ФУРАЖИ И ХРАНЕНЕ

SEASONAL VARIATION IN DILL ESSENTIAL OIL

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СЕЗОННИ ПРОМЕНИ В СЪДЪРЖАНИЕТО НА ЕСЕНЦИАЛНИ ЕТЕРИЧНИ МАСЛА В СЕМЕНА ОТ КОПЪР

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РЕЗЮМЕ

Домашният копър (*Anethum graveolens* L.) беше отгледан в експерименталното поле в Mošorin в продължение на четири години, с цел да се определи влиянието на метеорологичните условия върху съдържанието и състава на есенциални етерични масла в семена от копър. От получените резултати може да се заключи, че съдържанието им варира от 3,3 до 5,3%, в зависимост от годината. В етеричното масло доминира карвон и неговото съдържание варира от 28,4 до 52,2%. Втората най-често срещана съставка е лимонен, с вариации между 40,6 и 47,3%, следвана от транс-дехидрокарвон (2,2–26,9%). Съществува вероятност метеорологичните условия, в т.ч. засушаване, придружено от висока температура, да имат косвено влияние върху състава на етеричните масла в копъра чрез намаляване на съпротивлението към растителни патогени.

Ключови думи: *Anethum graveolens,* карвон, лимонен, транс-дехидрокарвон, метеорологични условия

INTRODUCTION

Dill (*Anethum graveolens* L.) is an annual plant from the Apiaceae family. It has been used in medicine since the ancient times and it is a popular herb widely used as a spice. It has been reported that dill has antibacterial, antispasmodic, hyperlipidimic, antiulcer activities and antioxidant, hypolipidemic, genotoxicity, diuretic effects (Heamalatha et al., 2011). Whole or ground dill seed is frequently used as a condiment. It serves as a flavor in pickling cucumbers as well as in bread, potatoes and other vegetables. In addition, the seeds are often added to pastries and sauces. Fresh or dried chopped dill leaves are used in soups and salads and with seafood such as lobster or crayfish (Embong et al., 1977).

Dill seed is rich in essential oil, with carvone and limonene as the main compounds. Because

of them, dill seed has similar taste to caraway. However, dill herb is also rich in essential oil, but the taste is significantly different, characteristic dill-like, floral and herbaceous (Blank and Grosch, 1996).The main constituents of herb essential oil are α-phellandrene and *p*-cymene (Said Al Ahl et al., 2015).

Essential oil content in other plants from Apiaceae family significantly varied depending on the weather conditions during the growing season. In our previous study it was established that essential oil in caraway varied between 3.78 and 4.12%, anise 3.52–3.93%, and in coriander 0.77–0.94% (Acimovic et al., 2015). Other authors have also come to similar results.

MATERIAL AND METHODS

Seed from dill plant cultivar "Domaća" were grown at the experimental field in Mošorin (45°18' N, 20°09' E), on a highly calcareous loamy chernozem soil type. The experiment lasted four years (2011–2014). Weather conditions during investigated years are shown in Table 1. In all investigated years, sowing was performed at the beginning of April, by hand, while the harvest was done during August, also by hand. During vegetation, only hoeing and weeding were done from care measures, while protection from diseases and pests, irrigation and fertilization were not performed.

RESULTS AND DISCUSSION

From the obtained results it can be concluded that essential oil content varied from 3.3 to 5.3%, depending on the year (Fig. 1). Significantly higher essential oil content was achieved in 2011 in comparison to the other years. During this year, the smallest precipitation amount during vegetation period was recorded (186 mm) and the average daily temperature was 19.4ºC. This year had favorable distribution of precipitation – during vegetative growth (IV–V) it was 88 mm, during flowering (VI–VII) it was 98 mm, while during ripening (VIII) there was no rain.

The smallest content of essential oil was achieved during 2012. This year had a slightly higher content of precipitation in comparison to the previous year (around 31 mm) and distribution was similar, but the temperature regime was unfavorable. Average temperatures during vegetative growth period were the same as in the previous year, but temperatures during the flowering (VI–VII) were significantly higher in comparison to the other years (24ºC). However, dur-

Table 1. Precipitations and temperatures during dill vegetation period (IV–VIII) 2011–2014

PRECIPITATION						
Year	**April**	**May**	**June**	**July**	**August**	**SUM**
2011	23	65	36	62	0	**186**
2012	83	51	31	48	4	**217**
2013	30	118	126	34	26	**334**
2014	50	202	38	143	80	**513**
TEMPERATURE						
Year	**April**	**May**	**June**	**July**	**August**	**AVERAGE**
2011	13	17	21	22	24	**19.4**
2012	13	17	23	25	24	**20.4**
2013	14	18	20	22	23	**19.4**
2014	14	16	20	23	21	**18.8**

ing humid 2013 and 2014, dill fruits accumulated 3.7–4.1% essential oil, respectively.

From this it can be said that the weather conditions during generative phases influence essential oil content. Generally, it can be concluded that precipitation around 100 mm and temperatures around 22ºC during period of flowering and ripening have positive influence on essential oil accumulation. Increasing the temperature by 2ºC during this period significantly reduces essential oil accumulation in dill fruits (by one-third). Also, the high content of rainfall during flowering decreases essential oil content in dill fruits by one-fourth. Similarly, Ghassemi-Golezani et al. (2008) concluded that essential oil yield of dill could be improved by moderate water stress during flowering and seed filling phases.

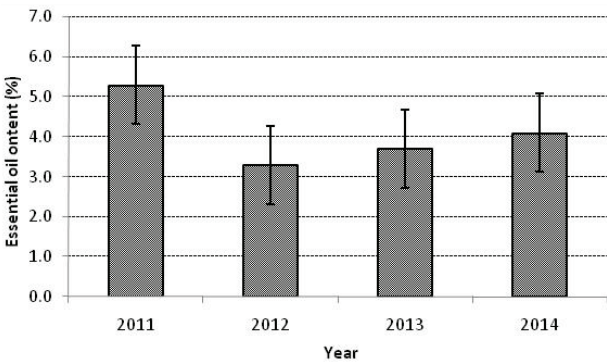

Fig. 1. Essential oil content in dill seeds depending on the year

A total of 12 compounds were identified from essential oil in all years (Table 2). It can be said that the stereochemistry of the main chiral compounds are present in the oils – limonene, carvone and *trans*-dihydrocarvone. Carvone dominates in essential oil with 44.6% in average for all years, while its content varied from 28.4 to 52.2%. Limonene was the second most abundant compound with 43.5% and varied between 40.6 and 47.3%, followed by *trans*-dihydrocarvone (9.4%). This compound had great variations through the years, from 2.2% to 26.9%.

Limonene, a monocyclic monoterpene, is the most widespread terpene. It is raw material for the chemical synthesis of other compounds, among which is carvone (Fig. 2). Acording to Bouwmeester et al. (1995), limonene and carvone are found in approximately equal amounts in dill and caraway seed essential oil.

Table 2. Compounds from dill seed essential oil

Compound	RI	2011	2012	2013	2014
α-pinene	933	tr	0.1	0.1	tr
sabinene	975	tr	tr	tr	tr
myrcene	994	0.1	0.1	tr	0.2
α-phellandrene	1008	0.6	1.2	1.0	0.8
p-cymene	1028	0.1	0.4	0.2	tr
limonene	1038	47.3	42.4	40.6	43.5
cis-limonene oxide	1130	0.1	0.2	0.1	0.1
trans-limonene oxide	1141	0.2	0.5	0.2	0.2
cis-dihydrocarvone	1199	0.1	0.2	2.2	0.8
trans-dihydrocarvone	1207	2.2	2.7	26.9	5.9
neoiso-dihydrocarveol	1228	tr	tr	0.3	0.2
carvone	1251	49.3	52.2	28.4	48.3
Total identified		100	100	100	100

RI - *Retention indices on HP-5 MS capillary column;* **tr** - *compound present in trace (< 0.1%)*

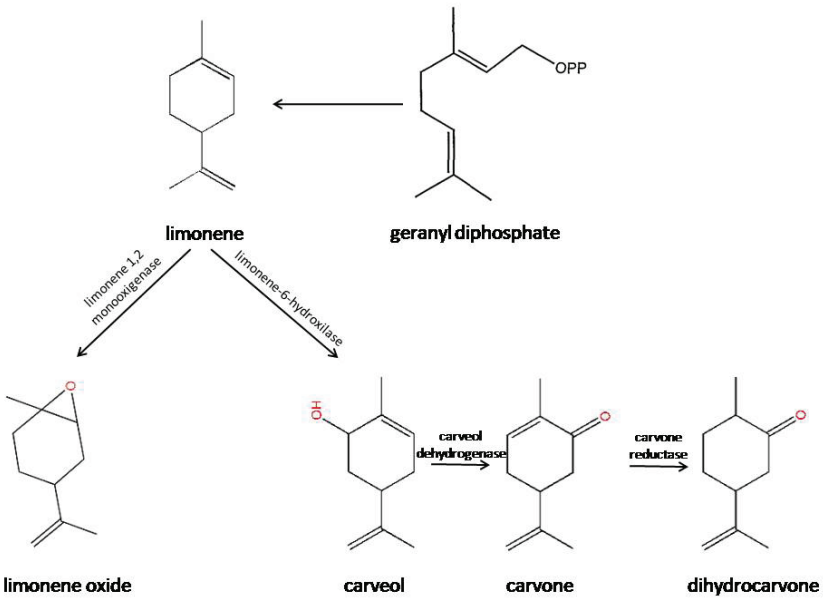

Fig. 2. Pathway of main compounds from dill oil

It is established that carvone can be further reduced to *trans*-dihydrocarvone and *cis*-dihydrocarvone with the plant pathogenic fungus such as *Absidia glauca,* as well as *Aspergillus niger*, *Beauveria sulfurescens* or bacteria *Pseudomonas ovalis*. It has been suggested that all these microorganisms contain very similar reducing enzymes which reduce the double C = C bond in carvone (Cossy, 2005; Porto et al., 2010). There is a possibility that unfavorable weather conditions can decrease resistance to plant pathogens, therefore having an indirect influence on the composition of dill essential oil. Apart from this, weather conditions can influence enzyme activity in dill fruits (Bouwmeester et al., 1995).

CONCLUSION

Weather conditions, especially during flowering and ripening, had a great influence not only on essential oil content but on chemical constituents in dill seed oil as well. It is assumed that weather conditions influence the enzyme activity, which will be the aim of our future investigations.

The weather induced variations of the content and quality of essential oil have great significance especially in the case when the seed is used as a dietary supplement for people and animals in predetermined quantities. This could lead to differences in the treatment efficiency depending on the year.

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ABSTRACT

Dill (*Anethum graveolens* L.) cv. "Domaća" was grown at an experimental field in Mošorin for four years in order to determine the influence of weather conditions on dill seed essential oil content and composition. From the obtained results it can be concluded that essential oil content varied from 3.3 to 5.3%, depending on the year. Carvone dominates in essential oil and its content varied from 28.4 to 52.2%. Limonene was the second most abundant compound with variations between 40.6 and 47.3%, followed by *trans*-dihydrocarvone (2.2–26.9%). There is a possibility that weather conditions, i.e. drought accompanied by high temperatures, can decrease resistance to plant pathogens, therefore having an indirect influence on the composition of dill essential oil.

Key words: *Anethum graveolens*, carvone, limonene, *trans*-dihydrocarvone, weather conditions

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