Quality of camelina oil cultivated in Black Sea region

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Abstract. Camelina is an oil-bearing crop that is increasingly gaining popularity in the world due to its high oil content and wide applicability. Since 2019, this crop has been cultivated in Black Sea region on an industrial scale. The study of the quality of Camelina oil showed the dependence of seed oil content on the Selyaninov’s hydrothermal coefficient (HTC). The highest oil content – 44.02% – was observed in the most favorable year in terms of water availability (HTC=1.11), while the lowest – 33.9% – in dry year (HTC=0.23). The comparison of fatty acid composition of Camelina oilseeds showed that the oleic acid content in varieties ranges from 14.46 to 16.57%, erucic – from 3.07 to 3.25%, linolic – from 17.89 to 19.66%, linolenic – from 33.02 to 37.06%. The consumer properties of Camelina oil include a relatively high total tocopherol content. In terms of its composition and properties the oil of Camelina seeds grown in Black Sea region is suitable for the synthesis of biodiesel fuel. Thus, in Black Sea region Camelina is a unique natural-biological resource that makes it possible to use oil in various areas of the national economy.

1. Introduction
Among industrial crops of Black Sea region Camelina is a new crop, which has been cultivated on production areas only since 2019 [1]. The interest in Camelina is caused by the fact that its winter form (Camelina sylvestris) gives satisfactory yields on the peninsula in a wide calendar range. The average yield of winter Camelina over 5 years of study made 1.35 t/ha. Spring Camelina is less harvested in the conditions of Black Sea region – when sown in the early season (in February) its yield of oilseed crops makes up to 0.8-0.9 t/ha.

Black Sea region belongs to the sunniest regions. The annual duration of sunshine here varies within 2180-2470 hours, and the natural conditions of the peninsula are particularly favorable for the formation of high-quality oil raw materials [2].

According to literary data, Camelina is not consumed much, especially as a dietary product, because it contains essential fatty acids omega-3 and omega-6, as well as other related substances – phospholipids, carotenoids, tocopherols, thioglycosides, vitamins [3-4]. Besides, oil is used for
technical purposes in various fields of industry – for the preparation of paint oil, paints, synthetic lipids [5-6], in medicine and cosmetics [7].

Camelina is becoming increasingly popular as a source for the production of biodiesel and bioaviokerosene. In modern studies Hoseini S.S. et al., it was found that biodiesel fuel obtained from Camelina has better physical and chemical characteristics and operational parameters than biodiesel fuel obtained from the oilseeds of *Oenothera lamarkiana* and *Ailanthus altissima* [8].

It was shown that compared to conventional fuels, the mixing of biofuels derived from Camelina raw materials reduces the number of particles and massive emissions of adverse substances into the atmosphere directly behind an aircraft make from 40 to 70%, which, according to scientists, is one of the main strategic vectors to mitigate the climate change [9-10].

Similar to the rest of the world, Russia’s agriculture is characterized by a consistent trend towards the exponential growth of irreparable energy costs for each additional unit of production. The increased requirements for environmental indicators of motor fuels, the focus on “green” production and cultivation of “healthy” food make the study on the search for alternative energy sources that combine environmental friendliness and economy, ever more relevant.

The purpose of the study was to assess the quality of the obtained oil from Camelina cultivated in Black Sea region.

2. Methods and conditions of study
The experimental work on the study of winter Camelina oil was conducted during 2015-2019 in the Department of Field Crops of the Research Institute of Agriculture, which is located in the central steppe zone of Black Sea region. The hydrothermal regime (Selyaninov’s HTC) of vegetative periods of winter Camelina during the years of study was quite contrasting: in 2015 – 1.11; 2016 – 0.82; 2017 – 0.61, 2018 – 0.23; 2019 – 0.60. The study of Spring Camelina was carried out in 2019, the HTC of the vegetation period made 0.62.

The fatty acid composition of oil was determined by gas chromatography on Chromatek-Crystal 5000 gas chromatograph with DAZh-2M automatic batcher on SolGelWax capillary column (30m×0.25mm×0.5µm) in carrier gas current – helium with a speed of 22 cm/s, with temperature programming within 178-230 °C. The production of methyl esters and their chromatography were carried out according to standard methods (GOST 31665-2012 Vegetable oils and animal fats. Preparation of fatty acid methyl esters).

The content of biologically active substances (tocopherol) in Camelina oil was studied using thin layer chromatography and spectroscopy.

Vegetable oils of Camelina, sunflower and rapeseed were used to synthesize the biofuel. After the qualitative and quantitative composition of fatty acid compounds was established in the studied oils, their molecular composition was identified using molecular spectroscopy in the field of infrared radiation, using Infralum FT-801 IR-Fourier spectrometer. The spectra were registered according to the license program ZaIR3.5 stored in the computer memory of the device, the number of scans – 16, resolution – 4cm⁻¹, amplification – 1.

3. Results
The analysis of oil accumulation dynamics in winter Camelina seeds in different weather conditions shows that under sufficient moisture supply (HTC 1.11) the Camelina realizes the potential for oil formation and accumulates the most optimal fat content, which indicates the absence of limiting factors (Figure 1). Thus, in 2015, the oil content of Penzyak variety was the largest and was above 44%. The oil content also decreased with the reduction of HTC. In extremely dry year (HTC 0.23) the level of oil accumulation was reduced to 33.9%.
Winter and spring Camelina oils are characterized by high content of polyunsaturated fatty acids (linolic and linolenoic) and low content of erucic acid (Table 1).

Table 1. Fatty acid composition of spring and winter Camelina oils

| n/n | Component           | Spring Camelina variety | Winter variety | Camelina variety |
|-----|---------------------|-------------------------|----------------|------------------|
|     |                     | Penzyak | Omich | Veles | Yubilyar | Penzyak | Baron |
| 1   | Myristic acid       | 0.05    | 0.05  | 0.04  | 0.05     | 0.05    | 0.05   |
| 2   | Palmitic acid       | 5.10    | 4.80  | 4.86  | 4.86     | 5.31    | 5.17   |
| 3   | Palmitoleic acid    | 0.09    | 0.09  | 0.08  | 0.09     | 0.08    | 0.09   |
| 4   | Stearic acid        | 2.05    | 1.91  | 1.97  | 1.92     | 2.21    | 2.15   |
| 5   | Oleic acid          | 16.57   | 15.68 | 14.57 | 14.46    | 15.50   | 15.70  |
| 6   | Linoleic acid       | 19.66   | 18.36 | 17.89 | 18.41    | 18.08   | 17.98  |
| 7   | Linolenic acid      | 33.02   | 35.20 | 37.06 | 36.98    | 33.56   | 33.79  |
| 8   | Arachic acid        | 1.52    | 1.35  | 1.61  | 1.52     | 1.60    | 1.57   |
| 9   | Eicosenic acid      | 14.47   | 15.03 | 14.46 | 14.18    | 15.96   | 15.84  |
| 10  | Eicosadienoic acid  | 1.82    | 1.91  | 1.77  | 1.90     | 2.00    | 1.97   |
| 11  | Eicosatrienoic acid | 1.10    | 1.25  | 1.25  | 1.30     | 1.33    | 1.35   |
| 12  | Behenic acid        | 0.36    | 0.32  | 0.36  | 0.34     | 0.36    | 0.38   |
| 13  | Erucic acid         | 3.12    | 3.07  | 3.25  | 3.20     | 3.17    | 3.15   |
| 14  | Lignoceric acid     | 0.22    | 0.20  | 0.20  | 0.21     | 0.16    | 0.19   |
| 15  | Selacholeic acid    | 0.83    | 0.78  | 0.64  | 0.58     | 0.62    | 0.62   |

The comparison of fatty-acid composition of oilseed Camelina varieties grown in Black Sea region showed that the content of oleic acid in Camelina varieties ranges from 14.46 to 16.57%, erucic – from 3.07 to 3.25%, linoleic – from 17.89 to 19.66%, linolenic – from 33.02 to 37.06%.

The consumer properties of Camelina oil include a relatively high total tocopherol content compared to sunflower and rapeseed (Table 2). The structure of Camelina oil tocopherols is mainly presented by γ-tocopherol, which causes the high level of oxidizing stability of oil in the course of storage despite the considerable content of polyunsaturated fatty acids, such as linoleic and eicosatrienoic.

Consumer properties of Camelina cake are characterized by low content of erucic acid in oil and glucosinolates in seeds, which corresponds to the safety index of this raw material.
Table 2. Content of tocopherols and glucosinolates, 2019

| Parameter                                      | Spring Camelina variety | Kristall | Omich | Veles | Yubilyar |
|------------------------------------------------|-------------------------|----------|-------|-------|----------|
| Total content of tocopherols, mg per 100 g of oil |                         | 92.3     | 88.7  | 91.2  | 90.6     |
| Tocopherol content, %:                           |                         |          |       |       |          |
| alpha α                                        |                         | 11.8     | 7.5   | 9.3   | 10.4     |
| gamma γ                                        |                         | 88.2     | 92.5  | 90.7  | 89.6     |
| Total content of glucosinolates, µmol/g         |                         | 13.2     | 12.8  | 12.3  | 13.2     |

The physical and chemical properties of obtained samples of biofuel synthesized from Camelina, rapeseed and sunflower oils are given in Table 3. The data show that the values of synthesized esters comply with the EN 14214-2003 requirements and can be used in the preparation of mixed motor fuel.

Table 3. Physical and chemical properties of biofuels synthesized from different types of oils

| Parameter                                      | EN 14214-2003 requirements | Obtained biodiesel fuel from oil | Obtained biodiesel fuel from Camellina | Obtained biodiesel fuel from sunflower | Obtained biodiesel fuel from rapeseed oil |
|------------------------------------------------|-----------------------------|---------------------------------|----------------------------------------|----------------------------------------|-------------------------------------------|
| Density, kg/m³                                  | 860-900                     | 880                             | 900                                    | 900                                    |                                           |
| Viscosity, 40 °C, mm²/s                          | 3.5-5.0                     | 4.0                             | 4.8                                    | 4.8                                    |                                           |
| Freezing point, ºC                              | not above –20               | –19                             | –19                                    | –19                                    |                                           |
| Smoking point, ºC                               | not below 120               | 161                             | 150                                    | 155                                    |                                           |
| Sulfur content, mg/kg                           | not more than 10            | less than 10                    | less than 10                           | less than 10                           |                                           |
| Liquid-water content, mg/kg                      | not more than 500           | 100                             | 105                                    | 95                                     |                                           |
| BS&W, mg/kg                                     | not more than 24            | N/A                             | N/A                                    | N/A                                    |                                           |
| Acid number, mgKOH/g                            | not more than 0.5           | 0.5                             | 0.35                                   | 0.45                                   |                                           |
| Monoacylglycerol content, %                     | not more than 0.8           | 0.5                             | 0.5                                    | 0.6                                    |                                           |
| Diacylglycerol content, %                       | not more than 0.2           | 0.105                           | 0.1                                    | 0.1                                    |                                           |
| Triacylglycerol content, %                      | not more than 0.2           | 0.002                           | 0.002                                  | 0.002                                  |                                           |
| Iodine index, g I₂/100g                         | not more than 120           | 111                             | 100                                    | 95                                     |                                           |
| Ash content, %                                  | not more than 0.01          | 0.01                            | 0.01                                   | 0.01                                   |                                           |

Hence it appears that the seed oil from Camelina grown in Black Sea region is suitable in its composition and properties for the synthesis of biodiesel fuel through the reaction of methanolysis using a homogeneous alkaline catalyst. In terms of physical and chemical properties the obtained biodiesel is similar to that of sunflower or rapeseed oils.
4. Conclusion
Thus, the unique natural conditions of Black Sea region allow producing Camelina seeds with oil content of up to 44.02% with high content of tocopherols. Oils of winter and spring Camelina are characterized by high content of polyunsaturated fatty acids (linoleic and linolenic) and low content of erucic acid. The above advantages of Camelina oil allow using it as a biologically valuable additive, in the food industry and for the production of environmentally friendly renewable fuel.

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