Possibilities of differentiation of individual *Achillea* species on the basis of redox potential measurements

K. PETŘÍKOVÁ, Z. KOMÁRKOVÁ, V. NAKVASIL

Mendel University of Agriculture and Forestry, Brno, Faculty of Horticulture, Lednice, Czech Republic

ABSTRACT: The redox potential of flowers of *Achillea* plants was measured by means of a puncture method. Measurements were performed in 6 taxa (species and hybrids) in the stage of bud formation, full flower and flower shedding in 2000 and 2001. The content of essential oil was estimated in the period of full flower. Differences in the values of redox potential (177–213 mV) and contents of essential oil (1.5–6.1 ml/kg) measured in individual *Achillea* species and their hybrids were significant. The correlation between the content of essential oil and values of redox potential was closely below 95% of significance.

Keywords: yarrow; *Achillea*; *Achillea* species; redox potential; content of essential oil; correlation between redox potential and essential oil content

Members of the genus *Achillea* L. belong to the oldest medicinal plants that are used both for pharmaceutical purposes and in folk medicine. These plants contain a complex of different pharmacological compounds, e.g. essential oils, flavonoids, bitters, tannins etc. The obtained drug shows antiphlogistic and spasmolytic effects and can be used as amarum, stomachicum, cholagolum and carminativum (HUBÍK et al. 1978; KASTNER et al. 1993).

There are altogether 9 indigenous species of the genus *Achillea* L. in the territory of the Czech Republic: 6 of them belong to the group of *Achillea millefolium* agg. (*A. setacea* Waldst. et Kit., *A. asplenifolia* Vent., *A. collina* Becker ex Rchb., *A. pratensis* Saukel et Länger, *A. millefolium* subsp. *millefolium* or *A. millefolium* L., and *A. pannonica* Scheele) and the remaining 3 are the species *A. ptarmica* L., *A. nobilis* L. and *A. styriaca* Saukel et Länger subsp. *bohemica* Saukel et Länger ined. (DANIHELKA 2000). Species belonging to the genus *Achillea* represent a polyploid complex (they are diploid to octoploid); they are very similar and they can be distinguished reliably only on the basis of their chromosome numbers. Besides the above-mentioned species there is a number of their natural hybrids. The content of effective substances is rather variable and depends not only on the species but also on individual populations (VETTER 1995).

In the Czech Pharmacopoeia 1997 the species *A. millefolium* L. is mentioned as the basic species used for the extraction of the drug *Millefolium herba seu flos*. *A. millefolium* L. and *A. collina* Rchb. are the most frequent species in the territory of the Czech Republic. They are very similar and can be distinguished only on the basis of their chromosome numbers. However, in contradistinction to *A. millefolium*, *A. collina* contains bluish chamazulene and for that reason it is more suitable for therapeutic purposes.

In recent years, there were some literary data available informing about the possibility to trace different plant materials on the basis of measurements of their electrochemical properties, i.e. redox potential, conductivity and resistance.

It was found out that these differences could be caused by nutrition (JEZIK 1997, 1998; EL-SCHERBINY 1997), cultivation method (organic and/or conventional growing; HOFFMANN 1997) and different resistance to pathogens (BENADA 1998, 2002).

The aim of this study was to find out if individual *Achillea* species and their hybrids could be distinguished on the basis of measured electrochemical values (i.e. redox potential) and if their content of essential oils was correlated with redox potential (RP) values.

MATERIAL AND METHODS

From the germplasm collection of the Faculty of Horticulture in Lednice (Mendel University of Agriculture and Forestry, Brno, Czech Republic), the following *Achillea* species and hybrids were selected:

A. collina
A. millefolium subsp. *mill.*
A. setacea
A. pratensis (original locality Hrádek)
A. pratensis (original locality Nejdek)
A. pratensis (original locality Borovnice)
A. collina × *A. pratensis*
A. millefolium × *A. pannonica*

The paper is an output of Research Project No. MSM 435100002 funded by the Ministry of Education, Youth and Sports of the Czech Republic.

Table 1. Variability of redox potential (mV)

Parameter	Number of measurements per plant									
	10	20	30	40	50	60	70	80	90	100
Average RP value (mV)	184	185	185	183	182	181	180	181	181	181
Variation coefficient (%)	5.4	5.6	5.4	5.3	5.2	5.4	5.2	5.3	5.4	5.3

Table 2. Average RP values (mV) in individual stages of flowering

Species/Locality Year 2000	Stage of flower buds	Stage of full flower	Stage of flower shedding
A. collina	179	183	174
A. millefolium subsp. *mill.*	162	159	196
A. pratensis (Hrádek, district Pardubice)	173	150	153
A. pratensis (Nejdek, district Břeclav)	175	178	161
A. pratensis (Borovnice, district Trutnov)	156	160	172
A. collina × *A. pratensis*	160	166	163
A. millefolium × *A. pannonica*	170	160	177
A. setacea	169	172	170
Year 2001			
A. collina	195	197	204
A. millefolium subsp. *mill.*	220	213	not estimated
A. pratensis (Hrádek, district Pardubice)	183	179	197
A. pratensis (Nejdek, district Břeclav)	184	177	213
A. pratensis (Borovnice, district Trutnov)	204	190	200
A. collina × *A. pratensis*	212	189	192
A. millefolium × *A. pannonica*	196	189	209
A. setacea	182	177	207

Measurements of redox potential (RP) and estimations of the content of essential oil were performed using 5 plants of each species (hybrid, locality). Experimental plants were obtained by means of vegetative propagation of one plant. The values of redox potential were measured in flowers with platinum (type PZE 21) and reference calomel (type RCE 102a) electrodes using a puncture method described by BENADA (2000, 2001).

Measurements: two flowers (or flower buds) from each inflorescence were pinned on the platinum electrode and dipped into Petri dishes with water containing a reference calomel electrode. (Prior to each measurement, the platinum electrode was immersed into a solution of potassium ferricyanide.) The maximum RP value (mV) was recorded using a digital multimeter. At the beginning of our measurements, 100 pairs of flowers were used from each plant. Later on, however, we came to a conclusion that only 10 pairs were sufficient. RP was measured in the stages of bud formation, full flower and flower shedding in 2000 and 2001. The content of essential oil was estimated in the period of full flower using simple distillation of the drug with a subsequent addition of decalin. Measured RP values and contents of essential oil were statistically analysed using the Unistat programme (Version 453) and regression analysis.

RESULTS AND DISCUSSION

The results of RP measurements of 10 to 100 pairs of yarrow flowers and calculations of variation coefficients (Table 1) showed that the variability of RP values was relatively low. For this reason it was concluded that in the subsequent measurements the RP values would be estimated only in ten pairs of flowers.

Average RP values are presented in Table 2.

Statistical analysis revealed significant differences in RP values due to the effect of cultivars and/or hybrids. Significant interspecific differences were found also between yarrow plants originating from various localities (Table 3).

The highest content of essential oil was found in *A. collina*; this finding corresponded with literary data (DANIHELKA 2000) (Table 4). A high content of essential oil was also found in the hybrid *A. collina* × *A. pratensis* while the lowest one in *A. pratensis* plants from the locality Nejdek. According to the Czech Pharmacopoeia 1997 the minimum content of essential oil in yarrow drug should be 2 ml/kg. With the exception of *A. pratensis* originating from 2 localities the content of essential oils in all species and hybrids under study was higher than this minimum value.

It was also found out that the content of essential oils was significantly influenced by species and/or hybrids (Table 5).

Table 3. Significant differences in RP due to the effect of *Achillea* species and hybrids during the years 2000–2001

Species	25	31	50	46	86	67	118	166
25	X		*			*	*	*
31		X	*	*				
50	*	*	X					
46			*	X				
86					X			
67	*					X		
118	*						X	
166	*							X

25 – *Achillea collina*
31 – *Achillea millefolium* subsp. *millefolium*
50 – *Achillea pratensis* (Hrádek, district Pardubice)
46 – *Achillea pratensis* (Nejdek, district Břeclav)
86 – *Achillea pratensis* (Borovnice, district Trutnov)
67 – *Achillea collina* × *Achillea pratensis*
118 – *Achillea millefolium* × *Achillea pannonica*
166 – *Achillea setacea*

Table 4. Content of essential oils in 2000–2001 (ml/kg)

Species/Locality	2000	2001
A. collina	6.1	4.7
A. millefolium subsp. *mill*.	not estimated	4.0
A. pratensis (Hrádek, district Pardubice)	2.4	1.8
A. pratensis (Nejdek, district Břeclav)	1.5	1.5
A. pratensis (Borovnice, district Trutnov)	3.2	3.3
A. collina × *A. pratensis*	3.2	4.2
A. millefolium × *A. pannonica*	2.0	2.0
A. setacea	3.0	3.0

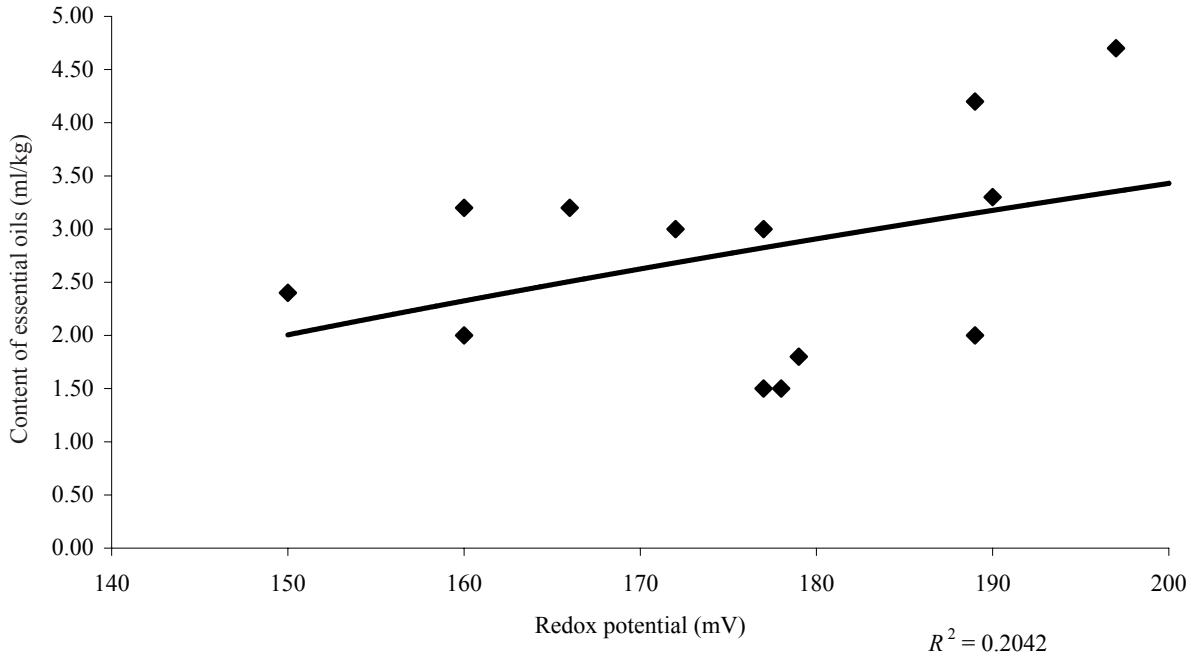

Fig. 1. Graphical presentation of correlations existing between RP values and the content of essential oils in individual yarrow species in full blossom (year 2000–2001)

Table 5. Evaluation of effects of year and species on the content of essential oils in yarrow plants

Source of variability	*F* calculated	*F* tab.
Year	0.22	5.98
Species	13.38	4.28

During the years 2000–2001, the correlation existing between the content of essential oil and RP values was closely below 95% of significance (Fig. 1). As one can see in these figures, the values of RP increased with the increasing content of essential oil.

The obtained results indicate that there were significant differences in essential oil contents and RP values between the individual yarrow species.

The general validity of correlations existing between RP values and species and/or varieties should be tested in further experiments.

References

BENADA J., 1998. Wird es möglich sein die Ungastlichkeit (Axenie) bei der Rezistenzzüchtung der Pflanzen auszunützen? In: Materialsammlung über die 49. Arbeitstagung der Vereinigung österr. Pflanzenzüchter, Bal. Gumpenstein, 24.–26. Nov. 1998: 113–116.

BENADA J., 2000. Význam biofyzikálních stavů pro fytopatologii a fyziologii rostlin. In: Sbor. prací ze VII. konference o.p.s. Beskydy Elektřina a lesní stromy. Ostrava, říjen 2000: 40–48.

BENADA J., 2001. Kritik am P-Wert-Konzept aus physiologischer Sicht. In: Materialsammlung 8. Internationale Tagung Elektrochemischer Qualitätstest 22.–24. 2. 2001 an der Universität für Bodenkultur, Wien: 2–7.

BENADA J., 2002. Redox potential in plants and its function in the mechanism of resistance to diseases and in plant physiology. In: Materialband 9. Internationale Tagung Elektrochemischer Qualitätstest 30. 5.–5. 6. 2002 an der Mendel Universität für Land- und Forstwirtschaft Brno, Fakultät für Gartenbau Lednice: 41–46.

Czech Pharmacopoeia, 1997. Volume 3. Praha, Grada Publishing: 595.

DANIHELKA J., 2000. *Achillea millefolium* agg. v České republice. [Dizertační práce.] Brno, Přírodovědecká fakulta MU: 258.

EL-SCHERBINY M., 1997. Wie Gemüse auf verschiedene Dünger reagiert. In: HOFFMANN M., Vom Lebendigen in Lebensmitteln. Bad Dürkheim, Deukalion: 141–149.

HOFFMANN M., 1997. Gesundheitsorientierte Küchenkunst. In: HOFFMANN M., Vom Lebendigen in Lebensmitteln. Bad Dürkheim, Deukalion: 105–118.

HUBÍK J. et al., 1978. Obecná farmakognosie (II. díl) – Sekundární látky. Praha, SPN: 275.

JEZIK K., 1997. Der P-Wert wird von vielen Faktoren beeinflusst. In: HOFFMANN M., Vom Lebendigen in Lebensmitteln. Bad Dürkheim, Deukalion: 135–140.

JEZIK K., 1998. P Wert bei Gemüse – Reaktion auf verschiedene Dünger, Spritzmittel/Nützlingseinsatz und Homöopathie. Sbor. z konf. Nové poznatky z testování kvality zeleniny, 4.–5. listopad 1998. Brno, MZLU, Lednice: 15–25.

KASTNER U., SOSA S., WOLF M. et al., 1993. Phytochemische und pharmakologische Untersuchungen von Tees aus verschiedenen Taxa der *Achillea millefolium*-Gruppe. Sci. Pharm., *61*: 47–54.

VETTER S., 1995. Kreuzungsexperimente mit tetraploiden Sippen der *Achillea millefolium*-Gruppe (Asteraceae): Sesquiterpene und morphologische Merkmale hybridogener F 1 – Populationen in Vergleich. Linzer Biol. Beitr.: 1161–1211.

Received for publication October 24, 2002
Accepted after corrections September 1, 2003

Možnosti rozlišení druhů *Achillea* pomocí měření redoxpotenciálu

ABSTRAKT: Vpichovou metodou byl stanoven redoxpotenciál v květech řebříčku – *Achillea.* Měření se provádělo v letech 2000, 2001 u šesti druhů a kříženců ve stadiu poupat, plného květu a po odkvětu. V době plného květu byl stanoven obsah silice. Byl zjištěn průkazný rozdíl v hodnotách redoxpotenciálu (177–213 mV) i v obsahu silice (1,5–6,1 ml/kg) vlivem druhů i kříženců řebříčku. Mezi obsahem silic a redoxpotenciálem byl zjištěn korelační vztah těsně pod 95% hladinou statistické významnosti.

Klíčová slova: řebříček; *Achillea*; druhy *Achillea*; redoxpotenciál; silice; korelace mezi redoxpotenciálem a silicí

Corresponding author:

Doc. Ing. KRISTÍNA PETŘÍKOVÁ, CSc., Mendelova zemědělská a lesnická univerzita, Brno, Zahradnická fakulta, Ústav zelinářství a květinářství, Valtická 337, 691 44 Lednice, Česká republika
tel.: + 420 627 340 105–7, fax: + 420 627 340 159, e-mail: petrk@zf.mendelu.cz