

Comparison of phenylethanoids content in *Rhodiola kirilowii* and *Rhodiola rosea* roots applying a newly developed UPLC-MS/MS method

AGNIESZKA GRYSZCZYŃSKA^{1*}, ZDZISŁAW ŁOWICKI¹, BOGNA OPALA¹, ANNA KRAJEWSKA-PATAN², WALDEMAR BUCHWALD³, BOGUSŁAW CZERNY^{1,4}, SEBASTIAN MIELCAREK¹, PRZEMYSŁAW M. MROZIKIEWICZ^{1,5}

¹Department of Quality Control of Medicinal Products and Dietary Supplements
Institute of Natural Fibres and Medicinal Plants
Libelta 27
61-707 Poznań, Poland

²Department of Pharmacology and Experimental Biology
Institute of Natural Fibres and Medicinal Plants
Libelta 27
61-707 Poznań, Poland

³Team of Botany and Agriculture of Medicinal Plants
Department of Botany, Breeding and Agricultural Technology
Institute of Natural Fibres and Medicinal Plants
Kolejowa 2
62-064 Plewiska/Poznań, Poland

⁴Department of General Pharmacology and Pharmacoeconomics
Pomeranian Medical University
Żołnierska 48
70-204 Szczecin, Poland

⁵Laboratory of Experimental Pharmacogenetics
Department of Clinical Pharmacy and Biopharmacy
Poznań University of Medical Sciences
Św. Marii Magdaleny 14
61-861 Poznań, Poland

*corresponding author: tel.: +4861 6659550, fax: +4861 6659551,
e-mail: agnieszka.gryszczynska@iwnirz.pl

Summary

A concentration of two phenylethanoids in the roots of two species: *Rhodiola kirilowii* and *rosea* were compared, aqueous and hydroalcoholic extracts from those plants were also analyzed. In order to determine the content of *p*-tyrosol and salidroside, the ultra performance liquid chromatography connected with a tandem mass spectrometry (UPLC-ESI MS/MS, Waters) was used. The obtained results shown that content of measured phenylethanoids depends on *Rhodiola* species. Roots of *R. kirilowii* contain more *p*-tyrosol, while *R. rosea* roots are richer in salidroside. Our results indicate that the application of UPLC MS/MS method allows to determine the phenylethanoids content in tested samples with satisfactory precision.

Key words: *Rhodiola kirilowii*, *Rhodiola rosea*, phenylethanoids, UPLC-MS/MS

INTRODUCTION

The history of use of *Rhodiola* species is very interesting. In 1885 nearly 15 species of *Rhodiola* were characterised. *R. rosea*, *R. quadrifida*, and *R. kirilowii* are of the widest popularity. They usually grow in cold climate in China [1], Europe and USA [2, 3] at an altitude of 1000–5600 m. Plants of this family have been used for centuries in traditional Eastern medicine to treat many diseases [4] and have been applied increasingly in Europe and USA [5]. Oral administration of *R. kirilowii* extract has a protective effect on people with circulatory system disorders living at high altitudes [6]. Preparations containing *Rhodiola kirilowii* affect the properties of human adaptive mechanism [7, 8]. Preparations from *R. rosea* influence central nervous system [2, 3], have an antioxidant [9–11] and immunological [12] activity.

The roots of *R. kirilowii* contain many bioactive compounds: phenylethanoids (*p*-tyrosol and salidroside) [13–15], phenylpropanoids [14, 15], catechins [8, 14, 16–19], coumarins [20], phenolic acids [8, 14–17], phytosterols [14], tannins [8], cyanogenic glycosides [19], arbutin [19] and terpenoids [18].

The roots of *R. rosea* contain: phenylpropanoids – rosavin, rosarin, rosin [21], phenylethanoids – salidroside, *p*-tyrosol [11, 21], flavonoids – rhodiocyanin, rhodiocyanin, rhodiosin, acetylrodalgin and triciclicin [22–24], phenolic acids [25], monoterpenes [25], phytosterols [26], tannins [25], cyanogenic glucoside – lotaustralin [27] and essential oils – *n*-decanol, geraniol [28]. The most typical compounds present in *Rhodiola* species are salidroside and *p*-tyrosol [4].

The aim of this research was to investigate a selective and specific analytical method to designate contents of individual compounds of phenylethanoids.

MATERIAL AND METHODS

Plant material

In this research, *Rhodiola kirilowii* and *Rhodiola rosea* roots were used. The plants were collected in October 2009 from field crops of the Institute of Natural Fibres and Medicinal Plants, Plewiska near Poznań, Poland. Roots were dried in a room temperature (22–24°C).

Preparation of plant extracts

Subsequently, dry roots were powdered (0.315) and 2 kinds of extract were prepared: aqueous extract and 50% (v/v) ethanol extract.

Preparation of aqueous extract

The powdered dry roots were extracted with purified water for 3 hours at 90°C (material to solvent ratio 1:10). After filtering, the extracts were frozen at –55°C and than lyophilised [29]. The dry plant extracts were stored at a temperature of 20–25°C.

Preparation of 50% (v/v) ethanol extract

The powdered dry roots were extracted with 50% (v/v) ethanol using the percolation method at plant material to solvent ratio 1:10. After the evaporation of the alcohol in reduced pressure at a temperature of 40–45°C the extracts were frozen at –55°C and than lyophilised [29]. Dry plant extracts were stored at a temperature of 20–25°C.

Standard substances

The following comparison substances were used in the experiment: *p*-tyrosol, salidroside (ChromaDex) and D-(-)-salicine (SIGMA).

Standard solution

Standards of phenylethanoids were purchased from ChromaDex. Internal standard in this analytical method was D-(-)-salicine (Sigma Aldrich). Methanolic solutions of substances in the range of 5 different levels of concentration 100–1000 ng/ml were used to prepare calibration curves.

Sample preparation

Roots of *Rhodiola*

1.0 g of plant material (ca. 1.0 of dried powdered (0.315)) *Rhodiola kirilowii* or *Rhodiola rosea* root was weighed out and placed in a 100 ml round-bottom flask. To 19.0 ml of 10% (v/v) methanol a methanolic solution of D-(-)-salicine (IS) was added. This sample was heated under a reflux condenser in the boiling point of solvent for 45 min. Next, the sample was filtrated and the extraction of sample was performed twice. The filtrate was concentrated to evaporate the methanol up to a volume of about $\frac{1}{4}$ in a rotary evaporator in vacuum. Sample was transferred quantitatively to 20 ml volumetric flask. Subsequently, the solution was made up to the mark with the 10% (v/v) methanol. The sample was filtered through a membrane filter with a diameter of 0.20 μm .

Extracts of *Rhodiola*

0.5 g of *R. kirilowii* or 0.1 g *Rhodiola rosea* extract was weighed out and placed in a 100 ml round-bottom flask. To 19.0 ml of 10% (v/v) methanol, a methanolic solution of D-(-)-salicine (IS) was added. This sample was heated under a reflux condenser in the boiling point of the solvent for 45 min. Next, the sample was filtrated and the extraction of sample was repeated one more time. The filtrate was concentrated to evaporate the methanol up to a volume of about $\frac{1}{4}$ in a rotary evaporator in vacuum. Sample was transferred quantitatively to 20 ml volumetric flask. Subsequently, the solution was then made up to the mark with the 10% (v/v) methanol. The sample was filtered through a membrane filter with a diameter of 0.20 μm .

LC-MS/MS assay

All analyses were conducted by ultra performance liquid chromatography connected with a tandem mass spectrometry (UPLC-ESI MS/MS; Waters). The separation of analytes was performed on an Acquity UPLC BEH C18 column, 1.7 μm 2.1 \times 50 mm (Waters). Mobile phase: phase A: methanol, phase B: acetonitrile. Mobile phase flow rate was: 0.45 ml/min. The assay was performed in gradient elution: 0.0 min. – 97% of phase A, 4.8 min. – 82% of phase A, 4.9 min. – 97% of phase A. Column temperature was 30°C; ion source temperature: 100°C; desolvation temperature: 300°C. Gas flow rate: desolvation gas: 700 l/h; cone gas: 10 l/h. All the substances were analyzed in the negative-ions source.

Method extraction of the phenylethanoids (fig. 1) was subjected to optimization determining the content of: *p*-tyrosol, salidroside, using D-(-)-salicine as an internal standard. To determine the content of several compounds fragmentation was used as follows: for salidroside MRM of m/z 299 \rightarrow 89 Da and SIR of *p*-tyrosol: m/z 137 \rightarrow 137 Da. Figure 1 gives the structure of individual phenylethanoids. The salidroside was identified by fragmentation of parent ion, *p*-tyrosol was identified as a parent ion, because this substance does not fragmentate.

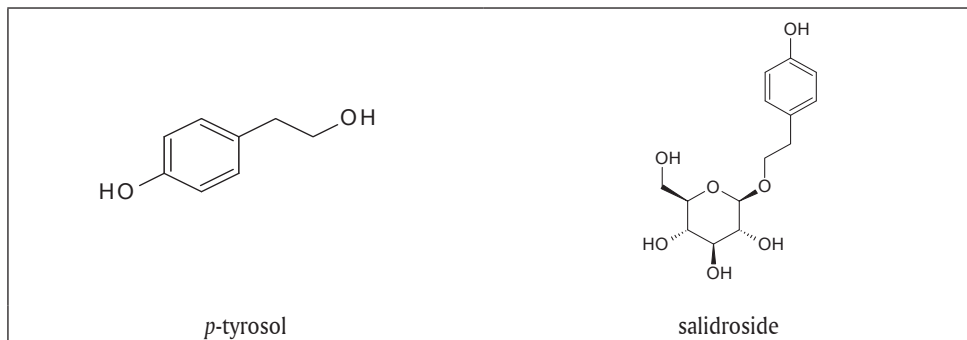


Figure 1.

Structures of phenylethanoids

Statistical method

For the phenylethanoids and internal standard, the regression analysis was performed at 5 concentration levels. Concentration of phenylethanoids was carried out for all samples in 6 repeats. The average and relative standard deviations (RSD) for those results were determined.

Validation

That method of extraction of phenylethanoids was validated with ICH rules. In a first step, linearity of calibrations curves was checked. Recurrence of time retention and peak area for all compounds were analyzed. The analytical method was characterized by a high recurrence and precision. The data for the roots and extract samples were itemised in 6 repeats. The accuracy of this method was conducted for 3 different levels. Percentage of recovery ranged from 89.72 to 101.38%.

RESULTS

In table 1 the analytical and statistical parameters of phenylethanoids are shown. The analytical method employed was evaluated for precision, linearity and accuracy. Precision and linearity were evaluated with use of regression analysis for each compared substance (tab. 2). The recovery of analytical method was analysed for for *R. kirilowii* roots using the enrichment method by the addition of dry hydroalcoholic extract of *R. rosea* with the determined level of phenylethanoids to the sample. Figure 2 gives the MRM chromatogram showing the fragmentation of phenylethanoids in *Rhodiola kirilowii* and Fig. 3 showing the fragmentation of *Rhodiola rosea* roots.

Table 1.

Characteristic parameters of phenylethanoids detection

Compound	Retention time [min]	RSD _t (n=15) [%]	RSD _p (n=5) [%]	Fragmentation m/z [Da]
<i>p</i> -Tyrosol	1.73	0.00	5.41	137→137
Salidroside	1.66	0.36	4.86	299→89
D-(-)-salicine (IS)	1.44	0.39	1.72	285→123

Table 2.

Method of recovery (n=3)

Sample	<i>p</i> -Tyrosol	Salidroside
20%	95.71±3.26	89.72±4.89
40%	93.51±4.85	96.62±5.21
80%	101.38±2.59	93.29±3.68

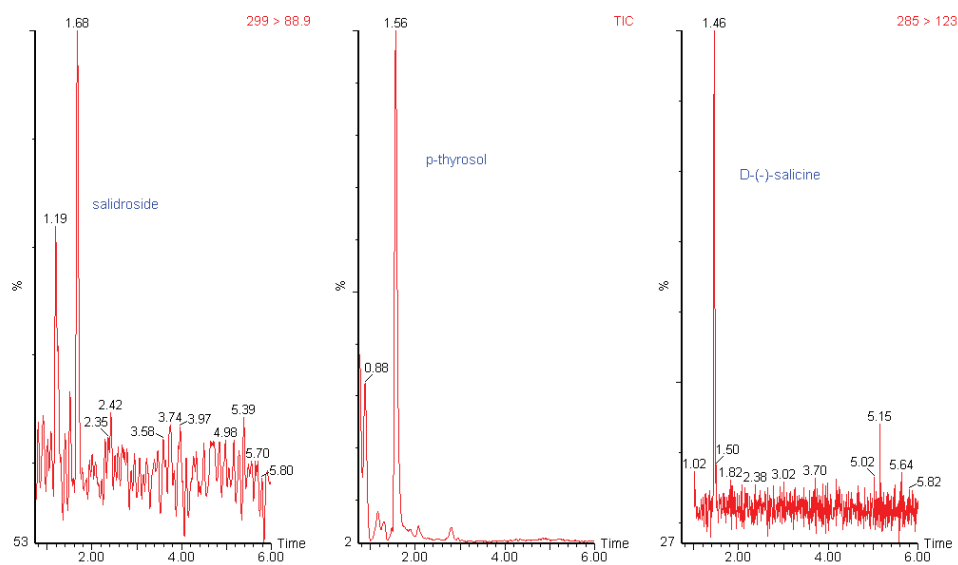


Figure 2.

The MRM chromatogram showing the fragmentation of phenylethanoids from *Rhodiola kirilowii* roots

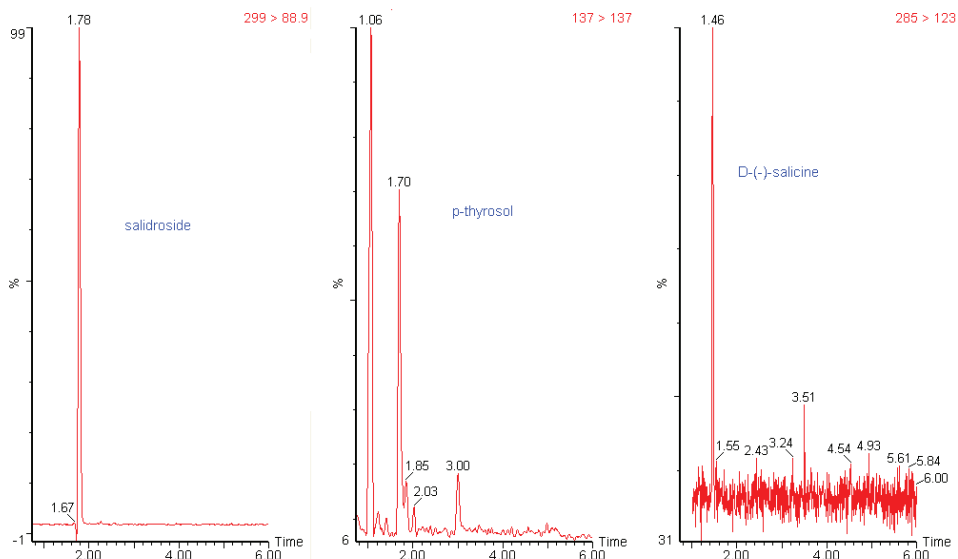


Figure 3.

The MRM chromatogram showing the fragmentation of phenylethanoids from *Rhodiola rosea* roots

The detection of each analysed compound was conducted in negative ions source. The signals visible in the chromatogram come from the parent ion fragmentation $[M-H]^-$. Among tested substances, only p-tyrosol does not fragmentate into daughter ions because it is not a part of the binding which could be cleaved in the structure of the compound.

DISCUSSION

The novel method of detection UPLC-MS/MS allows the identification of compounds with parent ions. The ESI detection allows the determination of very small amounts of the analyte. Additional advantage of this method, as compared to the HPLC-DAD is that fragmentation of the relevant parameters allows more accurate identification of tested substances, reducing the error in the determination of the content of particular component in the analysed sample.

In the comparison of the contents of 2 compounds (tab. 3) in the roots of 2 species of *Rhodiola* it can be seen that *R. rosea* has a lower content of individual phenylethanoids than *R. kirilowii*. Total amount of phenylethanoids in *R. rosea* is 5.506 mg/100 g of dry powdered material and 25.921 mg/100 g of dry powdered material in *R. kirilowii* root. In both cases, the content of phenylethanoids in the extracts was significantly higher than in the raw material. In *R. kirilowii*, extract

richest in these two compounds was an aqueous extract. However, in *R. rosea*, a richer source of *p*-tyrosol and salidroside was hydroalcoholic extract. In roots of *R. kirilowii*, the main phenylethanoid in the extract was *p*-tyrosol (22.891 mg/100 g of dry powdered material). However, a large concentration of salidroside (646.991 mg/100 g of dry powdered material) was found in the hydroalcoholic extract from *R. rosea*.

Table 3.

Content of phenylethanoids in *Rhodiola kirilowii* and *Rhodiola rosea* roots and extracts

Sample	<i>p</i> -Tyrosol		Salidroside	
	Content [mg/100 g of dry powdered material]	RSD [%]*	Content [mg/100 g of dry powdered material]	RSD [%]*
<i>Rhodiola kirilowii</i> root	25.682	6.35	0.239	4.18
50% Ethanol extract	18.800	2.66	0.054	2.38
Aqueous extract	22.891	5.55	0.133	2.86
<i>Rhodiola rosea</i> root	0.791	2.53	4.715	5.18
50% Ethanol extract	236.025	2.67	646.991	1.98
Aqueous extract	2.651	4.15	92.015	2.92

* RSD – relative standard deviation (n=6)

CONCLUSION

In summary, all the validation tests undertaken show that the analytical method confirmed that ultra performance liquid chromatography connected with a tandem mass spectrometry (UPLC-ESI MS/MS) can be successfully used for the determination of this group of components.

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PORÓWNANIE ZAWARTOŚCI FENYLOETANOIDÓW W KORZENIACH *RHODIOLA KIRILOWII* I *RHODIOLA ROSEA* ZA POMOCĄ METODY UPLC-MS/MS

AGNIESZKA GRYSZCZYŃSKA^{1*}, ZDZISŁAW ŁOWICKI¹, BOGNA OPALA¹, ANNA KRAJEWSKA-PATAN², WALDEMAR BUCHWALD³, BOGUSŁAW CZERNY^{1,4}, SEBASTIAN MIELCAREK¹, PRZEMYSŁAW M. MROZIKIEWICZ^{1,5}

¹Zakład Badania Jakości Produktów Leczniczych i Suplementów Diety
Instytut Włókien Naturalnych i Roślin Zielarskich
ul. Libelta 27
61-707 Poznań

²Zakład Farmakologii i Biologii Doświadczalnej
Instytut Włókien Naturalnych i Roślin Zielarskich
ul. Libelta 27
61-707 Poznań

³Zespół Botaniki i Agrotechniki Roślin Zielarskich
Zakład Botaniki, Hodowli i Agrotechniki
Instytut Włókien Naturalnych i Roślin Zielarskich
ul. Kolejowa 2
62-064 Plewiska k/Poznania

⁴Zakład Farmakologii Ogólnej i Farmakoeconomiki
Wydział Nauk o Zdrowiu, Pomorski Uniwersytet Medyczny
ul. Żołnierska 48
70-204 Szczecin

⁵Pracownia Farmakogenetyki Doświadczalnej
Katedra i Zakład Farmacji Klinicznej i Biofarmacji
Uniwersytet Medyczny w Poznaniu
ul. Św. Marii Magdaleny 14
61-861 Poznań

*autor, do którego należy kierować korespondencję: tel.: +4861 6659540,
faks: +4861 6659551, e-mail: agnieszka.gryszczynska@iwnirz.pl

Streszczenie

Przedmiotem badań było zwalidowanie metody analitycznej oznaczenia zawartości fenyletanoidów. Do detekcji *p*-tyrozolu i salidrozydu w analizowanych dwóch gatunkach różenia wykorzystano wysokosprawny chromatograf cieczowy sprzężony z tandemowym spektrometrem mas (UPLC-MS/MS). Analizie poddano *Rhodiola kirilowii* oraz *Rhodiola rosea* uzyskane z hodowli gruntowej w 2009 r. w Instytucie Włókien Naturalnych i Roślin Zielarskich w Poznaniu. Dodatkowo z surowca przygotowano dwa wyciągi suche: wyciąg wodny i wyciąg wodnoalkoholowy (50% wyciąg etanolowy). Zawartość poszczególnych składników różni się w zależności od analizowanej matrycy.

Słowa kluczowe: *Rhodiola kirilowii*, *Rhodiola rosea*, zawartość fenyletanoidów, UPLC-MS/MS, *p*-tyrozol, salidrozyd