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Intraspecific variability of wild thyme (*Thymus serpyllum* L.) occurring in Poland

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A B S T R A C T

The purpose of the study was to assess the variability between 16 wild thyme populations introduced into *ex situ* conditions, in terms of morphological traits and chemical profiles. The observations were carried out on 2-year-old plants. Total content of essential oil and phenolic compounds (flavonoids, phenolic acids and tannins) was determined according to Polish Pharmacopoeia 6th. The composition of essential oil was carried out by GC/MS and GC/FID. Populations differed in respect of examined traits, i.e.: plant's height (from 50 to 90 mm), plant diameter (from 21.3 to 53.0 cm), length of stems (from 8.1 to 20.5 cm). Fresh mass of herb per plant ranged from 36.0 to 307.0 g, while dry mass from 15.63 to 73.11 g (CV 55.0 and 47.5%, respectively). Total content of essential oil varied from 0.23 to 0.97%. Three chemotypes were distinguished within investigated populations: geranyl acetate + β-terpineol + β-myrcene, geranyl acetate + β-terpineol + borneol and pure linalool type. The total content of phenolic compounds ranged, as following: flavonoids (0.17–0.26%), tannins (0.57–1.32%), phenolic acids (0.28–0.61%). To sum up, investigated populations differed significantly in respect of developmental features as well as content and composition of identified compounds. Obtained results may be used in future works on selection and breeding of wild thyme, providing a high-quality raw material characterized by specific chemical composition and pharmacological activity.

1. Introduction

The genus *Thymus* is represented by 214 species and 36 subspecies. Very common hybridization, especially when two or even more species live together makes taxonomic studies on *Thymus* very difficult (Morales, 2002). Taking into consideration phylogenetic and evolutionary criteria the genus was divided into 8 sections, i.e. *Micantes*, *Mastichina*, *Piperella*, *Teucrioides*, *Pseudothymbra*, *Thymus*, *Hyphodromi* and *Serpyllum* (Jalas, 1971). The last section is one of the most diverse, with the widest chromosomal variation. It comprises around 120 species divided into 8 subsections, including *T. serpyllum* (2n = 24, 26) which is a typical European species of subsection *Serpyllum* (Morales, 2002). Three subspecies distinguished within *T. serpyllum* were identified in Poland, namely: *serpyllum*, *pycnotrichum* (Uechtr.), and *lanuginosus* (Mill) Ronn. The first one includes many botanical varieties and is the most typical for our country. The other two are very rare. *T. serpyllum* subsp *pycnotrichum* was recorded at individual sites in the western part of Lower Silesia, while *T. serpyllum* ssp. *lanuginosus* was found only in the vicinity of Bystrzyca Kłodzka in Lower Silesia (Pawłowski, 1967).

T. serpyllum (wild thyme) is a perennial with creeping stems, woody at the base, with tendency to rooting, especially in the nodes. The stems are quadrangular, with a sparse pubescence. The leaves are small, usually rounded at the top and tapered at the base (3–10 mm long and 1–3 mm wide), glabrous on both sides. At the base along the edge they are covered with glandular trichomes containing essential oils. Flowers, with pink corolla, grows in clusters at the top of older stems, forming inflorescences. As other *Thymus* species, *T. serpyllum* presents gynodioecy, i.e. it produce two types of individuals, one with female flowers, and the other with hermaphrodite ones. It blooms from the end of May to September. The plant occurs mainly on dry, sandy soils especially at the edges of coniferous forest or on open spaced river banks as well as on poor grasslands (Stahl-Biskup and Saez, 2002).

T. serpyllum herb (*Serpylli herb*) is a pharmacopoeial medicinal raw material. It has been used in official and traditional medicine of Europe for centuries. The biological activity of the herb results from the presence of essential oil (from 0.1 to 1%) and phenolic compounds, namely: flavonoids, phenolic acids and tannins. According to European Pharmacopeia (Ph. Eur.) (2008) the raw material is standardized on the content of essential oil (not less than 3.0 ml/kg^{-1}). Usually *T. serpyllum*

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essential oil is rich in carvacrol (up to 20–40%). It also contains thymol (1–5%), and smaller amounts of p-cymene, γ-terpinene, borneol, geraniol, citral, bornyl acetate, 1,8-cyneole, linalool, α-terpineol, β-caryophyllene (Wichtl, 2004; De Lisi et al., 2011). The species is characterized by chemical polymorphism. According to major components of essential oil, among *T. serpyllum* several chemotypes have been distinguished (Jarić et al., 2015). The most desired, from pharmacological point of view, are those with high content of thymol and carvacrol. Both compounds are monoterpenic phenols with distinct antiseptic activity.

Nowadays *Serpylli herb* is used for the production of syrups, tinctures, and tea preparations. Similarly to common thyme (*Thymus vulgaris* L.) it is applied internally as an expectorant and bronchospasmolytic. It increases the mucus secretion and reveals high antiseptic and antimicrobial effects (Nabavi et al., 2015; Nikolić et al., 2014; Pinto et al., 2006; Rasooli and Mirmostafa, 2002). In folk medicine, it is used as stomachic, carminative, diaphoretic and diuretic in bladder and kidney disorders (Wichtl, 2004). According to relatively high content of phenolic compounds it shows antioxidant activity, as well. The species is also valued due to its ornamental features and high production of pollen, eagerly collected by bees (Lewandowski, 1997).

Currently in European countries, *T. serpyllum* has become the subject of many works especially regarding chemical diversity and activity of local populations of the plant (De Lisi et al., 2011; Raal et al., 2004; Jarić et al., 2015; Menkovic et al., 2011). Recent publications on *T. serpyllum* populations originating from Poland show only fragmentary information on their botanical identification, selected data on specific morphological traits (Pióro-Jabrucka and Suchorska-Tropiło, 2003, 2004) as well as chemical composition of essential oils and their sensory value (Pióro-Jabrucka et al., 2006; Pióro-Jabrucka and Suchorska-Tropiło, 2005). Nerveless, there is only little data concerning intraspecific diversity of *T. serpyllum* in Poland (Węglarz et al., 2009; Pióro-Jabrucka and Osińska, 2003).

It is worth noting that Poland is one of the largest producers of herbal raw materials in Europe, including those originating from natural sites. The region where such plants are collected in the highest amounts is eastern part of the country. It is also considered as the most ecologically clean, with the highest biodiversity level. The tradition of harvesting medicinal plants from the wild is very old and still vivid in there.

The aim of this work was to determine the intraspecific variability of *T. serpyllum* occurring in eastern part of Poland. The objects of this work (populations that constitute germplasm collection) were transferred into *ex situ* conditions and described in terms of their morphological, developmental and chemical traits according to descriptors list developed by European Cooperative Programme for Plant Genetic Recourses, Medicinal and Aromatic Plants Working Group (ECPGR MAPs WG) (http://www.ecpgr.cgiar.org/working-groups/medicinal-and-aromatic-plants/, 2018).

2. Materials and methods

2.1. Plant material

In 2014, 16 wild thyme populations were identified in the eastern part of Poland (Table 1). From each population (accession) vegetative cuttings were taken to establish field collection. The cuttings were obtained from 25 randomly chosen mother plants, from each population separately. The collection site was located at the experimental field of Department of Vegetable and Medicinal Plants, Warsaw University of Life Sciences - SGGW (WULS-SGGW). On a single plot 25 cuttings at were planted out, in 60 × 40 spacing. The seeds of the populations were collected from natural sites, too. They were transferred to National Centre for Plant Genetic Resources (Polish Gene Bank).

2.2. Morphological and developmental characteristics

The characterization and evaluation of the objects was performed in 2016, on 2-year-old plants, according to the Descriptor List for *T. serpyllum* L., developed by the members of ECPGR MAPs WG. The observations were made on 15 randomly chosen plants per accession. Before the harvest of herb (July 2016) the following parameters were measured: plant height (mm), plant diameter (cm), foliage density, stem length (cm), leaf shape, length and width of leaf blade (mm), fresh and dry mass of herb (g). Other developmental and morphological traits were determined too, namely: length of flowering period (days), length of flowering stem (cm) and flowering part on a stem (mm), inflorescence shape, flower length (mm), corolla colour and length (mm). The herb was dried at 35 °C. After dry weight measurements it was mixed to obtain bulk sample per population. The herb was subjected to chemical analysis. Each analysis was performed in three replications.

2.3. Chemical analysis of essential oils

2.3.1. Hydrodistillation

The total content of essential oil was determined according to Polish Pharmacopoeia 6th (2002) with modifications. Air-dried raw material (100 g) was submitted to hydrodistillation for 3 h using Deryng-type apparatus. Obtained essential oils were stored in dark vials, at 4 °C.

2.3.2. Qualitative and quantitative analysis of essential oils

The qualitative analysis was carried out by GC–MS (gas chromatography – mass spectrometry), while the quantitative by GC-FID (gas chromatography – flame ionization detector). Both methods were described in our previous article (Bączek et al., 2015). All measurements were performed in triplicate.

2.4. Determination of total content of phenolic compounds

The total content of flavonoids (expressed as quercetin equivalent, g/100 g), phenolic acids (expressed as caffeic acid equivalent, g/100 g) and tannins (expressed as pyrogallol equivalents, g/100 g) were determined as described in the Polish Pharmacopoeia 6th (2002). All measurements were performed in triplicate.

2.5. Statistical analysis

Statistica® software was used to analyze the obtained results. The mean values were compared using a one-way analysis of variance (ANOVA) with application of the Tukey test ($P < 0.05$). The coefficient of variation (CV) was determined, too.

3. Results and discussion

In our study 16 wild growing populations introduced into *ex situ* conditions were evaluated. This treatment was applied to exclude soil variability and climatic differences occurring at the natural sites of these plants. In the second year of vegetation the plants grew up to 9 cm high. They formed compact clumps, ranged from 21.3 to 53.0 cm in diameter (Table 2). Numerous shoots of these plants, in their lower part formed roots. This makes the shoots creeping. Thus, in the following years the plants completely covered the soil surface. The length of the stems of investigated plants ranged from 8.1 to 20.5 cm. The leaves were elliptical, oval or spathulate. The length of the leaf blade varied from 4 to 8 mm and width from 2 to 5 mm. Among the analyzed morphological traits, the highest diversity was observed for fresh and dry mass of herb (CV 55.0 and 47.5%, respectively). Fresh mass of the herb ranged from 36.0 to 307.0 g per plant, and dry from 15.63 to 73.11 g per plant. The population Frampol 2 was distinguished by the highest mass of raw material (Table 2). According to the fact that the content of biologically active compounds in *T. serpyllum* herb is the highest during

Table 1
Geographical location of natural sites of wild thyme populations.

Population no.	Name of the natural site / population	Accession no.	Coordinates		Voivodeship
1	Drohiczyn Wąwóz	401279	N 52°23′021″	E 22°40′334″	podlaskie
2	Frampol 1	401207	N 52°24′683″	E 22°33′593″	podlaskie
3	Bonin	401265	N 52°14′732″	E 23°01′835″	podlaskie
4	Siemiatycze	401267	N 52°23′719″	E 22°53′218″	podlaskie
5	Drohiczyn	401264	N 52°23′555″	E 22°38′449″	podlaskie
6	Frampol 2	401263	N 52°25′054″	E 22°34′991″	podlaskie
7	Zdory	401262	N 53°42′012″	E 21°45′215″	warmińsko-mazurskie
8	Pruszkowo	401270	N 52°65′253″	E 20°51′670″	mazowieckie
9	Miszewo	401271	N 52°64′817″	E 20°61′760″	mazowieckie
10	Czarnów 1	401268	N 52°03′062″	E 21°06′124″	mazowieckie
11	Czarnów 2	401269	N 52°03′031″	E 21°06′202″	mazowieckie
12	Skowronno	401274	N 50°32′143″	E 20°30′591″	świętokrzyskie
13	Podłęże	401277	N 50°34′431″	E 20°34′054″	świętokrzyskie
14	Szczypiec	401276	N 50°33′445″	E 20°34′516″	świętokrzyskie
15	Chruścice	401275	N 50°33′125″	E 20°35′551″	świętokrzyskie
16	Skrzypiów	401278	N 50°29′375″	E 20°30′236″	świętokrzyskie

the flowering stage, the length of this period was noted. Among the analyzed populations, it varied from 20 to 28 days. The length of flowering stems ranged from 5 to 10 cm, and the flowering part at this stem was 10-30 mm long. The inflorescence was capitate, sub-capitate or cylindrical and the flowers (up to 6 mm long) were pale lilac or pale pink (Table 3). According to Węglarz et al. (2009) the intraspecific morphological variability among Polish *T. serpyllum* is relatively low. Our results confirm that statement only concerning specific features, like plant height or leaf length. The coefficient of variation (CV) for those traits does not exceeded 20%. More diversified were plant diameter and length of stems (CV 30.1 and 29.6%, respectively). As it was mentioned before, fresh and dry mass of herb differentiated examined populations at the highest degree (Table 2).

The content of the essential oils in the herb ranged from 0.23 (population Siemiatycze) to 0.97 g/100 g (population Frampol 2) (Table 4). Both, the content and composition of *Thymus* essential oil can be extremely diversified depending on the origin of the raw material, the developmental stage of the plant, the harvest term and postharvest treatment (Stahl-Biskup and Saez, 2002). According to the Ph. Eur. (2008), the total content of essential oil in wild thyme should not be lower than 3 ml/kg. Earlier works on Polish *T. serpyllum* populations show the value from 0.31 to 0.64% (Pióro-Jabrucka and Suchorska-Tropiło, 2003). Wichtl (2004) provided the values from 0.1 to 0.6%, while the results given by Raal et al. (2004), concerning wild Estonian populations, indicate the content ranged from 0.6 to 4 ml/kg. In the present study, 32 compounds were identified (Table 5). In most analyzed essential oils the dominant compounds were: β-myrcene, β-terpineol, borneol and geranyl acetate. Due to the major compounds in essential oil among the examined populations three chemotypes can be distinguished, i.e. geranyl acetate + β-terpineol + β-myrcene (populations: Podłęże, Skrzypiów, Skowronno and Siemiatycze), geranyl acetate + β-terpineol + borneol (populations: Drohiczyn Wawóz, Drohiczyn, Zdory) and linalool type (population Frampol 2). The other analyzed essential oils were diversified in the type of dominant compound, e.g. one accession (population Chruścice) was characterized by high share of neral (citral b) (16.55%) and citronellol (23.87%), another one (population Miszewo) by caryophyllene oxide (10.67%). In the case of *T. serpyllum*, the biological activity of the raw material is related not only to the content of the essential oil, but also to its composition. The most sought-after wild thyme forms are those with high content of carvacrol and thymol. Similarly to populations from Lithuania and Estonia, both compounds were not the principle components of the investigated Polish forms, what was also observed earlier by Pióro-Jabrucka et al. (2007). High content of thymol was detected in

Table 2
Morphological and developmental characteristics of *T. serpyllum* populations, (N = 15)*.

Name of population	Plant height (mm)	Plant diameter (cm)	Foliage density	Stem length (cm)	Leaf shape	Length of leaf blade (mm)	Width of leaf blade (mm)	Fresh mass of herb per plant (FW g)	Dry mass of herb per plant (DW g)
Drohiczyn Wąwóz	70 b	42.4 ab	Medium	19.3 a	Spathulate	6 b	3 b	148.0 b	40.51 b
Frampol 1	90 a	52.5 a	Medium	20.4 a	Ovate	8 a	5 a	117.0 bc	28.97 c
Bonin	70 b	53.0 a	Sparce	15.1 ab	Spathulate	7 a	3 b	239.0 a	56.89 a
Siemiatycze	70 b	39.6 b	Medium	13.7 b	Ovate	4 b	2 b	180.0 ab	44.37 b
Drohiczyn	60 c	33.6 c	Sparce	14.8 b	Ovate	8 a	4 a	147.0 b	40.37 b
Frampol 2	90 a	38.5 b	Dense	18.5 a	Spathulate	6 b	3 b	307.0 a	73.11 a
Zdory	70 b	48.3 a	Sparce	11.5 c	Spathulate	5 b	3 b	160.0 ab	41.25 b
Pruszkowo	60 c	33.0 c	Sparce	8.6 d	Ovate	6 b	3 b	144.0 b	31.92 c
Miszewo	70 b	25.5 d	Sparce	8.7 d	Ovate	7 a	3 b	55.0 c	15.63 d
Czarnów 1	60 c	26.3 d	Sparce	13.8 b	Elliptic	7 a	2 b	72.0 c	20.92 cd
Czarnów 2	50 cd	25.7 d	Sparce	9.4 d	Elliptic	8 a	3 b	103.0 bc	29.82 c
Skowronno	50 cd	26.1 d	Sparce	13.2 b	Ovate	6 b	3 b	83.0 c	22.84 cd
Podłęże	70 b	21.3 de	Sparce	8.1 d	Elliptic	8 a	2 b	36.0 d	16.44 d
Szczypiec	90 a	26.0 d	Sparce	17.7 ab	Elliptic	6 b	2 b	71.0 c	19.59 d
Chruścice	80 ab	24.4 d	Medium	20.5 a	Elliptic	8 a	3 b	68.0 c	18.64 d
Skrzypiów	90 a	34.1 c	Sparce	16.3 ab	Elliptic	7 a	3 b	136.0 b	30.55 c
mean	71	34.4		14.4		7	3	129	33.24
CV	19.1	30.1		29.6		17.9	26.3	55.0	47.5

$P < 0.05$.
* Measurements from 15 plants in each population.

Table 3
Morphological and developmental characteristics of *T. serpyllum* populations, (N = 15)*.

Name of population	Length of flowering period (days)	Length of flowering stem (cm)	Length of the flowering part (mm)	Inflorescence shape	Flower length (mm)	Corolla color	Corolla length (mm)
Drohiczyn Wąwóz	28	7 b	15 c	Sub-capitate	6 a	Pale pink	3 a
Frampol 1	23	9 a	15 c	Capitate	6 a	Pale lilac	4 a
Bonin	21	7 b	30 a	Cylindrical	6 a	Pale pink	3 a
Siemiatycze	21	7 b	15 c	Sub-capitate	4 b	Pale pink	3 a
Drohiczyn	28	6 c	15 c	Capitate	6 a	Pale lilac	4 a
Frampol 2	28	9 a	15 c	Sub-capitate	4 b	Pale lilac	2 b
Zdory	27	6 c	15 c	Sub-capitate	4 b	Pale pink	2 b
Pruszkowo	23	6 c	10 d	Capitate	3 b	Pale lilac	3 a
Miszewo	20	7 b	10 d	Capitate	6 a	Pale lilac	3 a
Czarnów 1	20	7 b	10 d	Capitate	5 ab	Pale lilac	3 a
Czarnów 2	20	5 c	20 b	Capitate	7 a	Pale lilac	4 a
Skowronno	20	5 c	15 c	Capitate	6 a	Pale lilac	4 a
Podłęże	20	7 b	15 c	Capitate	5 ab	Pale lilac	3 a
Szczypiec	22	10 a	15 c	Capitate	5 ab	Pale lilac	3 a
Chruście	22	8 a	15 c	Capitate	5 ab	Pale lilac	3 a
Skrzypiów	27	9 a	10 d	Capitate	5 ab	Pale lilac	3 a
Mean	23	7	15		5		3
CV	14.2	20.5	32.2		20.2		19.8

$P < 0.05$.
* Measurements from 15 plants in each population.

Table 4
Chemical characteristics of *T. serpyllum* populations – total content of analyzed compounds in dry herb (g/100 g DW), N = 3*.

Name of population	Essential oil	Flavonoids	Phenolic acids	Tannins
Drohiczyn Wąwóz	0.85 a	0.20 b	0.48 b	0.64 c
Frampol 1	0.50 b	0.21 b	0.47 b	0.85 b
Bonin	0.37 c	0.18 b	0.58 a	1.17 a
Siemiatycze	0.23 c	0.20 b	0.47 b	1.14 a
Drohiczyn	0.60 b	0.22 b	0.51 b	1.11 a
Frampol 2	0.97 a	0.21 b	0.54 b	1.32 a
Zdory	0.27 c	0.21 b	0.47 b	0.77 bc
Pruszkowo	0.35 c	0.19 b	0.52 b	1.08 ab
Miszewo	0.40 c	0.17 bc	0.51 b	0.72 bc
Czarnów 1	0.65 b	0.20 b	0.61 a	0.80 b
Czarnów 2	0.83 a	0.20 b	0.59 a	0.82 b
Skowronno	0.85 a	0.21 b	0.60 a	0.97 ab
Podłęże	0.35 c	0.18 b	0.54 b	0.86 b
Szczypiec	0.35 c	0.18 b	0.43 bc	1.00 ab
Chruście	0.30 c	0.19 b	0.49 b	0.80 b
Skrzypiów	0.50 b	0.26 a	0.28 d	0.57 c
Mean	0.52	0.20	0.51	0.91
CV	45.7	10.5	15.9	22.8

$P < 0.05$.
* Three repetitions for chemical analysis.

population form Pakistan (53.3%), India (64.6%), and Southern Italy (34.99%) (De Lisi et al., 2011; Ahmad et al., 2006; Puri et al., 1985). Other population, also from Pakistan, was described as rich in carvacrol (44.4%) (Hussain et al., 2013). Low content of both compounds in populations from Poland may be combined with the phenomena described earlier for *T. vulgaris*. Thymol and carvacrol, phenolic compounds of high biological activity, dominate in *T. vulgaris* chemotypes originated from hot and dry sites of Western Europe, whereas non-phenolic ones grow in cooler and wetter climate (Thompson, 2002). It was also observed that non-phenolic forms of the species suffer less due to low temperatures than phenolic types. This factors may similarly influence *T. sepyllum* populations. Although the analyzed essential oils are not rich in above mentioned phenolic compounds, due to diverse composition, they may be used in phytopharmaceutical or cosmetic industry, as well as in agriculture practice. It was shown that linalool-rich essential oils reveal sedative, antioxidant and anti-inflammatory actions. They have strong effect against *Leishmania amazonensis* (Rosa et al., 2003; Aprotosoaie et al., 2014; Peana et al., 2002). In turn, β-terpineol and citral are considered as antifungal drugs, citronellol may be applied against some dermatophytosos (Pereira et al., 2015), terpineol was distinguished as a potential insecticidal agent (Isman, 2000), whereas β-myrcene and camphor demonstrate antifungal activity against *Botrytis cinerea* (Wilson et al., 1997). Some *T. serpyllum* essential oils components of antibacterial activity may be also used as natural food preservatives in food industry (Kaĉàniovà et al., 2016).

T. serpyllum herb contains flavonoids, phenolic acids and tannins (Wichtl, 2004). The analyzed populations were rather uniform in the total content of the first two groups of substances. The content of flavonoids ranged from 0.17 to 0.26 g/100 g (CV 10.5%), whereas phenolic acids from 0.28 to 0.60 g/100 g (CV 15.9%) (Table 4). In contrary, Węglarz et al. (2009) showed a higher level of phenolic acids in *T. serpyllum* herb (0.46–1.17 %). Up to now among flavonoids luteolin, and its glucosides as well as kaempferol and apigenin glucosides were identified in *T. serpyllum* herb. Among phenolic acids gallic, protocatechuic, caffeic, chlorogenic, ferulic and rosmarinic acids were distinguished (Sonmezdag et al., 2016). According to Vila (2002) the content of flavonoids in *Thymus* species is related to altitude. The higher the altitude the lower the content of those compounds. Our study was carried out in uniform *ex situ* conditions. Thus, such relation was not observed. The content of flavonoids was rather stable and low in analyzed populations. Higher diversity among investigated populations was observed when regards total tannin contents (CV 22.8%). Similarly to essential oils, the highest concentration of those substances was observed for population Frampol 2 (1.32 g/100 g) (Table 4).

4. Conclusions

The obtained results showed significant differences among investigated Polish *T. serpyllum* populations, both in respect of developmental features as well as content and composition of identified compounds.

The mass of herb differentiated examined populations at the highest degree, while in the case of chemical traits – it was essential oil content and composition. Population Frampol 2 was characterized by the highest mass of herb. This population, recognized as pure linalool chemotype, was distinguished also by the highest content of essential oil and tannins in herb. Examined populations were characterized with rather low content of thymol and/or carvacrol. Nevertheless, due to high diversity in the content and composition of essential oils, they may

Table 5
The composition of essential oils (% peak area).

Identified compounds		geranyl acetate + β-terpineol + β-myrcene type				geranyl acetate + β-terpineol + borneol type			linalool type	other types							
	RI	Podłęże	Skrzypiów	Skowronno	Siemiatycze	Drohiczyn W	Drohiczyn	Zdory	Frampol 2	Bonin	Czarnów 1	Czarnów 2	Pruszkowo	Chruścice	Miszewo	Szczypiec	Frampol 1
α-thujene	1013	0.03	0.14	0.14	0.18	0.01	0.04	0.05	0.00	0.12	0.07	0.10	0.02	0.01	0.06	0.08	0.02
α-pinene	1028	0.67	3.44	1.52	2.91	0.43	0.88	0.90	0.07	1.87	1.02	1.21	0.53	0.41	1.35	2.09	0.46
camphene	1088	0.34	4.80	0.15	2.71	0.04	1.88	2.49	0.12	4.19	0.01	3.76	0.98	0.56	0.02	2.38	1.39
β-pinene	1113	0.11	2.30	0.47	0.70	0.06	0.33	0.38	0.02	0.53	0.41	0.45	0.18	0.18	1.39	1.47	0.24
sabinene	1124	0.04	1.74	0.60	0.01	0.08	0.39	0.09	0.04	0.15	0.32	0.66	0.75	0.31	1.15	1.09	0.33
β-myrcene	1166	16.19	11.22	10.22	11.28	8.09	3.75	5.54	0.61	11.29	10.45	8.25	5.23	0.96	9.42	15.71	2.88
α-terpinene	1182	0.08	0.13	0.08	0.04	0.03	0.02	0.05	0.00	0.01	0.06	0.08	0.11	0.31	0.02	0.08	0.06
1.8 cineole	1203	0.13	1.20	0.39	0.14	1.02	0.07	0.06	0.03	0.23	0.33	0.10	0.11	0.32	0.75	10.21	0.86
limonene	1209	0.75	0.02	0.98	0.92	0.66	0.74	0.30	0.15	0.79	0.80	0.87	0.42	0.83	0.72	0.96	0.22
γ-terpinene	1248	2.64	0.25	1.04	0.16	0.19	0.07	0.10	0.47	0.13	0.81	1.01	0.82	0.62	0.03	3.69	0.15
p-cymene	1273	0.19	5.27	0.08	2.66	3.83	4.08	0.41	0.06	10.57	0.16	0.27	6.37	1.76	0.62	0.26	1.56
α-terpinolene	1278	0.14	0.15	0.14	0.19	0.38	0.09	0.06	0.07	0.11	0.12	0.11	0.42	0.34	0.99	0.11	0.30
octen-3-ol	1431	0.87	1.66	2.19	1.23	2.30	1.74	0.53	1.03	1.67	1.53	2.04	1.31	0.27	3.58	1.41	1.85
menthon	1459	0.77	0.58	0.28	0.32	0.57	0.35	0.48	0.11	0.38	0.35	0.49	0.15	2.51	0.78	0.41	1.10
camphor	1509	1.19	0.84	6.80	5.98	4.38	1.94	5.17	0.12	3.72	7.37	5.67	0.42	0.25	3.33	1.48	1.23
linalool	1540	4.30	0.88	0.82	6.21	2.18	1.50	1.06	56.58	0.44	1.82	0.90	3.16	0.71	2.97	1.68	1.56
bornyl acetate	1576	0.77	0.02	0.05	0.02	0.02	0.00	0.05	12.67	0.05	0.05	1.29	0.05	0.00	0.16	0.04	0.05
terpinen-4-ol	1584	0.00	0.76	1.41	0.32	0.68	0.94	1.05	0.14	0.82	0.88	0.00	0.30	0.34	0.56	0.58	1.04
β-terpineol	1622	21.90	15.57	9.76	20.96	10.66	21.53	12.49	4.77	21.28	11.66	11.61	8.79	5.60	6.16	6.64	13.89
α-humulene	1657	0.03	0.72	0.86	0.42	0.56	0.58	1.51	0.02	0.73	0.36	0.83	0.12	0.37	0.12	0.48	0.08
cytral b (neral)	1661	0.14	0.07	2.18	1.69	1.25	1.01	2.28	0.42	1.77	9.68	2.09	0.24	16.55	0.73	1.16	0.03
α-terpineol	1681	0.23	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.00	3.35
borneol	1687	0.61	2.41	0.00	2.96	17.67	18.23	12.68	2.72	9.96	2.50	0.00	21.54	3.32	1.74	7.07	12.67
geranyl acetate	1735	22.90	11.32	11.13	15.91	12.40	17.87	15.26	3.75	11.04	9.50	11.70	18.00	4.33	0.36	9.01	5.54
citronellol	1757	0.18	0.10	0.02	0.08	0.10	0.04	0.34	0.69	0.07	0.12	0.07	3.06	23.87	0.04	0.09	0.06
δ-cadinene	1772	0.12	1.47	0.04	0.19	2.98	1.83	3.27	1.07	1.46	4.50	0.13	0.81	1.02	0.67	3.29	1.64
nerol	1795	0.04	0.04	0.04	0.11	0.06	0.04	0.21	0.03	0.06	0.14	0.01	0.06	3.86	0.04	0.03	0.05
geraniol	1826	0.03	0.02	0.01	0.03	0.25	0.03	2.65	1.04	0.01	0.36	0.01	0.01	0.01	0.07	0.27	0.09
caryophyllene oxide	1955	0.37	1.04	1.18	1.00	1.51	2.83	1.47	0.18	2.26	1.98	0.37	0.20	0.95	10.67	2.14	1.82
nerolidol	2024	0.87	3.19	1.66	1.38	2.02	2.76	0.07	0.30	2.46	1.32	0.13	0.12	0.32	0.38	1.15	2.98
thymol	2163	0.48	0.57	0.02	0.52	5.76	0.54	0.97	0.10	0.50	8.43	0.01	0.26	0.23	1.01	7.69	0.90
carvacrol	2212	1.25	1.67	1.82	1.42	1.90	1.82	3.73	0.24	1.38	1.64	0.24	0.55	1.01	2.71	1.16	2.65

be an interesting source of raw material used in phytopharmaceutical and cosmetic industry or in agriculture practice. The comprehensive characteristics of presented wild thyme populations can provide to better understanding of their potential use as bactericidal, antifungal, insecticidal or antioxidant agents. Results obtained in our study may be used in future investigations concerning selection and breeding of wild thyme, as well.

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