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NUTRITIVE QUALITY OF CAMELINA VARIETIES WITH SPECIAL FOCUS ON OIL

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Abstract

The oil extracted from Camelina sativa seeds is underused and not well known, making the camelina crop a niche one. However, the oil is a potential source of omega-3, omega-6, and omega-9 fatty acids, so the crop has started to draw attention and occupy increasingly larger areas. This is owed to the multiple uses of the oil (in medicine, chemistry, energy), as well as the economic efficiency of the crop. The objective of this study was to determine which of the three different varieties, each one with different provenience and from different pedoclimatic conditions, has a better fatty acid ratio in the extracted oil. This study covers the results obtained in the laboratory research phase on a selection of three camelina varieties (Camelia, created by the University of Agronomic Sciences and Veterinary Medicine of Bucharest, Calena, with Austrian origins and a local population by BUASVM Timisoara) regarding fatty acid content. The oil extraction and further determinations were made in the research platform of BUASVM Timisoara. Results showed that there are no major differences between the camelina varieties, with omega-3 fatty acid content ranging from 28.48% to 33.62%, omega-6 values between 21.28% and 23.62% and omega-9 between 30.11% and 31.64%, although their origin is from different.

Key words: *camelina, fatty acid profile, oil.*

INTRODUCTION

Camelina (*Camelina sativa* L. Crantz) or false flax is a crop from *Brassicaceae* family. In the last year crops have gained attention, especially due to their economic efficiency and multiple uses of the oil (medicine, chemistry, energy).
Speaking of economic efficiency, camelina does not have great requirements in matter of temperature and soil, as it is often grown on marginal land (Ehrensing et al., 2008). Furthermore, it is relatively easy to grow and requires few agricultural inputs compared to other crops (Ehrensing et al., 2008). This makes it a promising crop even in areas that are not generally favourable for agriculture.
Camelina's adaptation to vast areas of the world, combined with its unique oil composition and properties useful for the production of biofuels, jet fuel, bio-based products, feed and food and more recent, a potential medical use as novel antimicrobian has resurfaced interest in this ancient crop (Marisol, 2016; Bătrîna, 2021).
Different from other cultivated *Brassicaceae*, camelina has a unique seed oil composition (Vollmann & Eynck, 2015), with a high content of α-linolenic acid (20-35%), eicosenoic acid (11-19%) and tocopherols (Vitamin E) (Abramovič et al., 2007) as well as a naturally low content of the undesirable fatty acid erucic acid (<4%), rendering camelina oil well-suited for a variety of food, feed or non-food applications (Zubr, 1997; Faure, 2016; Zanetti, 2017).
The aim of this paper is to study the nutritive quality of three varieties of camelina, each from a different area, with different climate and of course different soil conditions. Increased emphasis is placed on oil content, more specifically on fatty acids and their percentage in oil composition for each of the varieties. It is important to mention that a similar fatty acid ratio for each variety, regardless of soil and

weather conditions, would make Camelina a versatile plant, potentially laying a foundation for satisfactory crops and predictable, high quality outcomes.

MATERIALS AND METHODS

There were three different varieties of camelina seeds taken into observation. First was Calena variety, produced by Saatbau Linz in Austria and provided by a subsidiary here in Romania; the second is Camelia variety produced by University of Agronomical Sciences and Veterinary Medicine Bucharest and the third variety which is a local population of camelina from the Banat's University of Agricultural Sciences and Veterinary Medicine from Timisoara (BUASVMT), provided by Crop Science Department.

The oil extraction is the same as described by Domil (2015). In a brief description, camelina seeds (100 g) were ground in a coffee grinder and oil was extracted with hexane for 24 h in a Soxhlet apparatus. Hexane was removed by rotary evaporation (10 mbar, 30ºC). For determination of total oil content, 10.0 g triplicates of ground seed were extracted (Soxhlet) for 24 h, and after hexane was removed by rotary evaporation (10mbar, 30ºC) the weight of the residual oil was calculated. The percentage of oil recovered from the samples was around 39.8 wt. % (rM ± 0.5%), with slight differences between the three varieties. This percentage is in the same range as in other studies (for example in Imbrea et al., 2011, oil content varied between 38.7-42.5%).

Fatty acids of oils were derivatised in their methyl esters (FAMEs) before gas chromatography (GC) analyses using Boron trifluoride methanol complex 20%from Merck Germany. Further, 3 ml of 20% boron trifluoride solution was added to methylate 0.10 g of the samples. Derivatisation was performed in an ultrasonic bath at 80ºC for 1 hour. After cooling, 2.5 ml of 10% sodium chloride solution and 2 ml of hexane were added and the mixture was shaken. Organic phases were separated by centrifugation at 3000 rpm for 10 minutes and transferred to vials for GC analysis.

FAMEs were determined using a Shimadzu GCMS QP 2010Plus Apparatus (Shimadzu Corporation, Tokyo, Japan) with a mass Spectrometer detector (MS) and equipped with a capillary column AT-Wax (30 m x 0.32 mm x 1 µm). The injection volume was 1.0 µL, the temperature of the injection port was 250ºC. The carrier gas (Helium) flow rate was 1.8 ml min^{-1} and the split ratio was 1:10. Oven temperature was set at 110ºC (2 minutes) increasing with 8ºC/min to 250ºC. The final oven temperature was maintained 7.5 minutes. MS parameters (Ion Source and Interface Temperature) were set at 210ºC and 255ºC respectively. For confirmation of identified and determined FAMEs in oils, the NIST05 library and area normalization method was used. The results of FAs were expressed as percentages of total FAMEs.

RESULTS AND DISCUSSIONS

Camelina oil is rich in oleic acid (18:1) with values ranging between 14-16%, linoleic acid (18:2) between 15-23%, α-linolenic acid (18:3) between 31-40% and gondoic acid (20:1) between 12-15%. Other minor fatty acids include palmitic (16:0), stearic (18:0), and erucic acid (22:1) (Singh et al., 2014). Camelina seed oil composition varies with cultivar, location, environment and extraction method (Berti et al., 2016).

As shown in Table 1, the three camelina varieties used in this study were richest in oleic acid, linoleic acid, linolenic acid and gondoic acid. Other fatty acids found include palmitic, stearic, eicosadienoic, eicosatrienoic, arachidic and erucic acid. In between varieties, there were minimal differences regarding fatty acid content.

The saturated fatty acids (SFA) found in the oil extracted from all three varieties were: palmitic acid, stearic acid and arachidicc acid. Out of these, the highest concentration was that of palmitic acid: 9.53% for 7C/1, 9.77% for 7C/2 and 9.13% for 7C/3, followed by stearic acid with 3.46% highest value for 7C/1, 3.34% for 7C/2 and 3.26% for 7C/3 and finally arachidic with a maximum value of 1.32 for 7C/3 and a minimum value of 0.41 for 7C/1.

Table 1. Fatty acid content in the three studied varieties

	Fatty acid	7c/1	7c/2	7c/3
1	palmitic acid C16:0	9.53	9.77	9.13
2	stearic acid C18:0	3.46	3.34	3.26
3	acid oleic C18:1	17.04	17.60	17.14
4	linoleic acid C18:2	19.78	19.75	21.38
5	α-linolenic acid C18:3	33.28	30.86	27.07
6	arachidic acid C20:0	0.41	1.02	1.32
7	gondoic acid C20:1	13.61	13.32	14.46
8	eicosadienoic acid C20:2	1.61	2.02	2.31
9	eicosatrienoic acid C20:3	0.24	1.35	1.45
10	erucic acid C22:1	1.07	0.92	2.41
11	SFA	13.40	14.13	13.71
12	MUFA	31.72	31.74	34.01
13	PUFA	54.81	53.98	52.21

The extracted monounsaturated fatty acids (MUFA) were oleic acid with a maximum of 17.60% for 7C/2, gondoic acid peaking at 14.46% for 7C/3 and erucic acid with the highest value of 2.41% for 7C/3 and the minimum of 0.92% for 7C/2.

The extracted polyunsaturated fatty acids (PUFA) were: linoleic, α-linolenic, eicosadienoic, eicosatrienoic. The highest concentrations were as follows: α-linolenic 33.28% for 7C/1, eicosadienoic 2.31% for 7C/3 and eicosatrienoic 1.45% in 7C/3.

Out of the total quantity of oil that was extracted, Calena variety had the highest amount of PUFA (54,8%), with 31.72% MUFA and 13.4% SFA. In comparison, Camelia variety had just 1% less PUFA (53.98%), with 31.74% MUFA and 14.13% SFA. The BUASVMT variety had the lowest PUFA content (52.21%), which is 2% less than Calena, while yielding a slightly higher value for MUFA (34.01%) and similar SFA content (13.71%).

Table 2. Comparative data between presented study and Abramovič et al. (2005) and Zubr & Matthaus (2002) studies

Fatty acid	Fatty acid content				
	This study			Abramovič et al. (2005)	Zubr et al. (2002)
	7C/1	7C/2	7C/3		
palmitic acid 16:0	9.53	9.77	9.13	6.43 ± 0.01	5.3 - 5.6
stearic acid 18:0	3.46	3.34	3.26	2.57 ± 0.01	2.3 – 2.7
oleic acid 18:1	17.04	17.60	17.14	17.40 ± 0.30	14.0 – 16.9
linoleic acid 18:2	19.78	19.75	21.38	16.90 ± 0.10	13.5 - 16.5
α-linolenic acid 18:3	33.28	30.86	27.07	35.20 ± 0.40	34.9 - 39.7
arachidic acid 20:0	0.414	1.02	1.32	1.24 ± 0.05	1.2 - 1.5
gondoic acid 20:1	13.61	13.32	14.46	14.90 ± 0.20	15.1 - 15.8
eicosadienoic acid 20:2	1.61	2.02	2.31	2.12 ± 0.02	1.7 - 2.0
eicosatrienoic acid 20:3	0.24	1.35	1.45	1.61 ± 0.03	1.3 - 1.7
erucic acid 22:1	1.07	0.92	2.41	1.62 ± 0.03	2.6 - 3.0

Legend: 7C/1 = Calena oil; 7C/2 = Camelia oil; 7C/3 = BUASVMT local camelina variety

At a first glance all results appear to be similar. Resemblances stand out especially in between the varieties included in this study, while the amount of fatty acids obtained in this study are akin to those obtained by Abramovič et al. in 2005 and Zubr & Matthaus in 2002.

Out of all the fatty acids, a-linolenic acid was obtained in the highest quantities both in this study (33.28% in the Camelia variety), as well as in the studies of Abramovič et al. in 2005 (35.2%) and Zubr & Matthaus in 2002 (between 34.9-39.7%). These numbers, more specifically their similarity, may bear significant importance for future studies, as it is known that a-linolenic content is influenced by environmental conditions (Zubr & Matthaus, 2002). It is essential to remind that two of the varieties used in this study were of Romanian origin and one was of Austrian origin, while the study carried out by Zubr & Matthaus was in Denmark and the study of Helena Abramovic took place in Slovenia, considerably closer to the Mediterranean Basin.

Other notable similarities between results include the percentage of oleic acid (about 17% in all varieties of this study, respectively an average of 17.4% obtained by Abramovič et al. (2005). The case is similar for gondoic acid, with a maximum of 14.46% in the BUASMVT variety, comparable to 14.9% (Abramovič et al., 2005) and 15% (Zubr & Matthaus, 2002).

Arachidic acid results were approximately 1% or a little above this value in most of the measurements: 1.02% 7C/2, 1.32 7C/3, comparable to 1.24% (Abramovič et al., 2005) and 1.2-1.5% (Zubr & Matthaus, 2002). There was a significant difference between these figures and the concentration of arachidic acid found in the oil extracted from AT, a mere 0.414%.

However, there are some subtle differences in the results that are worth mentioning. The highest difference can be seen in linoleic acid content, with an approximate difference of 3-4% between the highest values of this study and the results obtained by Abramovic. Another difference can be seen in the content of palmitic acid, with values above 9% in all three varieties taken under observation and in the studies chosen as comparison a mere 6.43% (maximum for Abramovic). The same situation goes for stearic acid, which can be found in more than 3.25%, which is almost 1% higher than the content found by Abramovic or Zubr.

As far as the practical uses of these oils are concerned, a distinction must be made between human consumption and industrial use.

Erucic acid is known to be potentially harmful if present in food (*Zealand, F. S. A. N.*), therefore the lowest possible content in oil is desirable. All three Camelina variants included in this study have shown a reduced content of erucic acid (0.92-2.41%), more specifically below the limits imposed by EU regulations (*The Commission of the European Communities (1980). "Commission Directive 80/891/EEC of 25 July 1980 relating to the Community method of analysis for determining the erucic acid content in oils and fats intended to be used as such for human consumption and foodstuffs containing added oils or fats". EurLex Official Journal. p.254*; *U.S. Dept. of Health and Human Services, CFR - Code of Federal Regulations Title 21 1 April 2010*). As a result, Calena oil, Camelia oil and BUASVMT local camelina variety are all sources of oils that are suitable for use in the food industry.

In order to be appropriate for biokerosene production, oils with an increased presence of saturated fatty acids have shown a proportional increase in both CFPP and biofuel viscosity (Golimowski et al., 2017). CFPP or cold filter plugging point is the minimal temperature expressed in degrees Celsius at which liquid fuel plugs the filters through which it must pass, and it is preferable to have it as low as possible. An inversed proportionality was observed in oils high in unsaturated fatty acids, therefore biokerosene obtained from oils rich in monounsaturated fatty acids and polyunsaturated fatty acids will have a lower CFPP and will be less viscous – more appropriate for use in this situation. The oil from camelina seeds contains over 50% polyunsaturated essential fatty acids, particularly linoleic and alpha-linolenic acids. Camelina oil is 10 times richer in these acids than many other vegetal oils (Putnam, 1993; Tabără, 2007; Bătrîna, 2020). Out of the three camelina varieties included in this study, Calena had the highest content of mono- and polyunsaturated acids combined (approximately 86%), making it the most suitable for biokerosene production.

CONCLUSIONS

There are no major differences between the three camelina varieties included in this study, although they were cultivated in different climates. Our results were similar to those obtained by Abramovic et al. (2005) and Zubr & Matthäus (2002), with the most notable differences in linoleic acid content, by about 3-4%, followed by stearic and palmitic acid.

This study of the oil content ultimately has its purpose in determining potential practical uses. Due to a reduced content of erucic acid, all three varieties yielded oil that is appropriate for human consumption, according to EU and US regulations. In terms of industrial use for the production of biokerosene, a high content of mono- and polyunsaturated fatty acids is desirable, thus making the Calena variety the most appropriate out of the three.

All in all, the results of this study may provide an interesting starting point for further research, with oils having a fatty acid ratio with specific characteristics, based on their intended use.

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