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Physicochemical parameters and antioxidant activity of summer savory essential oil (*Satureja hortensis* L.)

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Abstract. Summer savory (*Satureja hortensis* L.), Lamiaceae family, was used in folk medicine and food industry, and the resulting essential oil was used to flavor various food products, as well as a biologically active substance in cosmetics. The aim of the present work was the determination of the physicochemical parameters surfase tension and density of summer savory essential oil, obtained by steam distillation under industrial conditions, at four different temperatures 10, 20, 30 and 40°C. The temperature dependence of the two physicochemical parameters shows that the values for density were in the range of 0.921 g/cm^3 at 10°C to 0.898 g/cm^3 at 40°C, and for surface tension from 31.68 mN/m at 10°C to 27.51 mN/m at 40°C, respectively. The antioxidant activity was also determined on the summer savory essential oil by four methods DPPH (0.50 mM TE/mL), FRAP (1.23 mM TE/mL), ABTS (0.54 mM TE/mL), and CUPRAC (2.91 mM TE/mL). The investigation of these parameters and properties were a prerequisite for further studies on the application of summer savory essential oil in various food products.

1 Introduction

Plants of the genus *Satureja*, family Lamiaceae are annual or perennial herbaceous plants and small shrubs, with about 30 species. In our country the most common are species *Satureja hortensis* L., *S. montana* L., *S. pilosa* Vel. and others. They are mainly used in folk medicine and for flavoring various food products [1].

All species contain essential oil, and their chemical composition were studied by a number of authors. Its composition depends on the type, geographical and climatic features and the way of processing [1-3].

Summer savory is a new for our country essential oil culture, from which in industrial conditions essential oil is obtained [4].

The main components of the essential oil are: phenols carvacrol (14.3-77.6%) and thymol (0.01-46.0%), monoterpene alcohol linalool (up to 26.0%), monoterpene hydrogen γ-terpinene (7.6-52.9%), aromatic hydrogen *p*-cymene (2.8-16.0%), *etc.* [1-6].

The essential oil has proven antimicrobial and antioxidant properties that is why it is used as an additive in food, pharmaceutical and cosmetic products [1-6].

The authors explain these biological properties by the content of the phenols carvacrol and thymol.

Of interest is also the definition of certain physicochemical indicators, for example surface tension and density, which have their influence on the storage and application of essential oil.

The values of these two indicators were determined in aromatic substances and oils other than the essential oil studied. The surface tension data of various essential oils and their solutions in organic solvents were published in the literature [7-10].

Therefore, the aim of the present work is the determination of the physicochemical indicators surface tension and density of the summer savory essential oil as well as its antioxidant activity.

The investigation of these parameters and properties was a prerequisite for further studies on the application of this essential oil in various food products.

2 Materials and methods

2.1 Raw materials

The commercial summer savory essential oil was used in this study, provided by a producer in the vicinity of the city of Plovdiv.

The main compounds of the commercial summer savory essential oil were (up to 3%): phenol carvacrol (63.71%), monoterpene hydrocarbon γ-terpinene (20.47%), and aromatic hydrogen *p*-cymene (5.08%) [4].

2.2 Determination of physicochemical parameters

Surface tension is determined by equation (1) [11].

$$\gamma = (rg/2)(\Delta H\rho_O - r\rho) \quad (1)$$

where: r – radius of the capillary (m); g – acceleration of gravity (m/s^2); ΔH – the maximum difference in the two gauges of the gauge; ρ_0, ρ – density of the manometric (water) and test liquid (g/cm^3).

The density of the test liquid is determined by equation (2) [11].

$$\rho = \frac{m1-m}{V} = \frac{m1-m}{\frac{m1-m}{\rho 1}} = \frac{m1-m}{m2-m}\rho 1 \quad (2)$$

where: ρ – the density of the carvacrol (g/cm^3); ρ_1 – the density of distilled water (g/cm^3); m – mass of the pycnometer (g); m_1 – mass of the pycnometer with the carvacrol (g); m_2 – mass of the pycnometer with distilled water (g).

The physicochemical parameters were measured at four different temperatures (10, 20, 30, and 40°C), which were most often used in applying essential oils in various food products.

2.3 Antioxidant activity

Antioxidant activity was measured by four different methods:

DPPH assay. The method was described by Misharina [12].The results were expressed as µmol Trolox equivalents per mL essential oil (mM Trolox Equivalent (TE)/mL).

ABTS assay. The method was described by Re et al. [13]. The results were expressed as µmol Trolox equivalents per mL essential oil (mM TE/mL).

FRAP assay. The method was described by Benzie and Strain [14]. The Trolox equivalent antioxidant capacity was plotted as µmol Trolox equivalents per mL essential oil (mM TE/mL).

CUPRAC assay. The method was described by Apak et al. [15]. The Trolox equivalent antioxidant capacity was plotted as µmol Trolox equivalents per mL essential oil (mM TE/mL).

2.4 Statistical analysis

The experiment was provided with three parallel analysis and presented as ± standard deviation values. Statistical analysis was carried out using Excel software.

3 Results and discussion

The distribution of oxygen derivatives by functional group (% of their sum) is presented in Fig. 1. The data show that phenols (98.08%) are predominant, followed by alcohols (1.24%), oxides (0.36%) and ketones (0.29%).

3.1. Physicochemical properties

Surface tension and density at lower temperatures were measured because hydrocarbons were present in the oil composition (Fig. 1) which changed at higher values.

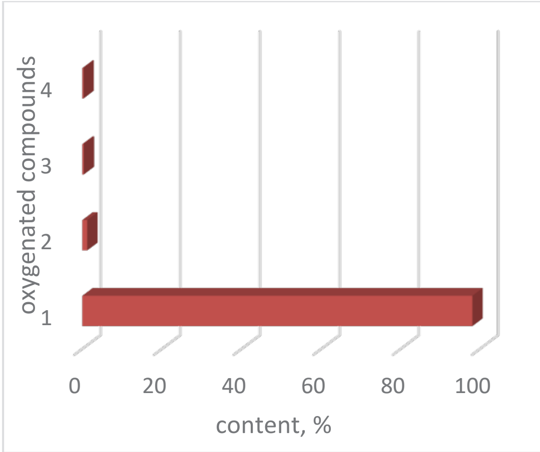

Fig. 1. Oxygenated compounds, %. 1 – phenols; 2 – alcohols; 3 – oxides; 4 – ketones

The temperature dependence on the surface tension is presented in Fig. 2. The data show that the values range from 31.68 mN/m at 10°C to 27.51 mN/m at 40°C. With increasing temperature, a smooth decrease of the surface tension values is found and the relationship between the two quantities found to be linear.

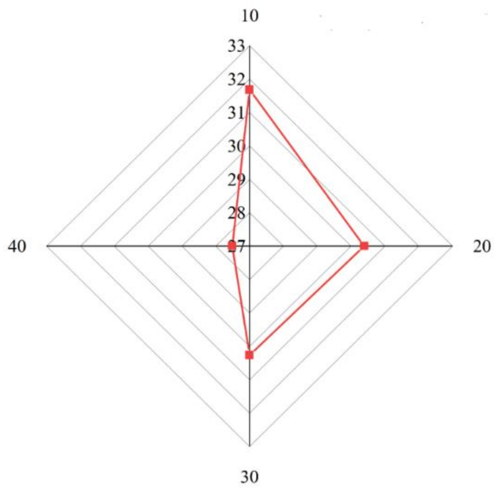

Fig. 2. Temperature dependence of surface tension in commercial summer savory essential oil

This confirms data from the literature on a linear relationship between temperature and surface tension also found for other substances [16].

The lower surface tension values of the essential oil studied compared to those of carvacrol [17] can be explained by the content of hydrocarbons that are directly related to this indicator.

The temperature dependence of the density is presented in Fig. 3. The data show that the values range from 0.921 g/cm^3 at 10°C to 0.898 g/cm^3 at 40°C.

They also gradually decrease with increasing temperament, as the dependence between the two quantities again is found linear. This confirms data from literature on a linear temperature-density relationship also found for other substances [16].

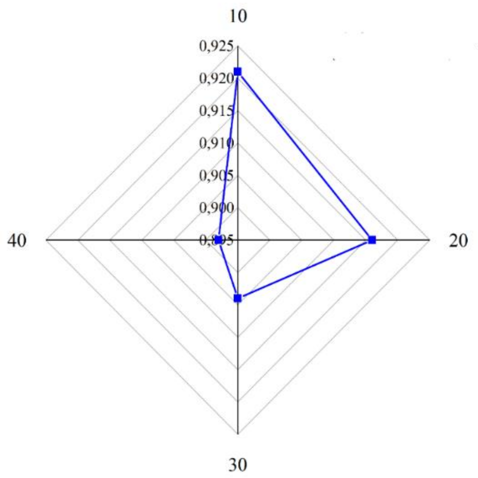

Fig. 3. Temperature dependence of density in commercial summer savory essential oil

No comparison can be made with the data of other authors who examined the temperature dependence of these indicators due to the different chemical composition of both essential oils and their main components – oxygenated monoterpenes linalool and linalyl acetate [18-20]. The main compound in the investigated summer savory essential oil was phenol carvacrol.

3.2. Antioxidant activity

The dependence of the investigated concentrations of commercial essential oil of summer savory (0.5; 5; 12.5; 25 and 50 µL/mL) on DPPP radical values and the resulting equation were presented in Fig. 4.

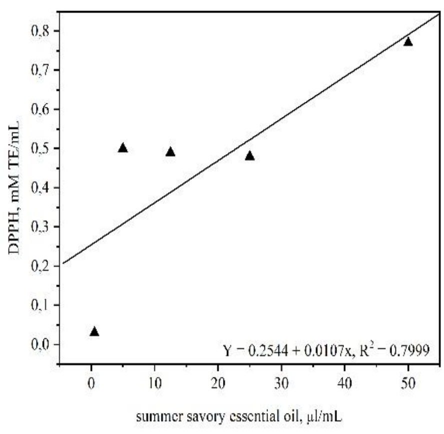

Fig. 4. Antioxidant activity of commercial summer savory essential oil against the DPPH radical

From the data, it is estimated that the IC_{50} was 30.6 µL/mL. Najafian and Zahedifar [21] also showed good DPPH-inhibitory effect, with IC_{50} ranging from 0.363 g/L to 0.720 g/L.

This value differs from those published in the literature: 8.47-8.67 µg/mL [22], 23.76 µg/mL [23] and 277.94 µg/µL [24], explained by the different composition of essential oils.

The antioxidant capacity of the studied essential oil (concentration 5 µl/mL) was determined against three other radicals, and the results are presented in Table. 1.

Table 1. Antioxidant activity of summer savory essential oil (5 µl/mL)

Summer savory essential oil	Methods for analysis, mM TE/mL			
	DPPH	ABTS	FRAP	CUPRAC
	0.50±0.03	0.54±0.00	1.23±0.10	2.91±0.20

The data show that the values differ, explained by the different principle of methods. Metal reducing methods (FRAP and CUPRAC) based on electron transferee shows higher antioxidant potential of their isolated essential oil. The highest activity is evaluated by CUPRAC method - more than 5 times higher activity than the hydrogen transferee based methods.

4 Conclusion

For the first time, physicochemical indicators surface tension and density of summer savory essential oil were determined at four different temperatures (10, 20, 30, and 40°C).

Summer savory essential oil was a suitable addition for food products due to its stability and antioxidant activity.

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