Chemical Composition Analysis and Biofunctionality of *Polygonatum sibiricum* and *Polygonatum odoratum* Extracts

Wayne C. Liao,[a] Jung-Ping Huang,[b] and Wen-Ying Huang [b,*]

Polygonatum sibiricum (*P. sibiricum*) and *Polygonatum odoratum* (*P. odoratum*) are commonly known Chinese herbal medicine sources. Although they had similar medical effects, the difference between these varieties was verified in this study. Liquid chromatography with tandem mass spectrometry (LC/MS/MS) was used to determine their chemical composition. *P. sibiricum* has seven chemical components, whereas *P. odoratum* has only five. Based on the DPPH radical scavenging activity analysis results, half maximal inhibitory concentration (IC_{50}) values of *P. sibiricum* and *P. odoratum* were 4.23 and 18.3 mg/mL, respectively. The results of $ABTS^+$ radical scavenging activity analysis showed that the IC_{50} values of *P. sibiricum* and *P. odoratum* were 4.77 and 19.3 mg/mL, respectively. Moreover, *P. sibiricum* had higher total phenolic content (10.0 mg of gallic acid / g of extract), and better reducing ability than *P. odoratum*. Again, *P. sibiricum* showed better tyrosinase inhibition ability than *P. odoratum*, and the IC_{50} values were 9.68 and 15.4 mg/mL, respectively. *P. sibiricum* was concluded to have better biofunctionality than *P. odoratum.*

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Keywords: Polygonatum sibiricum; Polygonatum odoratum; Chemical composition; Antioxidant ability; Tyrosinase inhibition activity

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INTRODUCTION

Polygonatum sibiricum (*P. sibiricum*, Huang Jing in Chinese) and *Polygonatum odoratum* (*P. odoratum*, Yu Zhu in Chinese) have been recognized as safe Chinese herbal medicine sources for hundreds of years. In some cases, they can be cooked with rice as a nutrition supplement. *P. sibiricum* and *P. odoratum* have many pharmacological applications because they contain a significant amount of polysaccharides. These polysaccharides are mainly composed of monosaccharides, such as glucose, fructose, mannose, galactose, rhamnose, and arabinose (Cui *et al*. 2018). Polysaccharides isolated from *P. sibiricum* rhizome can be used to treat immune system malfunction, diabetes, and Alzheimer's disease (Zhang *et al*. 2015; Wang *et al*. 2019; Wang *et al*. 2020). *P. sibiricum* extract shows remarkable anti-inflammatory, antioxidant, and antiaging abilities (Wong *et al*. 2006; Debnath *et al*. 2013; Yang *et al*. 2015). Similar to *P. sibiricum, P. odoratum* can be used to treat diabetes, reduce blood sugar, and inhibit tumor growth (Li *et al*. 2010; Tai *et al*. 2016). Because *P. sibiricum* and *P. odoratum* extracts show antioxidative ability to remove free radicals, they can be recognized as herbal medicines or functional foods.

Although *P. sibiricum* and *P. odoratum* have been used for hundreds of years, their complete chemical composition has not been discussed. Only a few studies have reported chemical compounds isolated from *P. sibiricum* and *P. odoratum* rhizome extracts with methanol (Song *et al*. 1990) and ethanol (Hu *et al*. 2015; Zhou *et al*. 2015; Wang *et al*. 2016). Several chemical compounds, such as homoisoflavanone, alkaloids, lignins, steroid saponins, triterpenoid saponins, and polysaccharides, have been found in *P. sibiricum* (Zhao *et al*. 2021). In addition, homoisoflavanones, steroidal glycosides, and cinnamic acid derivatives have been isolated from *P. odoratum*, and their inhibitory effects against influenza A virus have been studied (Pang *et al*. 2020). However, the chemical composition difference between these varieties has not been verified. To determine the medical effects of *P. sibiricum* and *P. odoratum*, the chemical composition of each variety was determined. In this study, liquid chromatography in tandem with mass spectrometry (LC/MS/MS), which is widely used to identify chemical compounds (Seger and Salzmann 2020), was used to examine the chemical difference between *P. sibiricum* and *P. odoratum*.

Biofunctionality studies include an analysis of antioxidant ability, reducing ability, and tyrosinase inhibition activity (Liao *et al*. 2018). Antioxidant and reducing ability define the ability to remove free radicals or attenuate an oxidant reaction. The DPPH (2,2-diphenyl-1-picrylhydrazyl) and $ABTS^+$ (2,2'-azino-bis(3-ethyl benzothiazoline-6-sulphonic acid) radical scavenging activities of *P. sibiricum* have been studied in the past (Oh *et al*. 2020). The results show that rhizome extracts had better DPPH and $ABTS^+$ radical scavenging activity than leaf extracts. Therefore, the DPPH and $ABTS^+$ radical scavenging activities of *P. sibiricum* and *P. odoratum* rhizome were analyzed in this study. Higher antioxidant ability represents higher radical scavenging activity. However, the total phenolic and flavonoid contents of *P. sibiricum* and *P. odoratum* extracts were analyzed in this study to explain their reducing ability.

Tyrosinase catalyzes the oxidation of L-tyrosine to 3,4-dihydroxyphenylalanine (DOPA), which results in DOPAchrome formation (Solano *et al*. 2006). These catalyzed reactions result in the formation of melanin, which is responsible for the pigmentation of skin (Olivares and Solano 2009). If *P. sibiricum* or *P. odoratum* can inhibit tyrosinase activity, it has potential application in cosmetic products to provide a whitening capacity. Since *P. sibiricum* and *P. odoratum* showed good antioxidant ability, their tyrosinase inhibition activity was analyzed in this study.

The study aimed to verify the chemical composition difference between *P. sibiricum* and *P. odoratum*. Then, biofunctionality studies were conducted to indicate their medical application.

EXPERIMENTAL

ABTS, BHA (butylated hydroxyanisole), DPPH, kojic acid, methanol (MeOH, HPLC grade), mushroom tyrosinase T3824, and sodium dihydrogen phosphate were purchased from Sigma-Aldrich (St. Louis, MO, USA). Folin-Ciocalteu's phenol reagent (FCP), iron (III) chloride ($FeCl_3$), potassium ferricyanide ($K_3Fe(CN)_6$), and trichloroacetic acid (TCA) were purchased from Merck (Darmstadt, Germany). Ascorbic acid, 3,4-dihydroxyphenyl-L-phenlanine (L-dopa), and trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) were purchased from ACROS Organics (New Jersey, USA). Acetonitrile (HPLC grade) was purchased from J.T. Baker (Petaling Jaya, Selangor, Malaysia).

Sample Preparation

P. sibiricum and *P. odoratum* rhizomes were purchased from a local herbal store located in Taichung, Taiwan. They were originally imported from China. *P. sibiricum* and *P. odoratum* rhizomes were placed in a vacuum oven at 60 °C for 24 h, pulverized, and saved in a moisture-control box with 40 ± 10% relative humidity. The extraction technology, including extraction parameters and process optimization, was reported previously (Yang *et al*. 2020). The results of this study can be used to improve the cosmetics applications of *P. sibiricum* and *P. odoratum*. Therefore, water was used as the extract solvent to avoid skin allergy caused by organic solvents. First, 2 g of *P. sibiricum* or *P. odoratum* powder samples were mixed with 6 mL of deionized water in a centrifugal tube. The tube was immersed in a T-680-DH ultrasonic water bath (ELMA, Germany) at 100% power for 30 min and then centrifuged at 6,000 rpm for 15 min. The supernatant was filtered through a 0.45 μm PVDF membrane filter then collected in a 20 mL volumetric flask. The residual was mixed with deionized water, and the previous procedures were repeated twice. After the entire extraction procedure was complete, deionized water was added to reach the 20 mL mark.

Table 1. Mobile Phase Combination and Solvent Gradients of Ultra Performance Liquid Chromatography Analysis

Polygonatum sibiricum extraction

Time (min)	Flow Rate (mL/min)	Mobile Phase A (%) (0.1 % Formic acid in H_2O)	Mobile Phase B (%) (ACN/MeOH=1/1)
0	0.17	100	0
6	0.17	100	0
9	0.17	98	2
18	0.17	95	5
24	0.17	90	10
30	0.17	85	15
36	0.17	75	25
42	0.17	65	35
48	0.17	55	45
54	0.17	25	75
60	0.17	0	100

Wavelength: 280 nm; Injection volume: 10 μL

Polygonatum odoratum extraction

Time (min)	Flow Rate (mL/min)	Mobile Phase A (%) (0.5 % Formic acid in H_2O)	Mobile Phase B (%) (ACN/MeOH=2/1)
0	0.17	100	0
5	0.17	95	5
25	0.17	35	65
35	0.17	5	95
40	0.17	0	100

Wavelength: 290 nm; Injection volume: 10 μL

Analysis of Total Phenolic and Flavonoid Contents

The total phenolic content was measured based on the method described by Singleton *et al*. (1999). 200-μL different concentrations of samples were mixed with 200 μL of 0.5 N Folin-Ciocalteu reagent, to which 200 μL of 10% (w/v) Na_2CO_3 and 400 μL

of distilled water were added. The mixture was incubated at 25 °C for 60 min in the dark. After incubation, the mixture was centrifuged at 5,000 rpm for 15 min. 100-μL supernatant was transferred to a 96-well plate and the absorbance of each well was measured using an ELISA reader at a wavelength of 700 nm. Gallic acid was used as a positive control. Each measurement was performed in triplicate. Flavonoid content was measured based on the method described by Ramamoorthy and Bono (2007). Different concentrations of samples (50 μL) were mixed with 50 μL of 5% $NaNO_{2(aq)}$. After 5 min, 50 μL of 10% (w/v) $AlCl_3$ was added and kept at 25 °C for 6 min. Then 100 μL of 1N NaOH (aq) was added and the mixture was incubated at 25 °C for 60 min in the dark. The absorbance of the mixture at 510 nm wavelength was measured using an ELISA reader. Quercetin was used as a positive control. Each measurement was performed in triplicate.

Analysis of Antioxidant Ability

The radical scavenging activities of *P. sibiricum* and *P. odoratum* extracts were measured using Hou *et al*. methods with modification (Hou *et al*. 2003) The radical scavenging activity of ascorbic acid, used as a positive control, was also measured. The sample (50 μL) was mixed with 50 μL of freshly prepared 200 μM DPPH in ethanol. The mixture was kept in the dark for 30 min, then the absorbance of the mixture at 517 nm wavelength was measured using an ELISA reader (TECANR, Austria). Each measurement was performed in triplicate. The radical scavenging activity was calculated as follows,

$$\text{DPPH radical scavenging activity (\%)} = \left(1 - \frac{A_{Sample}}{A_{Blank}}\right) \times 100\% \quad (1)$$

where A_{Sample} and A_{Blank} represent the absorbance of sample and blank solution, respectively.

The measured data were used to generate a regression equation. The regression of constructing a dose-response curve with 50% target activity lost was used to determine the IC_{50}. Pure water was used as the negative control when calculating IC_{50} value.

The ABTS radical scavenging activity was based on the method provided by Senthilkumar and Venkatesalu (2013) with modification. To form $ABTS^+$, 7 mM $ABTS_{(aq)}$ was mixed with 2.45 mM $K_2O_8S_{2(aq)}$, then the mixture was kept at 4 °C for 16 h. After the reaction was complete, 95% of ethanol was used to adjust the absorbance of $ABTS^+$ solution to 0.7 ± 0.05 at 730 nm wavelength. Again, 20 μL of extracted *Polygonatum* sample was added to a 96-well plate, then mixed with 180 μL of ABTS+ solution. The mixture was kept in the dark at 25 °C for 10 min. The absorbance of each sample was measured using an ELISA reader at 730 nm wavelength. Each measurement was taken in triplicate. Trolox was used as a positive control. The radical scavenging activity was also calculated using Eq. 1.

The reducing ability of the samples was measured using the method described by Boulekbache-Makhlouf *et al*. (2013). Each sample of different concentrations (100 μL each) was individually mixed with 100 μL of 1% (w/v) $K_3Fe(CN)_6$ and 100 μL of 2 mM phosphate buffer (pH 6.6). Then the mixture was incubated at 50 °C for 20 min. After incubation, 100 μL of 10% (w/v) TCA was added, and the mixture was centrifuged at 3,000 rpm for 2 min. 100-μL supernatant was transferred to the 96-well plate. Each well contained 100 μL of distilled water and 20 μL of 0.1% (w/v) $FeCl_{3(aq)}$. BHA was used as a positive control. The absorbance of each well was measured using an ELISA reader at 700

nm wavelength. Each measurement was performed in triplicate.

Analysis of Tyrosinase Inhibition Activity

The tyrosinase inhibition activity was measured based on the method described by Liao *et al*. (2018). First, 40 μL of *Polygonatum* extract was placed in a 96-well plate. Then, 40 μL of 20 to 200 units of mushroom tyrosinase and 120 μL of L-DOPA solution (dissolved in a sodium phosphate buffer at pH 6.8) were added. These mixed solutions were kept at 37 °C water bath for 30 min. The absorbance was measured at 475 nm using a Microplate-Reader (Sunrise Basic, Grödig, Austria). The tyrosinase inhibition efficiency (%) was calculated as follows,

$$\text{Inhibition efficiency (\%)} = \left(1 - \frac{\text{OD}_{\text{sample}}}{\text{OD}_{\text{control}}}\right) \times 100\% \quad (2)$$

The absorbance of sample (OD_{sample}) and control ($OD_{control}$) was measured at 475 nm.

The regression of constructing a dose-response curve with 50% target activity lost was used to determine the IC_{50}. Twenty units of mushroom tyrosinase were determined to be the optimal enzyme concentration.

An amount of 40 μL of extracted *Polygonatum* solution was placed in a 96-well plate; then 40 μL of mushroom tyrosinase (with 20 units) and 120 μL of (0.1-5 mM) L-DOPA solution were added. The solutions were kept at 37 °C water bath for 30 min. The tyrosinase inhibition rate (%) was calculated using Eq. 2. Each measurement was performed in triplicate. The optimal subtract concentration was 0.1 mM L-DOPA.

An amount of 40 μL of extracted *Polygonatum* solution (with 5-25 mg/mL) was placed in a 96-well plate; then 40 μL of mushroom tyrosinase (with 20 units) and 120 μL of L-DOPA solution (0.1 mM) were added. The solutions were kept at 37 °C water bath for 30 min. After the absorbance was measured, the tyrosinase inhibition efficiency (%) was calculated using Eq. 2. Each measurement was performed in triplicate. Kojic acid solutions (0.001 to 0.05 mg/mL) were used as the positive control.

Ultra Performance Liquid Chromatography Analysis

The chemical composition of *P. sibiricum* and *P. odoratum* was analyzed using ultra performance liquid chromatography (UPLC, Xevo™ TQ-S LC/MS/MS mass spectrometry, Waters, USA) with Acquity UPLC BEH C18 Column (No. 186002353, 2.1 mm inner diameter, 150 mm length) and Acquity UPLC PDA Detector (Waters). Mobile phase combination and solvent gradients are shown in Table 1. After PDA analysis, samples were analyzed by the LC/MS/MS. The MS/MS used a positive electrospray ionization source and operated at a 2.5 kV capillary voltage, 350 °C desolvation temperature, and 0.15 mL/min collision gas flow rate. To get the $[M+H]^+$ of each compound, the retention time of those peaks shown in UPLC chromatograms was compared with peaks shown in total ion chromatograms. The $[M+H]^+$ was used to determine the molecular weight of each compound.

Statistical Analysis

STATISTICA^R (version 7.0, StatSoft Inc., USA) was used to perform the statistical evaluation, which included a one-way analysis of variance (ANOVA). All data were presented as mean ± standard deviation (SD). When the p-value was less than 0.05, the differences were considered statistically significant.

RESULTS AND DISCUSSION

Analysis of Total Phenolic and Flavonoid Contents

The total phenolic and flavonoid contents of *P. sibiricum* and *P. odoratum* extracts are shown in Table 2. *P. sibiricum* extract contained four times more phenolic components than *P. odoratum* extract. However, the total flavonoid content of both extracts was close. According to Table 2, *P. sibiricum* extract contained more phenolics; therefore, *P. sibiricum* was expected to have better antioxidant activity than *P. odoratum*.

Table 2. The Total Phenolic and Flavonoid Content of *P. sibiricum* and *P. odoratum* Extracts

Samples	Total phenolic content (mg of gallic acid / g of extract)	Total flavonoid content (mg of quercetin / g of extract)
P. sibiricum	10.0246 ± 0.0003	12.6913 ± 0.0412
P. odoratum	2.6929 ± 0.0025	11.4761 ± 0.0460

Analysis of Antioxidant Ability

The antioxidant ability analysis involved DPPH and $ABTS^+$ radical scavenging activities and reducing ability. The DPPH radical scavenging activities of *P. sibiricum* and *P. odoratum* extracts were measured as the decrease of absorbance at a wavelength of 517 nm, and the results are shown in Fig. 1.

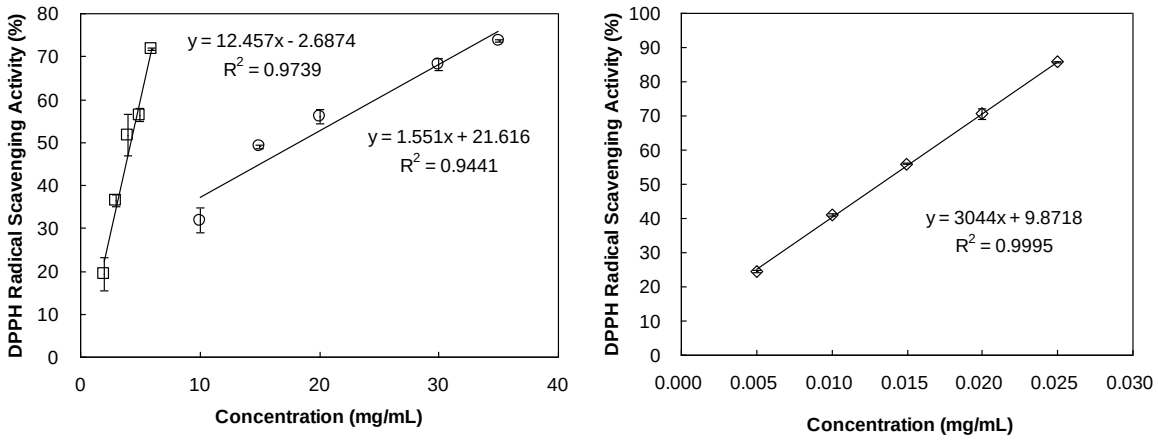


Fig. 1. DPPH (2,2-Diphenyl-1-picrylhydrazyl) radical scavenging activity (%) of *Polygonatum* extracts (□: *P. sibiricum*; ○: *P. odoratum*; ◇: ascorbic acid as the positive control)

The decreased absorbance represents higher DPPH radical scavenging activity. The DPPH radical scavenging activities of *P. sibiricum* and *P. odoratum* extracts increased as the increase of the extract concentration. The half maximal inhibitory concentration (IC_{50}) value of ascorbic acid (positive control) was 0.01 mg/mL, whereas those of *P. sibiricum* and *P. odoratum* extracts were 4.23 and 18.30 mg/mL, respectively. In terms of DPPH radical scavenging activity, *P. sibiricum* extract had better DPPH radical scavenging activity than *P. odoratum* extract. As shown in Fig. 1, when 6 mg/mL of *P. sibiricum* extract was used, DPPH radical scavenging activity was 72.1%. When 10 mg/mL of *P. odoratum* extract was used, DPPH radical scavenging activity was only 37.1%. Because

vitamin C is a well-known effective antioxidant, it is normally used as the positive control for the antioxidant ability study. *P. sibiricum* and *P. odoratum* are natural products, and their extracts are considered as a mixture. Therefore, their DPPH scavenging ability is lower than that of pure ascorbic acid. However, *P. sibiricum* and *P. odoratum* still had remarkable antioxidant ability.

Figure 2 shows the results of measuring the $ABTS^+$ radical scavenging activities of *P. sibiricum* and *P. odoratum* extracts as a decrease in absorbance at a wavelength of 730 nm. Higher $ABTS^+$ radical scavenging activity is associated with lower absorbance. The $ABTS^+$ radical scavenging activities of *P. sibiricum* and *P. odoratum* extracts increased as the increase of the extract concentration. The IC_{50} value of trolox (positive control) was 0.06 mg/mL, whereas that of *P. sibiricum* and *P. odoratum* extracts were 4.77 and 19.26 mg/mL, respectively. *P. sibiricum* extract had better $ABTS^+$ radical scavenging activity than *P. odoratum* extract, similar to the results of DPPH radical scavenging activity study. Based on the results of DPPH and $ABTS^+$ radical scavenging activity analysis, *P. sibiricum* had better radical scavenging ability; therefore, *P. sibiricum* had better antioxidant ability.

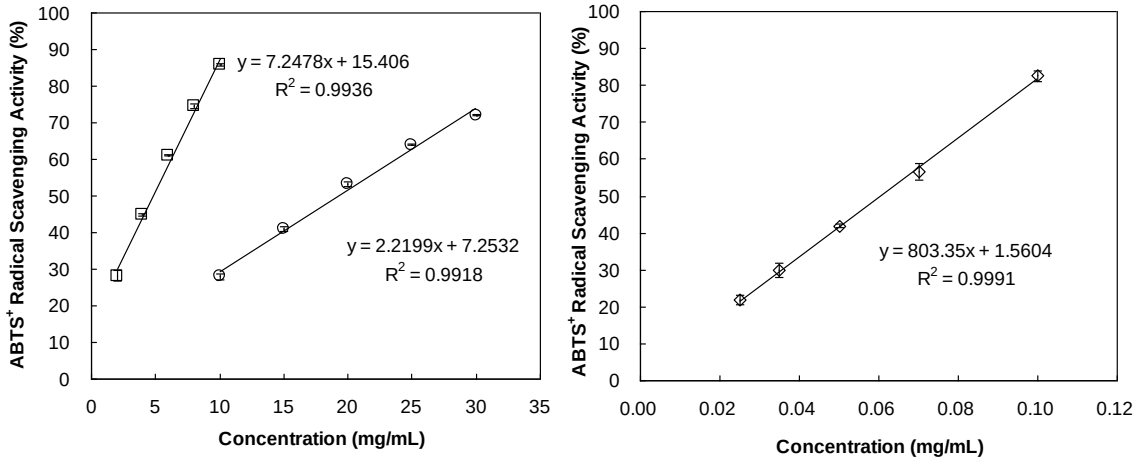


Fig. 2. $ABTS^+$ (2,2'-Azino-bis(3-ethyl benzothiazoline-6-sulphonic acid) radical scavenging activity (%) of *Polygonatum* extracts (□: *P. sibiricum*; ○: *P. odoratum*; ◇: trolox as the positive control)

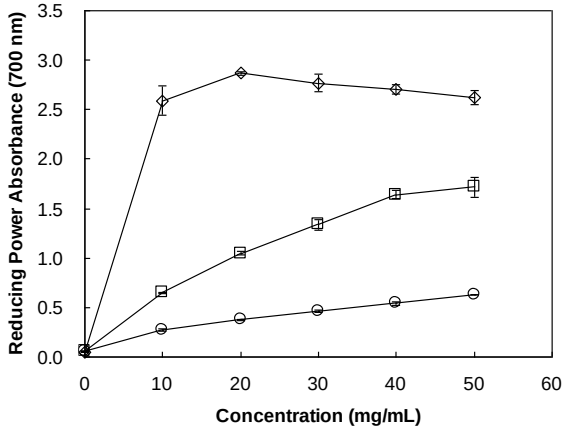


Fig. 3. Reducing ability analysis of *Polygonatum* extracts (□: *P. sibiricum*; ○: *P. odoratum*; ◇: BHA (butylated hydroxyanisole) as the positive control)

The reducing ability analysis of *P. sibiricum* and *P. odoratum* extracts is shown in Fig. 3. *P. sibiricum* extract had a better reducing ability than *P. odoratum* extract. Based on the above results, *P. sibiricum* extract was concluded to have better antioxidant ability than *P. odoratum* extract. The higher antioxidant ability of *P. sibiricum* was a result of higher total phenolic or flavonoid content. Total phenolic and flavonoid contents can be used to explain the difference in antioxidant ability between *P. sibiricum* and *P. odoratum*.

Analysis of Tyrosinase Inhibition Activity

The tyrosinase inhibition activity represents the potential of being a whitening ingredient in cosmetics. *P. sibiricum* and *P. odoratum* extracts showed the ability to inhibit the formation of DOPAchrome, which can be detected at 475 nm (Fig. 4). Tyrosinase inhibition activity was attributed to the presence of phenolics in *P. sibiricum* and *P. odoratum* extracts. Tyrosinase activity inhibition behaved in a dose-dependent manner. The IC_{50} values of extracted *P. sibiricum* and *P. odoratum* solutions were calculated to be 9.68 and 15.43 mg/mL, respectively. *P. sibiricum* extract had better tyrosinase inhibition activity than *P. odoratum*, especially at a lower dose. If 25 mg/mL extract was added, the tyrosinase inhibition activity difference would be close. The IC_{50} value of kojic acid (positive-control) was 0.01 mg/mL. *P. sibiricum* and *P. odoratum* are natural plants, and they are considered as a good source of tyrosinase inhibitors. *P. sibiricum* and *P. odoratum* are promising herbal medicine because they showed good antioxidant ability, strong reducing ability, and high tyrosinase inhibition activity. They can also be used as a whitening ingredient, but the cosmetic application requires more study.

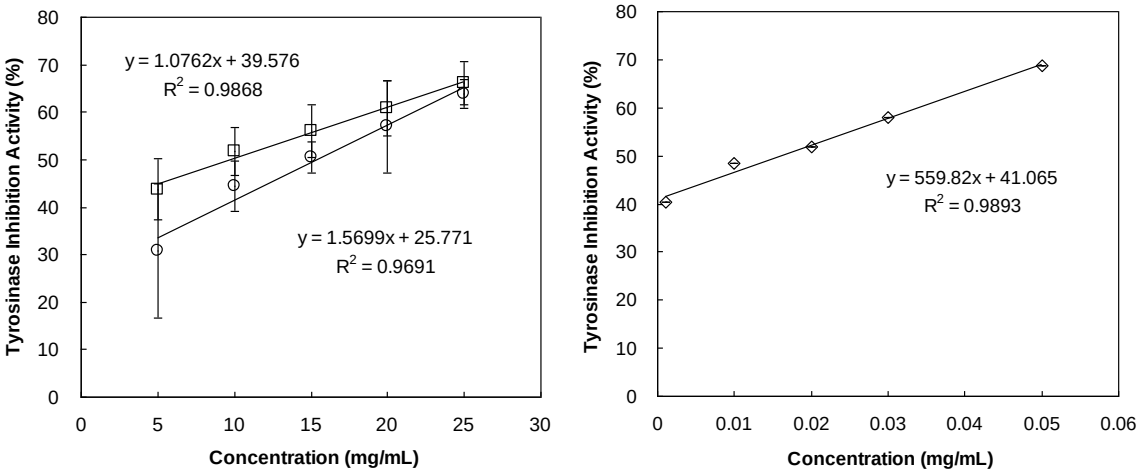


Fig. 4. Inhibition rate of tyrosinase activity using *Polygonatum* extracts as the inhibitor (□: *P. sibiricum*; ○: *P. odoratum*; ◇: Kojic acid as the positive control)

Chemical Composition Analysis

The LC/MS/MS analytical results were used to determine the chemical composition of *P. sibiricum* and *P. odoratum*. Table 3 shows the chemical composition of *P. sibiricum* which included 5- hydroxymethylfurfural, polygonatine B, polygonatine A, butyl-â-D-fructofuranoside, (6R, 9R)-roseoside, (6aR, 11aR)-10-hydroxy-3,9- dimethoxyptercarpan, and tianshic acid. Researchers have separately reported part of these compounds found in *P. sibiricum* (Son *et al*. 1990; Wang *et al*. 2016). *P. sibiricum* contained seven active components, and their chemical structures were verified in this study. The chemical structures of these seven compounds are shown in Table 3.

Table 3. Chemical Composition Analysis of *P. sibiricum*

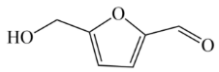
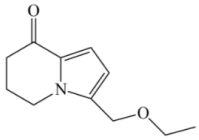
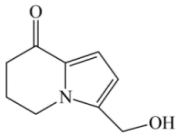
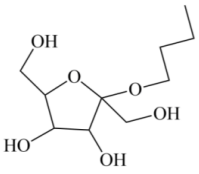
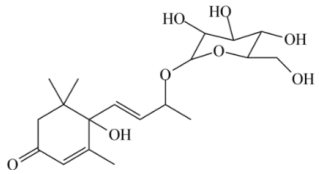
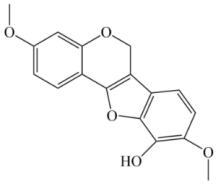
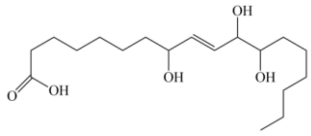
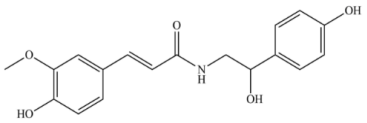
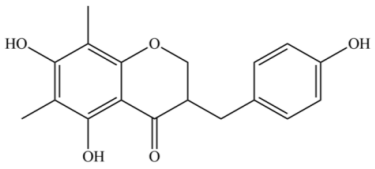
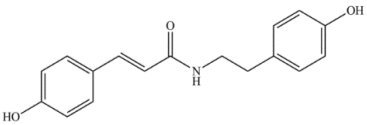
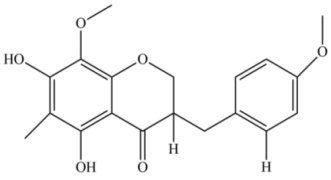
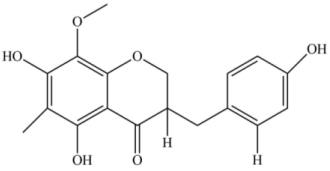
No.	Retention Time (min)	Compounds	Chemical Structure	$[M+H]^+$ (*m*/*z*)
1	12.440	5-hydroxymethylfurfural		127
2	22.339	polygonatine B		192
3	25.547	polygonatine A		166
4	27.358	butyl-*β*-*D*-fructofuranoside		238
5	59.080	(6R, 9R)-roseoside		387
6	59.880	(6aR,11aR)-10-hydroxy-3,9-dimethoxyptercarpan		269
7	60.010	tianshic acid		313

Table 4 shows the chemical composition of *P. odoratum*, which included feruloyloctopamine, 5,7,4’-trihydroxyl-6,8- dimethyl homoisoflavanone, coumaroyl-tyramine, 5,7-dihydroxy-6-methyl-8-methoxy-3- (4'-methoxylbenzyl)-chroman- 4-one, and 5,7-dihydroxy-6-methyl-8-methoxy-3- (4'-hydroxybenzyl)-chroman-4-one. Similar to *P. sibiricum*, chemical compounds of *P. odoratum* have been separately reported by other researchers in the past (Hu *et al*. 2015; Zhou *et al*. 2015). *P. odoratum* was verified to have five active components in this study. The chemical structure of these five compounds was shown in Table 4. Based on above results, the chemical compositions of *P. sibiricum* and *P. odoratum* were completely different. Although they had similar medical effects, their anti-oxidant ability and tyrosinase inhibition activity were expected to be different.

Table 4. Chemical Composition Analysis of *P. odoratum*

No.	Retention Time (min)	Compounds	Chemical Structure	$[M+H]^+$ (*m*/*z*)
1	4.988	feruloyl octopamine		328
2	8.280	5,7,4'-trihydroxyl-6,8-dimethyl homoisoflavanone		314
3	10.095	coumaroyl tyramine		265
4	10.306	5,7-dihydroxy-6-methyl-8-methoxy- 3-(4'-methoxylbenzyl)- chroman-4-one		344
5	11.656	5,7-dihydroxy-6-methyl-8-methoxy-3-(4'-hydroxybenzyl)-chroman-4-one		331

CONCLUSIONS

1. The chemical compositions of *Polygonatum sibiricum* and *P. odoratum*, traditional Chinese herbal medicines, are completely different. *P. sibiricum* had seven active components, whereas *P. odoratum* only had five. Therefore, their biofunctionality was different.
2. *P. sibiricum* had better DPPH and $ABTS^+$ radical scavenging activity than *P. odoratum*. Further, *P. sibiricum* had better reducing ability than *P. odoratum*, which was attributed to its higher total phenolic content.
3. Both *P. sibiricum* and *P. odoratum* showed good biofunctionality. In addition, *P. sibiricum* and *P. odoratum* extracts may be used in cosmetics as a whitening ingredient. However, *P. sibiricum* had better tyrosinase inhibition activity than *P. odoratum*. The results of this study have potential to improve the medical and cosmetics applications of *P. sibiricum* and *P. odoratum*.

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