Lipid composition and physicochemical parameters of unrefined sunflower oil

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Abstract. Unrefined sunflower oil is obtained by pressing of the sunflower seeds and subsequent fine filtration. It contains more biologically active substances compared to the refined one, it is more stable to oxidation processes, for that reason it is widely used in the composition of the various food products. The main acids in the oil are oleic (56.5%), linoleic (31.7%), palmitic (6.4%), and stearic acid (3.2%). Total sterol content is 0.7%, with *ß*-sitosterol as a main component (84.0%). The quantity of tocopherol is 188 mg/kg and it consists of one compound *α*-tocopherol (100%). Different physicochemical parameters were obtained at temperature ranges (from 20 to 80°C). The values of these parameters decrease with an increase in temperature, density (from 0.938 to 0.901 g/ml), surface tension (from 44.124 to 31.787 mN/m), dynamic viscosity (from 29.195 to 14.913 mPa.s), and kinematic viscosity (from 31.125 to 16.552 mm^2/s). All these changes are in confirmation of the data from the literature and are relevant in our next studies.

1 Introduction

The annual sunflower plant (*Helianthus annus* L.) belongs to the Asteraceae family. It was brought from the southern states of North America and Mexico, where it is still found in the wild. Today, it is cultivated throughout Europe, including in Bulgaria, where it is grown as a first-class oil crop. Sunflower oil is obtained by pressing and extracting of the seeds. Vegetable oil is a yellow liquid with a characteristic odor. The main fatty acids are oleic (from 20 to 40%) and linoleic (from 46 to 70%) [1-3]. The oil has the following applications: in the food industry, cosmetics, medicine, and technology [1]. To prevent oxidation and polymerization processes, various antioxidants are added to it [4-8].

Over the years, an oleic type of sunflower oil has been developed, which is high in oleic acid (60-80%) and low in linoleic acid (18-40%) [1]. This oil finds the same application as the linoleic type of sunflower oil.

Many producers obtain sunflower oil only by cold pressing and subsequent fine filtration without refining. It is known that unrefined vegetable oils contain more biologically active substances and various natural color substances, such as chlorophyll, and *ß*-carotene. Due to

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the binding of free fatty acids and peroxide compounds, a more pleasant taste and smell is obtained [9-11]. They are suitable for various food products, such as marinades, dressings, salads and sauces, but adding them after the heat treatment is desirable.

Vidrih et al. [12] found that unrefined oils are more stable to oxidation compared to refined ones, i.e. unrefined oils are more stable over time and during technological food processing.

Fedorov et al. [13] using unrefined sunflower oil onto determined specific heat capacity and dynamic viscosity at different temperatures (20, 40, 60, 80, 100, and 120℃). These parameters, according to the authors, affect the quality of the oil.

One of the most important indicators characterizing vegetable oils used in the composition of food products is viscosity. Temperature, pressure, moisture, concentration and flow rate influenced in viscosity. These dependencies have been investigated in many vegetable oils such as groundnut oil, sesame oil, and olive oil [14, 15], sunflower oil [14, 16], palm oil [14], *etc*. [17-20].

Determination of the chemical composition of unrefined sunflower oil and establishment of changes in some of its physicochemical parameters is the aim of this work with a view to its application in various food products.

2 Materials and methods

The tested unrefined sunflower oil was purchased from the commercial network of Plovdiv in 2023.

2.1 Determination of lipid composition

The analysis of the chemical composition of the oil includes the determination of: fatty acid [21, 22], unsaponifiable matter [23, 24], sterols [25], and tocopherols [26].

2.2 Determination of physicochemical parameters

Physicochemical analyses of surface tension, density, dynamic and kinematic viscosity were carried out at different temperatures (20, 30, 40, 50, 60, 70, and 80°C) according to the conditions of application of the oil in the composition of food [27].

2.3 Statistical analysis

All experiments were carried out trictratly as arithmetic mean values with their standard deviation (SD), using Microsoft Excel.

3 Results and discussion

Tabвe 1 presents the data for fatty acid content.

The main fatty acids from the 20 identified (100% of the total composition) are oleic (56.5%), linoleic (31.7%), palmitic (6.4%), and stearic acid (3.2%). The differences in the fatty acids can be explained by the method of obtaining the oil.

The ratio of saturated and unsaturated fatty acids is summarized in Fig. 1. This ratio is 1:8, and 2:1 for monounsaturated to polyunsaturated. This data does not differ from that, published in the literature for high-oleic sunflower oil.

Table 2 presents the content of the main biologically active substances in the lipid fraction.

Table 1. Lipid composition of unrefined high oleic sunflower oil.

Fatty acids		Content, %
Capric	$C_{10:0}$	0.1 ± 0.0
Lauric	$C_{12:0}$	0.1 ± 0.0
Myristic	$C_{14:0}$	0.1 ± 0.0
Palmitic	$C_{16:0}$	6.4 ± 0.06
Palmitoleic	$C_{16:1}$	0.2 ± 0.0
Stearic	$C_{18:0}$	3.2 ± 0.03
Oleic	$C_{18:1}$ (n-9)	56.5 ± 0.55
Linoleic	$C_{18:2}$ (n-6)	31.7 ± 0.30
α-Linolenic	$C_{18:3}$ (n-3)	0.1 ± 0.0
Arachidic	$C_{20:0}$	0.3 ± 0.0
Gondoic	$C_{20:1}$	0.2 ± 0.0
Behenic	$C_{22:0}$	0.8 ± 0.0
Erucic	$C_{22:1}$	0.1 ± 0.0
Nevronic	$C_{24:1}$	0.1 ± 0.0
Docosahexaenoic	$C_{22:6}$ (n-6)	0.1 ± 0.0

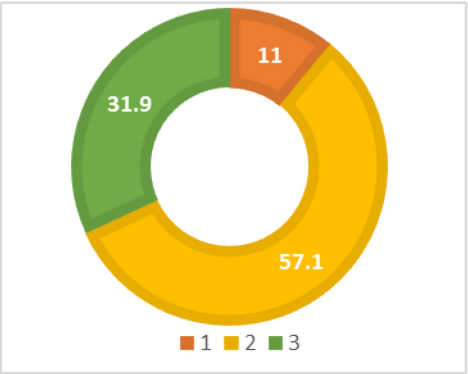

Fig. 1. Distribution of saturated and unsaturated fatty acids, %: 1 – saturated fatty acids; 2 – polyunsaturated fatty acids 3 – monounsaturated fatty acids.

In the composition of the unsaponifiable fraction, many compounds, different in their structure and biological activity, have been found, which are important in the use of the oil [27]. The content of the unsaponifiable fraction is higher than the published results for sunflower (1.5%), rapeseed (2.0%), and grapeseed oil (2.0%), but it is lower than that of maize oil (2.8%) [28].

The amount of the sterol fraction mainly consists of *β*-sitosterol (84.0%), with the rest of the identified sterols being in significantly lower quantities [28].

The tocopherol fraction is lower compared with another oils [28]. Only the compound *α*-tocopherol (100% of total tocopherols) was identified in the sample.

The results for the measured physicochemical parameters are given in Table 3 and in Figs. 2 and 3.

Density values decrease from 0.938 g/ml at 20°C to 0.901 g/ml at 80°C, which is about 5%. More drastic is the decrease in surface tension – from 44.124 at 20°C to 31.787 mN/m at 80°C, which is about 23%. In the case of dynamic viscosity, the reduction in values is about 39%. The dynamic viscosity values were used to calculate the kinematic viscosity.

Table 2. Biologically active substances in unrefined high oleic sunflower oil.

Biologically active components	**Content, %**
Unsaponifiable matter, % of the oil	2.3 ± 0.02
Sterols, % of the oil	0.7 ± 0.0
Sterol composition, % of the sterol fraction	
Cholesterol	0.8 ± 0.0
Brassicasterol	0.5 ± 0.0
Campesterol	0.9 ± 0.0
Stigmasterol	9.8 ± 0.09
Δ^7-campesterol	4.0 ± 0.04
β-sitosterol	84.0 ± 0.80
Tocopherols, mg/kg in the oil	188 ± 0.0
α-Tocopherol, % of total tocopherols	100

Table 3. Physicochemical parameters of unrefined high oleic sunflower oil.

Temperature, °C	**Density, g/ml**	**Surface tension, mN/m**
20	0.938 ± 0.0	44.124 ± 0.40
30	0.930 ± 0.0	41.924 ± 0.40
40	0.924 ± 0.0	39.886 ± 0.38
50	0.921 ± 0.0	37.908 ± 0.36
60	0.914 ± 0.0	36.545 ± 0.35
70	0.908 ± 0.0	34.170 ± 0.33
80	0.901 ± 0.0	31.787 ± 0.30

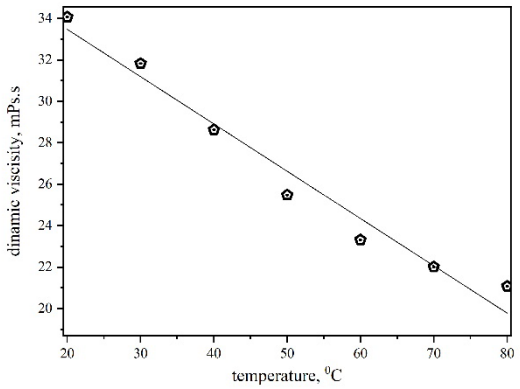

Fig. 2. Temperature dependence of viscosity.

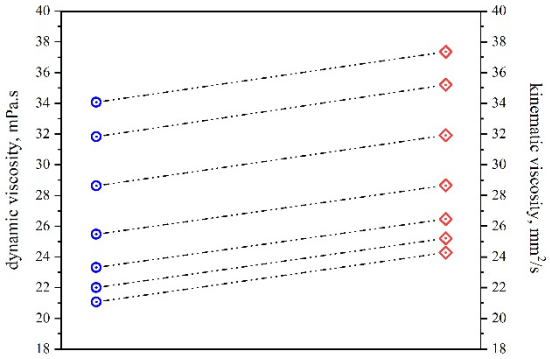

Fig. 3. Relationship between dynamic and kinematic viscosity of unrefined medium oleic sunflower oil.

The decrease in viscosity with increasing temperature a dependence was observed in vegetable oils [30].

The influence of temperature on the change of other physicochemical parameters in different vegetable oils, such as density, dynamic viscosity and others, have been studied by several authors [14, 18, 19]. Confirming our results were found and according [30-32].

4 Conclusion

The chemical composition of unrefined sunflower oil was studied. The main biological activity substances are: fatty acids – oleic (56.5%), linoleic (31.7%), palmitic (6.4%), and stearic acid (3.2%), sterols – *β*-sitosterol is (84.0%), tocopherols – α-tocopherol (100%).

Some physicochemical parameters were measured at seven temperatures (from 20 to 80°C). The obtained data will be used and apply at different foods.

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