

Monika SPOREK<sup>1</sup>

## ESSENTIAL OILS IN THE NEEDLES OF SCOTS PINE (*Pinus sylvestris* L.)

### WYDAJNOŚĆ OLEJKÓW ETERYCZNYCH Z IGLIWIĄ SOSNY ZWYCZAJNEJ (*Pinus sylvestris* L.)

**Abstract:** The aim of the study was to determine the content of essential oils in pine needles in 3 canopy zones (lower, middle and upper) of model trees, for 3 youngest needle cohorts (1, 2 and 3 years old). The research revealed a clear increase in the content of essential oils from the lower through the middle to the upper part of the crown. The lowest oil content was found in 3-year-old needles (0.40%), while 1-year and 2-year old needles contained 0.48 and 0.49% of oil, respectively.

**Keywords:** essential oil, pine needles, Scots pine

Natural essential oils, the possibility of their isolation and use in various industries, have been receiving increasing attention. Considering the highest share of pine stands in Poland, pine essential oils are of the greatest economic importance in our country. Results of earlier studies on the content of essential oils in needles indicate that their content depends on such factors as tree age, needle age, time of harvest, or atmospheric pollution [1-4].

In Scots pine, the highest concentration of essential oil is found in the needles, but it can also be isolated from shoots, cones, bark and wood. Annual production of the pine oil is about 40 tons, and the leaders are China and Russia. Poland used to be the greatest manufacturer of pine oil in the 1960s and 1970s, with annual production up to 30 tons [5].

The aim of the study was to determine the content of essential oils in the needles of Scots pine (*Pinus sylvestris* L.), divided into 3 cohorts (year 1, 2, and 3), collected from different parts of the crowns (lower, middle and upper zone).

### Material and methods

The study was conducted in a pine stand located in the south-western Poland and characterized by a mountain climate of Sudety.

Study material were pine branches collected in 15 years old pine stands. At each site, 6 model trees were selected, growing in full sun in the fresh mixed mountain forest. The needles were collected from the lower, middle and upper crown of standing trees. The branches were gathered in the morning on rainless days. In the laboratory, the needles were separated from the shoots, divided into three cohorts, and pulverized in a cutting mill. The material was used to determine the content of essential oils by steam distillation. One sample contained 100 g of fresh needles. Distillation time since the boiling point was 70 min.

<sup>1</sup> Ecology and Nature Protection Unit, Independent Chair of Biotechnology and Molecular Biology, Opole University, ul. kard. B. Kominka 6a, 45-032 Opole, Poland, tel. +48 77 401 60 60, email: mebis@uni.opole.pl

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## Results and discussion

The study evaluated the changes in the content of essential oil in the needles of Scots pine, depending on the age of the needles and their location in the crown. Mean content of the essential oils, not accounting for the needle age and location within the crown, was 0.46%, with a minimum of 0.29% and a maximum of 0.72%. The mode for 27 analyzed samples was 0.36%, and the median 0.44%. Variability of mean analysis results reached 25% (Table 1).

Table 1  
Content of the essential oils in the needles of 15 years old Scots pine (*Pinus sylvestris* L.)

Statistical characteristic	Volatile oil content [%]
$\bar{x}$	0.46
SD	0.11
Min	0.29
Max	0.72
Mode	0.36
Median	0.44
Coefficient of variation [%]	25.06

Comparable amounts of the essential oils obtained from pine needles have been reported by other authors [1, 5, 6], although their content is highly variable. According to Głowacki [1], it ranges from 0.3 to 0.7%. Essential oil content depends also on the sampling location. Numerous papers confirmed that pine needles obtained from the positions exposed to air pollution and from locations characterized by different soil type, differed not only in the essential oil content, but also in its chemical composition [2-4, 6-8]. Most authors [1, 9, 10], claim that the needles collected from young trees contain more essential oils. Głowacki [1] showed that mean content of the essential oil in the needles collected from 5 year old pines was 0.54%, in those from 15 year old young stand it was on average 0.52%, and in 100 years old stand it was 0.38%.

In this study, the analysis of the essential oil content was based on the age of the needles. A very similar content was detected in 1 and 2-year old needles, while the 3-year old needles were characterized by the lowest content of water and the oil. Mean oil content in 1-year old needles was 0.48%, in 2-year old needles 0.49%, and in 3-year old needles it amounted to 0.40% (Table 2, Fig. 1).

Table 2  
Content of the essential oils in 1-, 2- and 3-year old needles of Scots pine (*Pinus sylvestris* L.)

Statistical characteristic	Age of needles		
	I 1-year-old	II 2-year-old	III 3-year-old
	Volatile oil content [%]		
$\bar{x}$	0.48	0.49	0.40
SD	0.15	0.09	0.05
Min	0.36	0.29	0.31
Max	0.72	0.63	0.46
Mode	0.36	0.49	0.44
Median	0.38	0.49	0.43
Coefficient of variation [%]	31.7	19.0	13.9

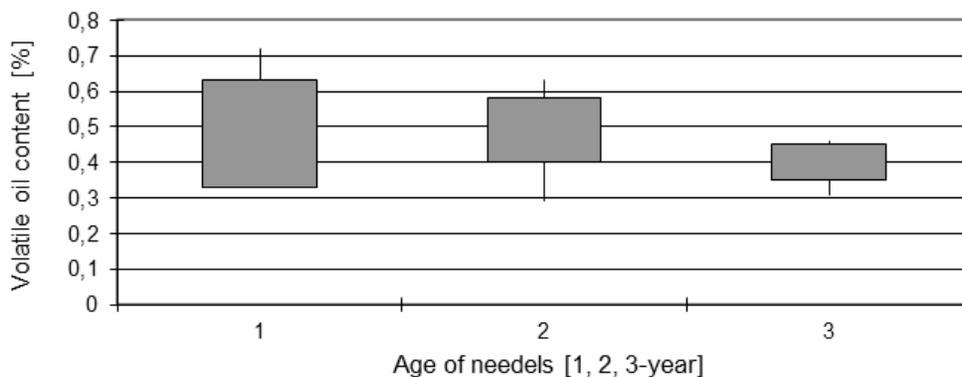


Fig. 1. Volatile oil content of Scots Pine needles in relation to the needles' age

A similar analysis concerning the content of essential oils was performed for the pine needles collected from the lower, middle and upper part of the crown. The age of the stands determines tree growth conditions. Crow density and closure may be very variable, thus providing different light conditions, especially at the crown base. When selecting the model trees, we tried to collect the samples from well-lit crowns, characterized by similar closure, understood as fulfilling the ecological space by the crown. Analysis of the needle samples revealed a linear distribution of the essential oil. The higher the needles were located in the crown, the more essential oils they contained. The oil content in the needles from the lower part of the crown was 0.36%, from the middle part 0.46%, and from the upper part 0.55% (Table 3, Fig. 2).

Table 3  
Content of the essential oils in the needles of Scots pine (*Pinus sylvestris* L.) from different parts of the crown

Statistical characteristic	Crown zones		
	Bottom	Middle	Top
	Volatile oil content [%]		
$\bar{x}$	0.36	0.46	0.55
SD	0.05	0.09	0.11
Min	0.29	0.36	0.44
Max	0.49	0.63	0.51
Mode	0.36	0.43	0.51
Median	0.36	0.43	0.51
Coefficient of variation [%]	15.3	18.4	19.2

The subject literature provides different reports on the content of the essential oils depending on the needle position in the crown. For example, spruce needles coming from the upper and middle part of the crown contained respectively 0.21 and 0.19% of the oil, while those from the lower part were characterized by a 40% decrease in the oil content that amounted to 0.12% [11].

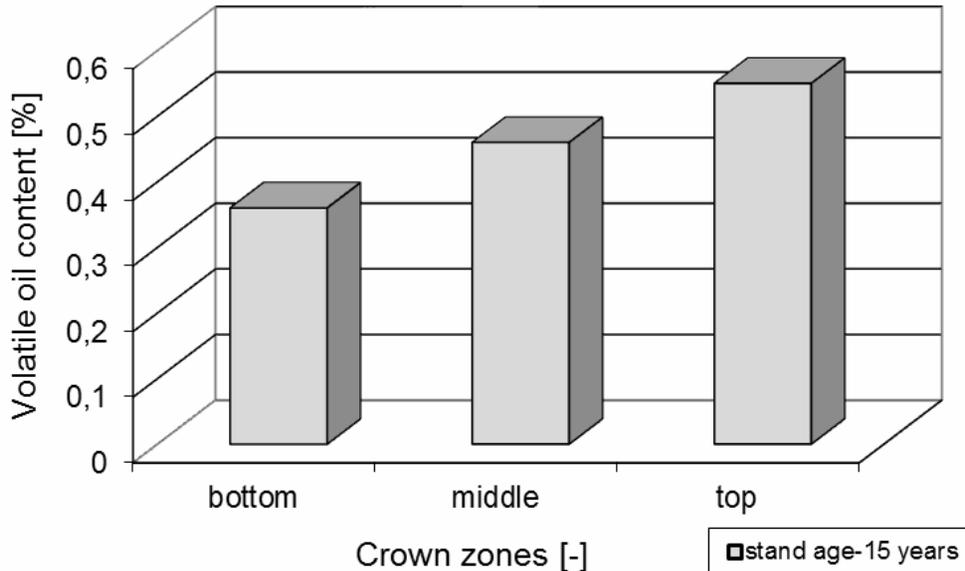


Fig. 2. Volatile oil content of Scots Pine (*Pinus sylvestris* L.) needles collected from three zones of the canopy

### Conclusions

1. Mean oil content decreases with the age of the needles. The lowest content of the essential oil was found in 3-year old needles (0.40%), but similar amounts were detected in 1- and 2-year old needles.
2. In the stand of age class Ib (15 years old), the content of the essential oils increases at higher crown levels. The highest content of the oil was detected in the needles from the top part of the crowns.

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## WYDAJNOŚĆ OLEJKÓW ETERYCZNYCH Z IGLIWIA SOSNY ZWYCZAJNEJ (*Pinus sylvestris* L.)

Pracownia Ekologii i Ochrony Przyrody, Samodzielna Katedra Biotechnologii i Biologii Molekularnej  
Uniwersytet Opolski

**Abstrakt:** Celem badań było określenie wydajności olejków eterycznych w igliwiu sosnowym w 3 strefach korony drzew modelowych (dolnej, środkowej i górnej) dla 3 najmłodszych roczników igliwia (1-, 2- i 3-letniego). W wyniku przeprowadzonych badań stwierdzono wyraźny wzrost wydajności olejków eterycznych w kierunku od dolnej poprzez środkową do górnej części korony. Najmniejszą zawartość olejku stwierdzono w igliwiu 3-letnim (0,40%), natomiast igliwie 1-roczne i 2-letnie zawierało odpowiednio 0,48 i 0,49%.

**Słowa kluczowe:** olejek eteryczny, igliwie, sosna zwyczajna

