500 to more than 1500 mg GAE/100 g meal. The greatest TPC

Table 2

RELATIVE RATE OF AUTOOXIDATION OF VARIOUS VEGETABLE OILS

Vegetable oil	Relative rate of autooxidation ± SD*
Camelina oil	1.00 ± 0.05^a
Rapeseed oil	1.34 ± 0.01^b
Flax seed oil I	1.22 ± 0.01^b
Flax seed oil II	0.46 ± 0.01^c

*Relative rate of autooxidation is presented with the respect to the camelina seed oil. The results are mean ± SD from two experiments. Values marked with the same letter are within the same confidence interval.

occurred for ethanol extract of meal that was not defatted prior to the extraction. In the case of other extracts, TPC was less affected by the extraction method. Higher TPC was obtained when defatted camelina meal was used for preparation of polyphenol extracts. Antiradical properties of the prepared extracts were characterised by DPPH and GO assays. The concentration that inhibits 50% of free radical DPPH (starting concentration 100 μM) varied in the range 2-5 μg GAE/mL. The antiradical effect of the camelina meal extracts (5 μg GAE/mL) was comparable with activity of well-known antioxidant vitamin C (solution with concentration range 13–37 μM). The antiradical activity was higher when extraction of crude camelina meal was done under reflux in comparison to extracts prepared at room temperature. The opposite situation was observed for extracts prepared from defatted meal. Similarly, several false flax meal extracts showed remarkable activity against galvinoxyl. However, the extracts obtained under reflux were a 2–6 times better source of antioxidants than those prepared at room temperature.

DISCUSSION

Camelina sativa oil is oxidatively rather unstable due to its relatively high content of unsaturated acids, in comparison to other vegetable oils: the amount of oleic acid varies from 14 to 19%, linoleic acid — 18–26%, linolenic acid — 26–33% and 11-eicosenoic acid — 13–16%. The oil usually does not contain more than 10% of saturated fatty acids (Belayneh *et al*., 2015). However, despite the fatty acid composition, we observed that oxidative stability of camelina oil was even higher than that demonstrated by rapeseed or flaxseed oil (Table 2). These results are consistent by findings that camelina oil in comparison with other vegetable oils is a better source of the natural antioxidant tocopherol (Belayneh *et al*., 2015): the amount of tocopherols varies from 700 mg/kg oil (Belayneh *et al*., 2015) to 830 mg/kg (Zubr and Matthäus, 2002). γ-Tocopherol has been identified as the major tocopherol (Zubr and Matthäus, 2002; Abramovič *et al*., 2007). Additionally, camelina oil contains polyphenols (up to 130 mg/kg). Polyphenol extract from false flax seed oil was observed to slightly increase the oxidative stability of sufflower oil (Abramovič *et al*., 2007).

Table 3

TOTAL POLYPHENOL CONTENT OF CAMELINA MEAL EXTRACTS PREPARED BY DIFFERENT METHODS AND INHIBITION OF DPPH AND GO FREE RADICALS

No	Solvent	Method of extraction	TPC[*,**]	DPPH test		GO test
				IC_{50}[**,***]	$Eq._{vit\ C}$[**, ****]	IC_{50}[**, ***]
1	H_2O	A	896 ± 43[a]	3.0 ± 0.2[b]	23.9 ± 1.5[b]	n.d.
2	EtOH	A	498 ± 3[c]	3.7 ± 0.1[d]	18.1 ± 0.2[c]	3.9 ± 0.5[e]
3	EtOH:H_2O (7:3)	A	997 ± 32[d]	2.1 ± 0.1[a]	20.8 ± 0.3[c]	12.3 ± 0.8[b]
4	EtOH:H_2O (1:1)	A	958 ± 11[c]	2.9 ± 0.3[e]	19.4 ± 0.5[d]	12.1 ± 0.4[d]
5	EtOH:H_2O (3:7)	A	930 ± 2[c]	4.0 ± 0.1[d]	16.4 ± 0.3[f]	13.8 ± 0.7[a]
6	H_2O	B	739 ± 6[c]	5.0 ± 0.3[b]	13.4 ± 0.9[b]	n.d.
7	EtOH	B	925 ± 15[c]	4.4 ± 0.7[e]	15.5 ± 2.3[e]	3.8 ± 0.0[c]
8	EtOH:H_2O (7:3)	B	1061 ± 1[c]	4.6 ± 0.1[f]	14.8 ± 0.3[f]	3.5 ± 0.1[d]
9	EtOH:H_2O (1:1)	B	1172 ± 6[c]	4.1 ± 0.2[a]	16.2 ± 0.7[a]	4.6 ± 0.1[f]
10	EtOH:H_2O (3:7)	B	1055 ± 62[b]	5.1 ± 0.1[f]	13.0 ± 0.3[b]	3.7 ± 0.1[d]
	Extracts of defatted *Camelina sativa* meal					
11	H_2O	A	945 ± 33[d]	4.8 ± 0.0[c]	14.1 ± 0.0[c]	n.d.
12	EtOH	A	732 ± 55[e]	4.7 ± 0.5[e]	14.3 ± 1.3[e]	9.7 ± 0.3[d]
13	EtOH:H_2O (7:3)	A	1536 ± 40[d]	4.2 ± 0.1[f]	14.5 ± 0.2[c]	16.2 ± 1.6[e]
14	EtOH:H_2O (1:1)	A	1437 ± 103[e]	4.6 ± 0.3[b]	14.0 ± 0.5[d]	24.1 ± 0.9[d]
15	EtOH:H_2O (3:7)	A	1381 ± 62[a]	5.4 ± 0.3[b]	12.6 ± 0.6[a]	18.1 ± 2.6[e]
16	H_2O	B	593 ± 6[c]	4.7 ± 0.1[f]	14.4 ± 0.4[d]	n.d.
17	EtOH	B	711 ± 16[f]	2.0 ± 0.1[a]	37.4 ± 1.0[d]	5.1 ± 0.5[e]
18	EtOH:H_2O (7:3)	B	1090 ± 26[f]	4.3 ± 0.0[c]	16.2 ± 0.1[c]	4.1 ± 0.1[f]
19	EtOH:H_2O (1:1)	B	1256 ± 7[c]	4.6 ± 0.0[c]	14.7 ± 0.1[c]	4.2 ± 0.0[c]
20	EtOH:H_2O (3:7)	B	779 ± 46[b]	3.5 ± 0.3[e]	20.8 ± 1.7[e]	6.4 ± 0.1[c]

[*]Expressed as mg GAE/100 g. [**]The results are mean ± SD from two experiments. Values marked with the same letter within a column are within the same confidence interval. [***]Concentration (μg GAE/mL) that inhibits 50% of free radical with starting concentration 100 μM. [****]Concentration of vitamin C that possess equivalent inhibition of DPPH as camelina meal extract with concentration 5 μg GAE/mL.

We observed that e.g., flax seed oil II possesses even two times higher oxidative stability than camelina oil.

In order to test the increase of the oxidative stability of camelina oil we analysed camelina oil extracts of different plant materials. To the best of our knowledge, the only studies dealing with improvement of the oxidative stability of false flax oil are based on addition of commercially available extracts of rosemary, green tea, olive leaf, and pomegranate to oil. As an exception, rosemary extract was previously observed to reduce the oxidative stability of the camelina oil (Moslavac *et al*., 2014). We demonstrated that the oxidative stability of the oil can be effectively increased by herb extracts in oil. In contrast to the examples described by Moslavac *et al*. (2014), our extracts are "ready for use" and difficulties with dissolving of extracts are precluded. In order to improve organoleptic properties of camelina oil, we tested various spices as potential sources of natural antioxidants. Oat grain additive was selected in the experiments, as we have previously observed that both oat grains (Jure *et al*., 2010) and hulls (Zēberga *et al*., 2014) are excellent sources of antioxidants for various vegetable oils. Dense extract of conifer needles (Rubens *et al*., 2011) and barley grains (Gangopadhyay *et al*., 2016) also are well known sources of antioxidants, but the sprouts of barley grains, a by-product from malt production, are not enough investigated. Unfortunately, despite the well-known antioxidant properties of extracts of oat grains, barley sprouts and the plants tested, including the dense extract of conifer needles, in most of the cases these extracts demonstrated negligible impact on the oxidative stability of the oil. Even the opposite was observed, as oat extract had a strong pro-oxidant effect (Table 1, extracts 5O, 2.5O, 0.5O, and 0.1O). This opposite effect of oat extract most probably is related to the antioxidant-prooxidant nature of tocopherols (Nadeem *et al*., 2012) — both camelina oil and oats (Chu *et al*., 2013) are well-known sources of these antioxidants. The oat extract had a similar effect as clove or bay leaf extract on the oxidative stability. The highest antioxidant effect was demonstrated by thyme, both in comparison to pure camelina oil and extracts of clove or bay leaf, and in that case no antioxidant–pro-oxidant effect was observed in the studied range of the concentrations. These findings on thyme antioxidants are in agreement with results obtained by Bensmira *et al*. (2007) and Saoudi *et al*. (2016), who studied out oxidative stability of sunflower seed oil at high temperatures. It was previously observed that during accelerated oxidation processes the concentration of tocopherols decreased slower in the presence of thyme addition (Saoudi *et al*., 2016): probably, the increased stability of the thyme extracts is achieved both due to the presence of thyme antioxidants and reduced degradation of tocopherols.

Traditionally, *Camelina sativa* press-cake is used as fodder (Kahindi *et al*., 2014). In order to broaden applicability of camelina seed meal, we investigated press-cake as a potential source of antioxidants. Till now only few studies have been devoted to preparation of polyphenol rich methanol (Terpinc *et al*., 2012a; Terpinc *et al*., 2012b) and ethanol (Terpinc *et al*., 2012b) extracts of camelina press-cake. The methanol extracts appeared half as active as BHT in prevention of formation of conjugated dienes and trienes (Terpinc *et al*., 2012b).

Our results indicate that the optimal solvent for extraction of polyphenols from meal is a water-ethanol mixture. It should be pointed out that defatting of the press-cake was crucial, when extracts were prepared at room temperature: total amount of polyphenols increased more than 50% in comparison to extracts obtained from crude, non-defatted camelina meal. Total amount of polyphenols in camelina meal extracts was comparable or even about two times higher than in similar extracts of rapeseed (about 700 mg GAE/100 g (Barba *et al*., 2015) up to 1000 mg GAE/100 g (Teh and Birch, 2014)), flax or hempseed meal (for both last, about 400 mg GAE/100 g (Teh and Birch, 2014)). Thus, false flax press-cake is a potential source of polyphenols in comparison with other oil seed meals.

In order to determine antiradical activity of the prepared extracts, assays of two classical free radicals — DPPH and GO (Mierina and Jure, 2010) — were carried out. The antiradical activity was characterised by the concentration IC_{50} which inhibited 50% of the free radical solution with starting concentration 100 μM. It should be mentioned that the inhibition of oxygen and nitrogen free radicals was comparable in case of the extracts obtained by method B. In contrast, the antiradical activity of the extracts prepared by method A did not dependent on the radical used: the extracts were better DPPH scavengers. Unfortunately, we did not find a good correlation between total polyphenol concentration and DPPH or GO assays. However, some tendencies were observed: antiradical activity estimated by DPPH increased with total amount of polyphenols in extracts obtained from crude meal by method A (with the exception of ethanol extract). We did not observe obvious antioxidant–pro-oxidant activity according to GO assay. Ethanol extracts (method A) demonstrated higher antiradical activity estimated by GO in comparison to ethanol-water extracts. In contrast, the extracts (method B) of defatted meal showed strong antioxidant–pro-oxidant effect regarding DPPH. Similar pro-oxidant action has been observed for other seed meals, e.g., rapeseed (Szydłowska-Czerniak and Łaszewska, 2015). It was postulated that particularly polyphenols with a dual antioxidant–pro-oxidant role could act as selective cytotoxic agents against cancer cells (León-González *et al*., 2015). Despite similar action of free radicals, correlation was not observed in IC_{50} values between DPPH and GO assays. Most likely this was due to different reactivity of phenolate ion with free radicals. It is considered that the reaction between an antioxidant and a free radical proceeds according to the SPLET (sequential proton loss and electron transfer) mechanism; thus, formation of phenolate ion is crucial for antioxidant activity (Litwinienko and Ingold, 2005). Phenolate ions react better with free radicals, which are formed from parent molecules with low pK_a: pK_a of the DPPH parent molecule is around 8.5, while pK_a of alcohol is 15-19 (Litwinienko and Ingold, 2003). It should be stressed that the water extracts demonstrated good antiradical activity despite the relatively low total polyphenol content. This might be explained by synergism between polyphenols and water soluble aminoacids and their derivatives, as it is known that peptides can act as antioxidants (Jin *et al*., 2016). Free amino functionalities can serve as bases, able to increase the amount of phenolate ions, and addition of these bases to the antioxidant increases the reaction rate with free radicals through SPLET process (Foti, 2012).

In order to compare antiradical activity of the prepared camelina meal extracts, data obtained from DPPH assay were expressed as equivalents of vitamin C. Inhibition of free radical DPPH was measured when the concentration of the extract was 5 μg GAE/mL and then converted to vitamin C equivalents. It was observed that extracts of camelina meal are even better antioxidants than ascorbic acid. In order to achieve the activity of camelina extracts, the concentration of vitamin C should be at least 6 μg/mL.

It seems that besides the huge variety of applications for *Camelina sativa*, such as fodder, false flax could also serve as a promising source of valuable food ingredients for human consumption.

CONCLUSIONS

Oxidative stability of *Camelina sativa* oil, despite the huge amount of polyunsaturated fatty acids, is comparable or even better than that of rapeseed or flaxseed oil. The stability can be increased even more by addition of lipophylic extracts of thyme antioxidants. Unfortunately, oat extract addition to camelina oil demonstrated pro-oxidant effect. On the other hand, camelina meal is an undervalued source of polyphenols with excellent antiradical properties.

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CAMELINA SATIVA EĻĻAS UN SPRAUKUMU ANTIOKSIDANTU ĪPAŠĪBAS

Camelina sativa eļļa ir zināma kā lielisks polinepiesātināto taukskābju avots. Līdz šim ir pētīts eļļas pielietojums, galvenokārt tehnikā kā izejviela sveķu, biodīzeļa vai ogļūdeņražu degvielas sintēzei. Šis raksts ir par auksti spiestas *Camelina sativa* (zināma arī kā sējas idra) eļļas un tās garšaugu ekstraktu oksidatīvās stabilitātes pētījumiem. Par spīti augstajam polinepiesātināto taukskābju saturam *Camelina sativa* eļļa bija oksidatīvi stabilāka nekā rapšu vai linu eļļa. Idras eļļas dažādu garšvielu ekstrakti pagatavoti ar macerēšanas metodi, procesu veicot istabas temperatūrā 24 stundas. Ekstraktu stabilitāte noteikta, paraugus izturot paātrinātas oksidēšanās apstākļos; stabilitātes izmaiņām sekots, nosakot peroksīdu skaitli. Noskaidrots, ka vairums no piedevām (piemēram, lauru lapas, smaržīgie pipari, krustnagliņas, miežu asni, koriandrs, ingvers) neietekmēja vai pat pazemināja eļļas oksidatīvo stabilitāti. Turpretī eļļa ar timiāna piedevu uzrādīja ievērojami augstāku stabilitāti nekā *Camelina sativa* eļļa bez piedevas. *Camelina sativa* spraukumi ekstrahēti ar diviem polāriem šķīdinātājiem (ūdeni vai etanolu) vai to maisījumiem dažādos apstākļos (istabas vai viršanas temperatūrā). Pagatavotos polāros spraukumu ekstraktus raksturojām ar kopējo polifenolu saturu (Folina-Čikolteu metode) un antiradikāļu aktivitāti pret 1,1-difenil-2-pikrilhidrazilu un galvinoksilu.