Changes of the characteristics of *Satureja hortensis* L. herb during flowering period

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Summary: In this study the changes of the characteristics of *Satureja hortensis* herb were investigated during flowering period, in case of savories of 4 different origins. The change of drying ratio, leaf/stem ratio, essential oil content, the ratio of several essential oil components (carvacrol, γ-terpinene, p-cymol, α-pinene, β-pinene and β-caryophyllene) were studied from bud formation till seed ripening.

Introduction

Summer savory (*Satureja hortensis* L.) is a spicy member of Lamiace family, from the Mediterranean region. It is used mainly as a spice, in kitchen and food industry. The crude drugs are the crumbled herb (*Saturejae herba*) and essential oil (*Aetheroleum saturejae*) (*Halászné*, 2000).

There were several investigations in order to ascertain the quality of herb, the accumulation of essential oil and its components during the development of summer savory. *Svoboda and Hay* (1990) found, that the essential oil content increased during flower bud formation, had a maximum during flowering and declined rapidly with senescence. The ratio of essential oil compounds varied depending on developmental phases and also on weather conditions. So maximum essential oil content and an acceptable oil composition could be gained from early to full flowering. In the experiment of *Thieme & Nguyen* (1972b), the essential oil content was high at the end of the intensive vegetative growth, fell back a little at the beginning of the bud formation, at the end of this period reached the maximum and declined fast at the beginning of flowering. Carvacrol content had its maximum at the beginning of bud formation with a lower one at the end of flowering, and γ-terpinene at the beginning of flowering, while p-cymol content was increasing slowly until seed ripening, when started to grow faster. They cited (*Thieme and Nguyen*, 1972a) the results of other authors, too, in connection with the essential oil content and the ratio of oil compounds. For example *Bauer & Pohloudek* (1942) found that essential oil content was high at the beginning of bud formation, increased further to the maximum at full flowering, and declined after this time. However, *Felklova* (1958) found the first maximum earlier, at the beginning of strong vegetative growth (after branching), and after a great decrease till the start of buds, the similar, second maximum was at the beginning of full flowering, decreased a little during this time and declined after it.

The run of essential oil content and composition depends on several factors, including plant material and environmental circumstances (*Svoboda* et al, 1990; *Bernáth*, 2000). Our aim was to investigate the herb and essential oil of different origins of summer savory during the whole flowering period, in order to gain data about their characteristics under Hungarian conditions.

Materials and methods

The location of field experiment was in Soroksár, at the Research Station of the Department of Medicinal and Aromatic Plants. We investigated the effect of harvesting time on herb qualities of 4 *Satureja hortensis* populations of different origin in the year 2000.

The plant material (*Table 1*) was originated from

Table 1. Origins of the savory populations in the experiment

Code	Origin of the populations
No3:	Botanischer Garten St. Gallen, Switzerland
No6:	cultivation, from Békés county, Hungary
No8:	Institut za Hmeljarstvo in Pivovarstvo, Zalec, Slovenia
No16:	cultivation, from "Rédei Kertimag Rt" Seed Trading Stock Co., Hungary

cultivation or from botanical seed exchange (original seeds (botanically schizocarps) in case of No6 and No16, isolated seeds from the previous experiments with the original seed samples in case of No3 and No8). Some individuals of No3 and No8 can be seen in *Figure 1* and *Figure 2* (photos of plants with greater plant distance, from our other experiments with savory).

Figure 1 Savory No3 in the second flowering phase (Soroksár, 2000)

Figure 2 Savory No8 in the second flowering phase (Soroksár, 2000)

Seeds were sown 14th April, 2000, in 2.5 m long rows, with 60 cm row distance, in 3 replications. While the germination rate was different, density was set to about 20 plants/m at 5-8 cm height of seedlings. Irrigation was done regularly from May to July. Weeding was done mechanically.

Plants were cut 10 times from the beginning of flowering (bud phase) till the end of flowering (schizocarp ripening), above the woody part of the stems. It is quite difficult to define flowering phases, due to the small size and great number of flowers and the fact that blooming does not happen together on each branch, and also that bud formation continues after the occurrence of first flowers, too. The actual flowering phase was estimated at each cutting as seen in *Table 2*.

The plant material was dried naturally, laid onto drying frames in a drying room, when dry it was crumbled and sieved through 2 mm sieve. Drying ratio (per cent) shows that the dry weight is how many per cent of the fresh weight

Table 2. The description of different flowering phases of Satureja hortensis

Code	Description of flowering phase
0	no (open) flowers
1	1–10 flowers/plant
2	more than 10 flowers/plant
3	much more flowers (about full flowering)
4	over full flowering; seed ripening starts to dominate
5	only a few flowers, seed ripening dominates

(dry weight/fresh weight*100). Leaf/stem ratio was calculated as crumbled drug weight/stem weight.

Essential oil content was measured by hydrodistillation (ml/100g dry material), using Clevenger apparatus, according to the method of *PhHg VII*.

Analysis of essentiale oil was carried out by capillary gas chromatograph. The chromatographic circumstances were: Shimadzu Class-VP Chromatography Data System Version 4.2 PC-system; 30m x 0.25 µm quartz colonna with SE-30 liquid film; IB 220°C, detector place 250, flame ionisation detector (FID); colonna place 110°C (IT 3 min) 8°C/min 220°C (FTS min); carrier gas: nitrogen, flow speed about 1 ml/min, 100:1 splitter.

The experimental field is situated in the N47°24' latitude, E19°10' longitude, 100-150 m altitude, the soil is sandy. Average daily temperature in June was 21,5°C, in July 20.6°C, in August 23.4°C. Daily average of sunny hours in June was 12.4 (372 total), in July 8.29 (257 total), in August 10.23 (317 total). Data of weather conditions are from the Meteorological Station in Pestlőrinc (*Daily Weather Reports*).

Mathematical analysis was done with Excel 97 and a biometrical program called MiniStat 3.2 (*Vargha, 2000*).

Results and discussion

Flowering phases

The estimated values of flowering phases can be seen in *Table 3*. No8 started flowering earlier, it had open flowers on 10th July, while No3 and No6 had only 3 days later, and

Table 3. The flowering phases of Satureja hortensis (Soroksár, 2000).

	July				August					
No	7.	10.	13.	19.	1.	3.	8.	15.	24.	29.
3	0	0	1	1	2	2.5	3	4	5	5
6	0	0	1	1	2	2.5	3	4	5	5
8	0	1	1	2	3	3	4	5	5	5
16	0	0	0.5	1	2	2.5	3	4	5	5

No16 a week later. No8 reached the second phase also earlier, and on 1st August it was in the third phase, while the others only in the second phase, and they all were in full flowering a week later. In the middle of August all savories passed full flowering, seed ripening became the main activity, but it was the most intensive in case of No8. The last week of the measurements each origin had only a few flowers, but was full of ripened seeds (schizocarps).

Herb material

The drying ratio (*Figure 3*) was between 22–23% at the beginning of July, and became 33–37% at the end of August. After a small increase the drying ratio was about 23–26% in the second part of July, and had a short decrease (except No3) back to the starting level during the first decade of the next month: No16 – 3rd , No6 and No8 – 8th August. After rising back a strong increase was in the last two weeks. The declining of water content during the whole period could be due the increasing woodiness of stems and quantity of drier parts, like schizocarps, and also the falling of leaves from the main stem. The two small decreases of drying ratio were maybe in connection with the flower formation or falling of schizocarps. There was no significant difference among the savories from the point of drying ratio.

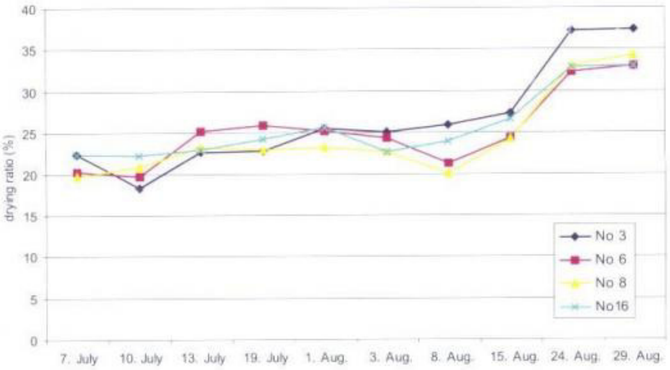

Figure 3 Drying ratio (per cent) of *Satureja hortensis* during flowering period

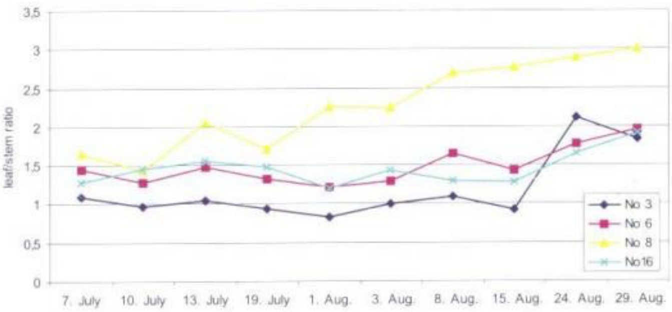

Figure 4 The leaf/stem ratio of *Satureja hortensis* during flowering period

From the point of leaf/stem ratio (exactly the crumbled drug/stem ratio) (*Figure 4*) there were 2 groups: in the first one the ratio moved around the starting level till the middle of August (No 3: 0.83-1.11, No6: 1.23-1.65 and No16: 1.21-1.57). The last 2 weeks there was an increase to 1.87-1.94. No8 was different: it increased from 1.65 to 3.0, with 2 set-backs in July. These 2 groups were proved by Games-Howell pair test. No8 is different from the others morphologically: it is more compact, has shorter stems and much more flowers, than the others, so the more intensive increase of leaf/stem ratio could be due to the much greater number of flowers and schizocarps (*Figure 1* and *Figure 2*).

The change of essential oil content (*Figure 5*) followed the flowering phases. No3 had a smaller, No6 a greater maximum at the end of bud formation, and a decrease in the phase of a few open flowers (first phase) was followed by a second maximum just before the third phase. After this

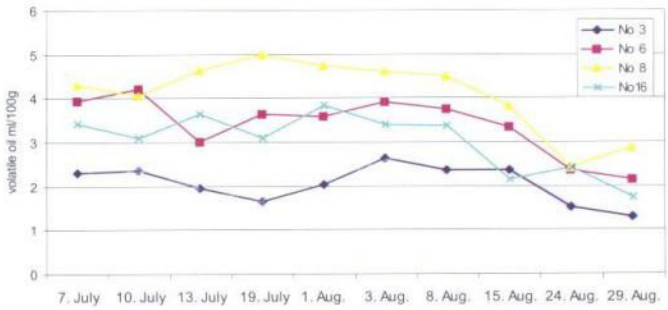

Figure 5 The essential oil content of savory (ml/100 g dry material) during flowering period

maximum, essential oil content decreased first slowly, and after main flowering faster. No8 started flowering earlier, maybe that is why it had in the detected period only one maximum (in second phase, a bit longer before the main flowering). No16 started flowering last, it had another maximum during bud formation, reached the third maximum 2 days earlier, than No3 and No6, in the second phase. The first part of run of essential oil content, mainly in case of No16, seems to be similar to the results of *Thieme and Nguyen*, (1972b), with the two maximums before and at the end of bud formation. In case of No3, No6 and No8, the phase of the first measurement probably passed partly this phase, so it cannot be correctly decided, whether there are two maximums or just one. However, the second part is similar rather to the results of the others, with a maximum during flowering or at (the beginning of) full flowering, remarking that it happened in our case a bit earlier. No8 had the highest (2.44-4.99 ml/100g dry material), No6 and No16 had similar (2.14-4.22 and 1.76-3.86 ml/100g, respectively) and No3 had the lowest (1.31-2.66 ml/100g) essential oil content. They were distinguished by Tukey-Kramer pair test. The essential oil content was higher, than in the experiment of *Thieme and Nguyen*, (1972b) (1.55 ml/100g maximum). It was similar rather to the results of *Eger and Heine* (1998), with 1.2-5.4 ml/100g values.

Essential oil composition

The carvacrol content (*Figure 6*) changed relatively balanced, did not show sudden changes during flowering; the differences between minimum and maximum were the 20-23% of the values. Carvacrol content was the lowest around the first part of July (during 0-first fowering phase), and as flowering went on, it increased until around second phase, then maintained till late August and then after a small increase went back. Comparing with the results of *Thieme and Nguyen* (1972a), the carvacrol content also increased during flowering. However, contrary to them, it did not

Figure 6 The carvacrol content of savory essential oil during flowering period

decline immediately after full flowering, moreover had a maximum during seed ripening in case of No3 and No8. It started declining just at the very end of August. The carvacrol content of No8 was higher (52.9-69.1%) than that of the others (45.3-59.3%). They were distinguished by Tukey-Kramer pair test. The carvacrol content of No3, No6 and No16 were similar or a bit higher than in literature (*Thieme and Nguyen*, 1972a, *Eger and Heine*, 1998), but in case of No8 it was higher.

The γ-terpinene content (*Figure 7*) moved in the opposite direction and was not so balanced, like carvacrol. The γ-terpinene content was the highest around the first part of July,

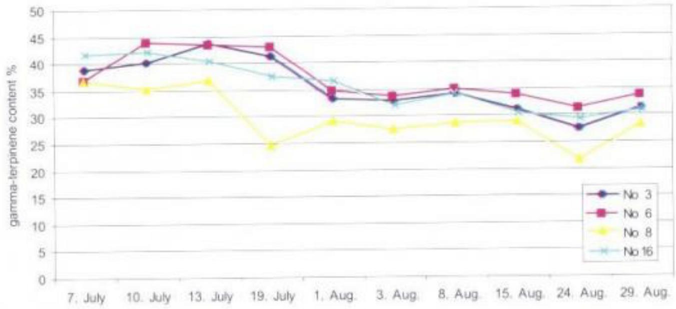

Figure 7 The gamma-terpinene content of savory essential oil during flowering period

when plants had maximum a few flowers (0-first phase), and decreased (20–34% of values) when reaching the second phase. This happened till 19th July with No8, with No3 and No6 till 1st August, and two days later, on 3rd August with No16. Then the γ-terpinene content did not show really much change till 24th August, when it lowered again but increased back to the previous level next time (just the opposite like with carvacrol). This small decrease could be due to the weather conditions: the daily medium temperature decreased 5°C during the previous 3 days. Comparing to the data of *Thieme and Nguyen* (1972a), γ-terpinene content had a maximum about the beginning of flowering and declined, as time went on. The γ-terpinene content of No3, No6 and No16 were mainly similar (27.5-43.7%), but No8 had much lower per cents (21.2-36.6%) and more sudden differences during the observation period. These 2 groups were distinguished by Tukey-Kramer pair test. Comparing to the literature (*Thieme and Nguyen*, 1972a), the maximim of γ-terpinene content was a bit lower, and in case of No8 much lower, than the 46-52% in their work.

The p-cymol content (*Figure 8*) was first high, became lower in the intensive flowering period: from the starting 6-7% to about 5% (with 16-39% of them), and increased again to 7–9%: with No3, No6 and No8 this was higher than the starting value (with 16-33%) and was lower with No16 (with 4%) till the end of the whole period. There was no significant difference among the savories from this point. The p-cymol content was different from that in the experiments of *Thieme and Nguyen* (1972a), because they found a continuous increase with passing of time, and the increase during seed ripening was also intensive, but much more, than in our experiment.

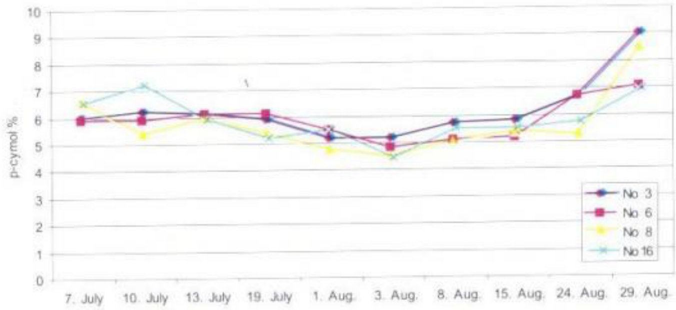

Figure 8 The p-cymol content of savory essential oil during flowering period

Among the other components of the savory essential oils the following components were both showed and identified: α-pinene (0.4-0.8%), β-pinene (1.6-2.4%). The ratio of β-caryophyllene was, in case of No3, No6 and No16 about 0.6% at the beginning and increased to a 1.5% value. With No8 the content also showed a similar tendency, but moved only between 0.2–0.7%.

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