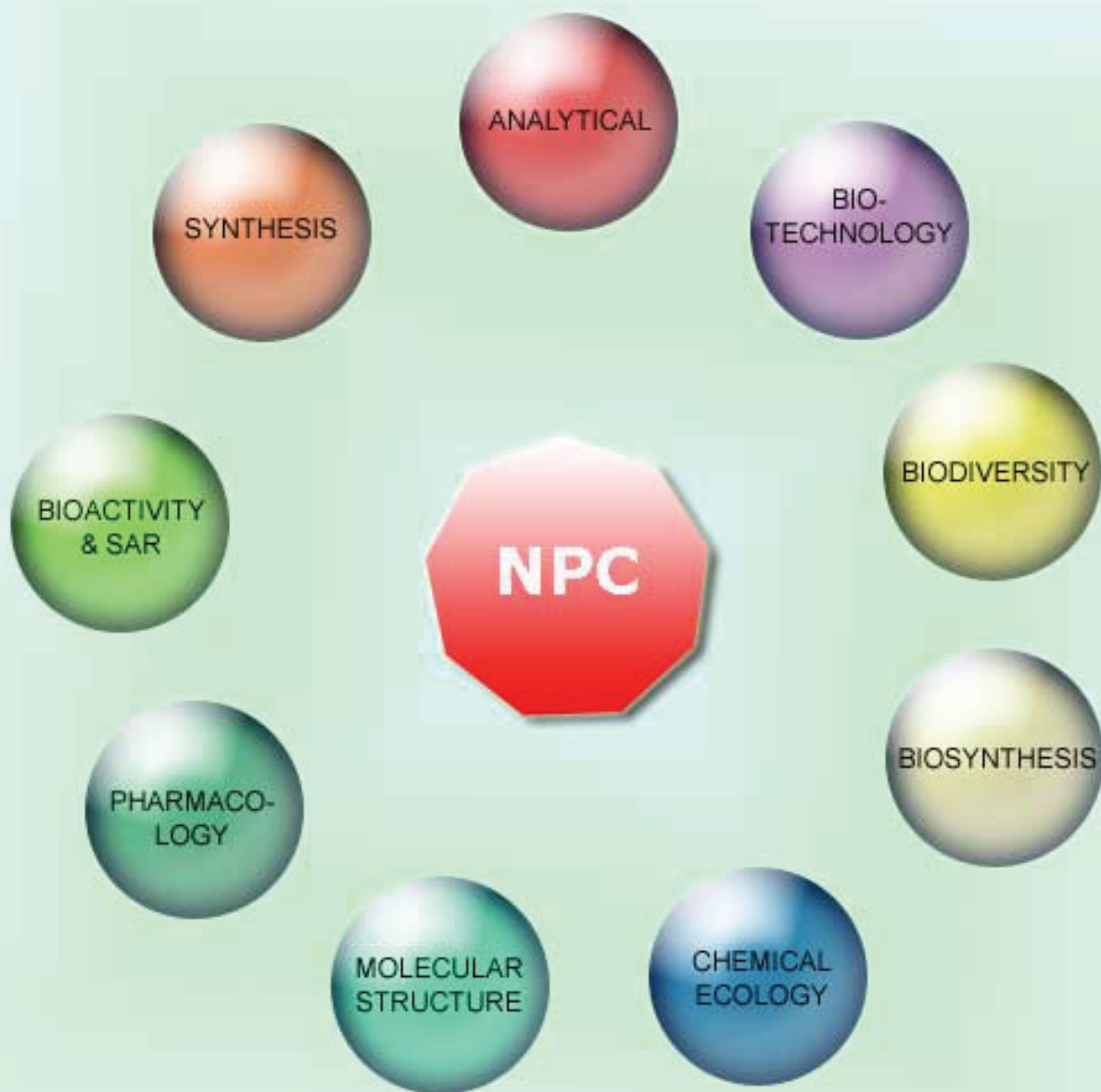


NATURAL PRODUCT COMMUNICATIONS

An International Journal for Communications and Reviews Covering all
Aspects of Natural Products Research



Volume 12. Issue 12. Pages 1821-1970. 2017
ISSN 1934-578X (printed); ISSN 1555-9475 (online)
www.naturalproduct.us

EDITOR-IN-CHIEF**DR. PAWAN K AGRAWAL**

Natural Product Inc.
7963, Anderson Park Lane,
Westerville, Ohio 43081, USA
agrawal@naturalproduct.us

EDITORS**PROFESSOR ALEJANDRO F. BARRERO**

Department of Organic Chemistry, University of Granada,
Campus de Fuente Nueva, s/n, 18071, Granada, Spain
afbarre@ugr.es

PROFESSOR MAURIZIO BRUNO

Department STEBICEF,
University of Palermo, Viale delle Scienze,
Parco d'Orleans II - 90128 Palermo, Italy
maurizio.bruno@unipa.it

PROFESSOR VLADIMIR I. KALININ

G.B. Elyakov Pacific Institute of Bioorganic Chemistry,
Far Eastern Branch, Russian Academy of Sciences,
Pr. 100-letya Vladivostoka 159, 690022,
Vladivostok, Russian Federation
kalininv@piboc.dvo.ru

PROFESSOR YOSHIHIRO MIMAKI

School of Pharmacy,
Tokyo University of Pharmacy and Life Sciences,
Horinouchi 1432-1, Hachioji, Tokyo 192-0392, Japan
mimakiy@ps.toyaku.ac.jp

PROFESSOR STEPHEN G. PYNE

Department of Chemistry, University of Wollongong,
Wollongong, New South Wales, 2522, Australia
spyne@uow.edu.au

PROFESSOR MANFRED G. REINECKE

Department of Chemistry, Texas Christian University,
Forts Worth, TX 76129, USA
m.reinecke@tcu.edu

PROFESSOR WILLIAM N. SETZER

Department of Chemistry, The University of Alabama in Huntsville,
Huntsville, AL 35809, USA
wsetzer@chemistry.uah.edu

PROFESSOR PING-JYUN SUNG

National Museum of Marine Biology and Aquarium
Checheng, Pingtung 944
Taiwan
pjsung@nmmba.gov.tw

PROFESSOR YASUHIRO TEZUKA

Faculty of Pharmaceutical Sciences, Hokuriku University,
Ho-3 Kanagawa-machi, Kanazawa 920-1181, Japan
y-tezuka@hokuriku-u.ac.jp

PROFESSOR DAVID E. THURSTON

Institute of Pharmaceutical Science
Faculty of Life Sciences & Medicine
King's College London, Britannia House
7 Trinity Street, London SE1 1DB, UK
david.thurston@kcl.ac.uk

HONORARY EDITOR**PROFESSOR GERALD BLUNDEN**

The School of Pharmacy & Biomedical Sciences,
University of Portsmouth,
Portsmouth, PO1 2DT U.K.
axuf64@dsl.pipex.com

ADVISORY BOARD

Prof. Giovanni Appendino
Novara, Italy

Prof. Norbert Arnold
Halle, Germany

Prof. Yoshinori Asakawa
Tokushima, Japan

Prof. Vassaya Bankova
Sofia, Bulgaria

Prof. Roberto G. S. Berlinck
São Carlos, Brazil

Prof. Anna R. Bilia
Florence, Italy

Prof. Geoffrey Cordell
Chicago, IL, USA

Prof. Fatih Demirci
Eskişehir, Turkey

Prof. Francesco Epifano
Chieti Scalo, Italy

Prof. Ana Cristina Figueiredo
Lisbon, Portugal

Prof. Cristina Gracia-Viguera
Murcia, Spain

Dr. Christopher Gray
Saint John, NB, Canada

Prof. Dominique Guillaume
Reims, France

Prof. Duvvuru Gunasekar
Tirupati, India

Prof. Hisahiro Hagiwara
Niigata, Japan

Prof. Judith Hohmann
Szeged, Hungary

Prof. Tsukasa Iwashina
Tsukuba, Japan

Prof. Leopold Jirovetz
Vienna, Austria

Prof. Phan Van Kiem
Hanoi, Vietnam

Prof. Niel A. Koorbanally
Durban, South Africa

Prof. Chiaki Kuroda
Tokyo, Japan

Prof. Hartmut Laatsch
Gottingen, Germany

Prof. Marie Lacaillle-Dubois
Dijon, France

Prof. Shoei-Sheng Lee
Taipei, Taiwan

Prof. M. Soledade C. Pedras
Saskatoon, Canada

Prof. Luc Pieters
Antwerp, Belgium

Prof. Peter Proksch
Düsseldorf, Germany

Prof. Phila Raharivelomanana
Tahiti, French Polynesia

Prof. Stefano Serra
Milano, Italy

Dr. Bikram Singh
Palampur, India

Prof. Leandros A. Skaltsounis
Zografou, Greece

Prof. John L. Sorensen
Manitoba, Canada

Prof. Johannes van Staden
Scottsville, South Africa

Prof. Valentin Stonik
Vladivostok, Russia

Prof. Winston F. Tinto
Barbados, West Indies

Prof. Sylvia Urban
Melbourne, Australia

Prof. Karen Valant-Vetschera
Vienna, Austria

INFORMATION FOR AUTHORS

Full details of how to submit a manuscript for publication in Natural Product Communications are given in Information for Authors on our Web site <http://www.naturalproduct.us>.

Authors may reproduce/republish portions of their published contribution without seeking permission from NPC, provided that any such republication is accompanied by an acknowledgment (original citation)-Reproduced by permission of Natural Product Communications. Any unauthorized reproduction, transmission or storage may result in either civil or criminal liability.

The publication of each of the articles contained herein is protected by copyright. Except as allowed under national "fair use" laws, copying is not permitted by any means or for any purpose, such as for distribution to any third party (whether by sale, loan, gift, or otherwise); as agent (express or implied) of any third party; for purposes of advertising or promotion; or to create collective or derivative works. Such permission requests, or other inquiries, should be addressed to the Natural Product Inc. (NPI). A photocopy license is available from the NPI for institutional subscribers that need to make multiple copies of single articles for internal study or research purposes.

To Subscribe: Natural Product Communications is a journal published monthly. 2017 subscription price: US\$2,595 (Print, ISSN# 1934-578X); US\$2,595 (Web edition, ISSN# 1555-9475); US\$2,995 (Print + single site online); US\$595 (Personal online). Orders should be addressed to Subscription Department, Natural Product Communications, Natural Product Inc., 7963 Anderson Park Lane, Westerville, Ohio 43081, USA. Subscriptions are renewed on an annual basis. Claims for nonreceipt of issues will be honored if made within three months of publication of the issue. All issues are dispatched by airmail throughout the world, excluding the USA and Canada.

Chemical Composition of Essential Oil, Antioxidant, Antidiabetic, Anti-obesity, and Neuroprotective Properties of *Prangos gaubae*

Mir Babak Bahadori^a, Gokhan Zengin^b, Shahram Bahadori^{c*}, Filippo Maggi^d and Leila Dinparast^e

^aResearch Center for Pharmaceutical Nanotechnology, Tabriz University of Medical Sciences, Tabriz, Iran

^bDepartment of Biology, Science Faculty, Selcuk University, Konya, Turkey

^cYoung Researchers and Elite Club, Urmia Branch, Islamic Azad University, Urmia, Iran

^dSchool of Pharmacy, University of Camerino, Camerino, Italy

^eBiotechnology Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

shahrambahadori28@yahoo.com

Received: January 21st, 2017; Accepted: May 29th, 2017

Chemical composition of essential oil and the potential of *Prangos gaubae* for the management of public health problems such as Alzheimer's disease, obesity, Diabetes mellitus, and skin diseases were evaluated for the first time. In this direction, enzyme inhibitory effects, antioxidant activity, and total bioactive contents of the plant were determined. EO showed high acetylcholinesterase (2.97 mg GEs/g oil), α -amylase (1.35 mmol ACEs/g oil), α -glucosidase (38.84 mmol ACEs/g oil), and lipase (1.59 mmol OEs/g oil) inhibitory activities. Moreover, strong antioxidant effects were observed in antiradical (DPPH and ABTS), reducing power (CUPRAC and FRAP), total antioxidant, and metal chelating assays. Methanol extract exhibited promising DPPH radical scavenging activity (0.47 mmol TE/g extract) and also high reducing power in CUPRAC (0.89 mmol TE/g extract) and FRAP (0.52 mmol TE/g extract) assays. All extracts showed low total flavonoid but high total phenolics content. Furthermore, they exhibited strong skin-care effect in tyrosinase inhibition assay. EO analysis showed the presence of germacrene D (26.7%), caryophyllene oxide (14.3%), (*E*)-caryophyllene (13.8%), and spathulenol (11.3%) as the major volatile components. Results indicated that *P. gaubae* has promising potential for possible uses in food, cosmetic, and pharmaceutical industries due to its valuable phytoconstituents and biological activities.

Keywords: *Prangos gaubae*, Diabetes mellitus, Alzheimer's disease, Obesity, Antioxidant, Essential oil.

The genus *Prangos* L. belonging to the Apioideae subfamily of the Apiaceae family contains around 45 herbaceous hemicryptophyte species worldwide. The members of the genus are mostly distributed in the southwest and central Asia. *Prangos* represents by 14 species in Iran, of which 5 species including *P. gaubae* (Bornm.) Herrnst. & Heyn are endemic to the country [1, 2].

The genus traditionally have been used as spice, food, fodder, and medicine for treatment of some health problems like seizures, headaches, leukoplakia, bleeding, and digestive disorders [3, 4]. Some pharmacological properties such as aphrodisiac, tonic, carminative, emollient, anthelmintic, antispasmodic, antiinflammatory, anti-hemorrhoid, abortifacient, antifatulent, diuretic, and soothing effects have been also reported for *Prangos* species [5, 6]. In addition, scientific studies have been resulted in detection of some biological functions such antibacterial, allelopathic, cytotoxic, anti-oxidant and anti-fungal activities [7]. *Prangos* species are rich in coumarin compounds like osthol, oxypeucedanin and isoimperatorin which show wide range of bioactivities. Furthermore, flavonoids, alkaloids, terpenoids, and essential oils constitute other remarkable chemical content of the genus [8].

Prangos gaubae has not previously been subjected to any phytochemical or biological studies. So, at the present study, we aimed to investigate the bioactivities and phytoconstituents of *P. gaubae* for the first time. In this direction, antioxidant and enzyme inhibitory activities and the EO composition of the plant were evaluated using several bioassays. The fresh plant is not much pleasantly aromatic. The ripen fruits of the plant are edible. Unlike the other members of the genus, *P. gaubae* is not a polycarpic species. On the other hand, nutritional usages of fruits in the long

term by the locals, has been one of the anthropological reasons of the restricted distribution of *P. gaubae* in the area.

The chemical composition of *P. gaubae* essential oil has not been investigated up to now. At the present work, the EO yield was 0.4% v/w. Chemical composition of the EO is shown in Table 1. The EO was characterized by the presence of 41 volatile constituents, representing 92.8% of total composition. Germacrene D (26.7%), caryophyllene oxide (14.3%), (*E*)-caryophyllene (13.8%), and spathulenol (11.3%) were identified as the most abundant components (Figure 1). Sesquiterpene hydrocarbons (48.5%) represented the main fraction of the oil, followed by oxygenated sesquiterpenes (32.0%). In comparison, the essential oil analyzing of some *Prangos* species such as *P. denticulate*, *P. cheilanthifolia*, *P. ferulacea*, *P. acaulis*, and *P. pabularia* indicated that the major volatile constituents in the genus are as followed: sabinene, *p*-cymene, δ -3-carene, (*Z*)-3,5-nonadiyne-7-ene, β -myrcene, camphor, *trans*-caryophyllene, α -pinene, *cis*-ocimene, spathulenol, α -bisabolol, caryophyllene oxide, linalool, 3-ethylidene-2-methyl-1-hexen-4-yne, α -terpinene, limonene, lavandulyl acetate, 1,8-cineole, and geranyl isobutyrate [9-13].

As could be seen in Table 2, all of the extracts showed moderate concentration of phenolic compounds (12-53 mg Gallic acid equivalents/g extract) and low concentration of flavonoid components (1.7-12.4 mg Rutin equivalents/g extract). This is in agreement with this fact which major compounds in the genus *Prangos* are coumarins [8]. Total phenolic content of methanolic and water extracts of 4 *Prangos* species (roots, leaves, and fruits) from Konya, Turkey showed the range of 37-140 mg GAEs/g extract [14].

Oxidant compounds such as reactive oxygen (ROS) and nitrogen (RNS) species are responsible for oxidative stress which plays an important role in many human disorders [15-17]. In this work, several methods were used to evaluate the antioxidant potential of *P. gaubae*. As shown in Table 2, radical scavenging activity analysis revealed that EO has strong 2,2-azino-bis (3-ethylbenzothiazolone-6-sulfonic acid) radical cation (ABTS) scavenging activity (2.02 mmol Trolox equivalents/g oil) and the MeOH extract has promising antiradical activity against 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals (0.47 mmol TE/g extract). Similarly, the MeOH extract exhibited high reducing power activity in the cupric ion reducing activity (CUPRAC) (0.89 mmol TE/g extract) and the ferric reducing antioxidant power (FRAP) (0.52 mmol TE/g extract) assays (Table 2). Phenolics together with coumarin compounds may be responsible for antioxidant capacity of MeOH extract. There some reports in the literature showing that these metabolites have strong antioxidant properties in the genus [5, 14, 18]. The EO exhibited the highest antioxidant potential in the total antioxidant (9.17 mmol TE/g sample) and metal chelating (37 mg EDTAs/g sample) assays (Table 2). These observations may be interpretable by antioxidant abilities of oxygenated sesquiterpenoids found in *P. gaubae* EO such as spathulenol and caryophyllene oxide.

Discovery of enzyme inhibitors is an important strategy to find effective drugs for treatment of many diseases such as obesity (lipase), Alzheimer's diseases (cholinesterases), inflammation (cyclooxygenases), skin disorders (tyrosinase), and diabetes mellitus (amylase and glucosidase) [19, 20]. In this regards, at the present study, *in vitro* enzyme inhibitory potential of *P. gaubae* was evaluated against acetylcholinesterase, butyrylcholinesterase, α -amylase, α -glucosidase, tyrosinase, and lipase. The results are expressed as equivalents of reference drugs (Table 3). The EO demonstrated the highest inhibitory activity against cholinesterases followed by DCM extract. There are several reports in the literature indicating that coumarins have strong cholinesterases inhibitory activities [21, 22]. All of the plant samples showed moderate α -amylase inhibition and strong α -glucosidase inhibition (7-38 mmol Acarbose equivalents/g sample). The tyrosinase inhibitory activity of the EO and extracts of *P. gaubae* varied from 16 to 36 mg Kojic acid equivalents/g sample. As shown in Table 3, Hex extract and EO exhibited promising tyrosinase inhibitory effects (36 and 29 mg KAEs/g oil or extract, respectively) and could be considered for possible uses in cosmetic industries as skin-care agents. Antibioactivity potential of *P. gaubae* was also evaluated by its inhibitory effect on porcine pancreatic lipase (type-II). The EO showed strong activity (1.59 mmol Orlistat equivalents/g oil) and may be

Table 1: Essential oil composition of aerial parts of *Prangos gaubae*.

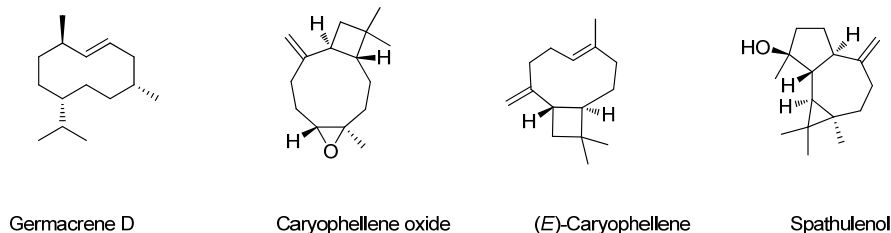
No.	Compound ^a	Percentage ^b	RI ^c	RI lit ^d	Identification Method ^e
1	α -Pinene	1.4	926	932	RI,MS
2	Camphene	0.2	939	946	RI, MS, Co-I
3	Sabinene	0.2	965	969	RI, MS, Co-I
4	β -Pinene	0.1	969	974	RI,MS
5	Myrcene	0.2	989	988	RI, MS, Co-I
6	<i>p</i> -Cymene	1.0	1021	1020	RI, MS, Co-I
7	Limonene	2.8	1024	1024	RI, MS, Co-I
8	(<i>E</i>)- β -Ocimene	0.5	1046	1044	RI, MS, Co-I
9	γ -Terpinene	0.1	1055	1054	RI, MS, Co-I
10	Terpinolene	0.1	1084	1086	RI, MS, Co-I
11	<i>p</i> -Cymen-8-ol	0.2	1183	1179	RI, MS, Co-I
12	Carvacrol, methyl ether	1.6	1242	1241	RI, MS, Co-I
13	Bornyl acetate	0.1	1282	1287	RI,MS
14	Thymol	0.1	1294	1289	RI, MS, Co-I
15	<i>n</i> -Tridecane	0.1	1300	1300	RI,MS
16	Carvacrol	0.1	1302	1298	RI,MS
17	α -Copaene	1.1	1368	1374	RI,MS
18	β -Cubebene	0.7	1383	1387	RI, MS, Co-I
19	β -Elemene	2.1	1385	1389	RI,MS
20	(<i>E</i>)-Caryophyllene	13.8	1409	1417	RI, MS, Co-I
21	α -Humulene	1.0	1443	1452	RI,MS
22	Germacrene D	26.7	1472	1484	RI, MS, Co-I
23	(<i>E</i>)- β -Ionone	0.4	1481	1487	RI, MS, Co-I
24	Bicyclogermacrene	1.3	1487	1500	RI,MS
25	α -Muurolole	0.2	1494	1500	RI, MS, Co-I
26	<i>n</i> -Pentadecane	1.3	1500	1500	RI,MS
27	γ -Cadinene	0.3	1505	1513	RI,MS
28	δ -Cadinene	1.2	1517	1522	RI,MS
29	Spathulenol	11.3	1567	1576	RI, MS, Co-I
30	Caryophyllene oxide	14.3	1571	1582	RI,MS
31	Salvial-4(14)-en-1-one	0.2	1583	1594	RI, MS, Co-I
32	Humulene epoxide II	0.8	1597	1608	RI, MS, Co-I
33	epi- α -Cadinol	0.4	1632	1638	RI,MS
34	epi- α -Muurolole	0.4	1633	1640	RI, MS, Co-I
35	α -Cadinol	1.2	1646	1652	RI,MS
36	Eudesma-4(15),7-dien-1 β -ol	3.0	1676	1687	RI,MS
37	<i>n</i> -Heptadecane	0.1	1699	1700	RI, MS, Co-I
38	Neophytadiene	0.4	1838	1846	RI,MS
39	Hexahydrofarnesyl acetone	0.2	1844	1845	RI,MS
40	<i>n</i> -Hexadecanoic acid	1.1	1965	1959	RI,MS
41	<i>trans</i> -Phytol	0.4	2104	2104	RI,MS
	Monoterpene hydrocarbons	6.5			
	Oxygenated monoterpenes	2.1			
	Sesquiterpene hydrocarbons	48.5			
	Oxygenated sesquiterpenes	32.0			
	Diterpenes	0.4			
	Others	3.3			
	Total identified (%)	92.8			

^a Compounds are listed in order of their elution from a HP-5MS column. ^b Relative percentage values are means of three determinations with a RSD% in all cases below 10%. ^c RI: Linear retention index on HP-5MS column, experimentally determined using homologous series of C₈-C₃₀ alkanes. ^d RI lit: Linear retention index taken from Adams (2007) and/or NIST 08 (2008). ^e Identification methods: Co-I: Co-injection: based on comparison with authentic compounds; MS, based on comparison with WILEY, ADAMS, FFNSC2 and NIST 08 MS databases; RI, based on comparison of calculated RI with those reported in ADAMS, FFNSC 2 and NIST 08.

Table 2: Total bioactive compounds and antioxidant properties of *P. gaubae*.

Assay	EO	Hex	DCM	MeOH
Total phenolic content (mg GAEs/g extract) ^a	-	12.22 ± 0.11	37.46 ± 1.18	53.85 ± 1.28
Total flavonoid content (mg REs/g extract) ^b	-	1.77 ± 0.14	1.80 ± 0.07	12.42 ± 0.16
Total antioxidant (mmol TEs/g sample) ^c	9.17 ± 0.20	1.35 ± 0.07	2.01 ± 0.12	1.47 ± 0.06
DPPH radical (mmol TEs/g sample) ^c	-	0.04 ± 0.01	0.12 ± 0.01	0.47 ± 0.01
ABTS radical cation (mmol TEs/g sample) ^c	2.02 ± 0.07	0.08 ± 0.01	0.76 ± 0.03	1.34 ± 0.05
CUPRAC (mmol TEs/g sample) ^c	0.47 ± 0.02	0.21 ± 0.01	0.64 ± 0.02	0.89 ± 0.01
FRAP (mmol TEs/g sample) ^c	0.37 ± 0.01	0.14 ± 0.01	0.41 ± 0.01	0.52 ± 0.02
Metal Chelating (mg EDTAEs/g sample) ^d	37.89 ± 0.95	18.91 ± 0.28	15.84 ± 0.84	11.60 ± 0.16

^a GAEs: gallic acid equivalents. ^b REs: rutin equivalents. ^c TEs: trolox equivalents. ^d EDTAEs: EDTA equivalents.

**Figure 1.** Chemical structures of the major compounds from *Prangos gaubae* essential oil.**Table 3:** Enzyme inhibitory activities of *P. gaubae* linked to public health problems.

Sample	Neuroprotective effects		Antidiabetic effects		Skin-care effects	Anti-obesity effects
	AChE (mg GEs/g sample) ^a	BChE (mg GEs/g sample) ^a	α -amylase (mmol AEs/g sample) ^b	α -glucosidase (mmol AEs/g sample) ^b	Tyrosinase (mg KAEs/g sample) ^c	Lipase (mmol OEs/g sample) ^d
EO	2.97 ± 0.01	3.30 ± 0.10	1.35 ± 0.04	38.84 ± 1.20	29.24 ± 3.91	1.59 ± 0.03
Hex	1.55 ± 0.14	2.33 ± 0.25	0.64 ± 0.03	19.70 ± 0.29	36.33 ± 2.18	0.42 ± 0.03
DCM	2.62 ± 0.29	3.51 ± 0.24	0.93 ± 0.08	20.07 ± 0.54	27.82 ± 0.62	0.56 ± 0.03
MeOH	1.80 ± 0.03	1.26 ± 0.04	0.47 ± 0.02	7.42 ± 0.16	16.85 ± 2.79	0.23 ± 0.01

^a GEs: galanthamine equivalents. ^b AEs: acarbose equivalents. ^c KAEs: kojic acid equivalents. ^d OEs: orlistat equivalents.

considered as a natural lipid absorption inhibitor in food and pharmaceutical products. This is the first report on the therapeutic target enzyme inhibitory potential of *Prangos* species against cholinesterases, amylase, glucosidase, tyrosinase, and lipase. So, this work may open a new window for possible uses of *Prangos* species for the management of some public health problems

Experimental

Plant material: The aerial parts of the plant including flowers, leaves, and juvenile stems were collected during flowering season in early spring from Urmia, West Azerbaijan province of Iran and authenticated by Mr. Shahram Bahadori as *Prangos gaubae*. In addition, a voucher specimen was deposited in Herbarium of Urmia Pharmacy School (HUPS-202), Urmia, Iran.

Extraction: The studied extracts of the aerial parts of *P. gaubae* were obtained using maceration method. Twenty g of the crushed dried material were extracted using 200 mL of *n*-hexane (Hex), dichloromethane (DCM), and methanol (MeOH) consecutively. The extractions were yielded by shaking at room temperature during 48 h. The extracts were passed through a paper filter and finally the filtrated solution was evaporated by a rotary vacuum evaporator at 40 °C.

Isolation of essential oil: In accordance with the British pharmacopoeia, the essential oil was obtained by hydrodistillation of the dried aerial parts of the plant using a Clevenger-type apparatus in 3 h. The oil sample was stored at 4 °C in the dark until analysis.

Essential oil identification: Separation and analysis of essential oil components were achieved on an Agilent 6890N gas chromatograph coupled to a 5973N mass spectrometer and equipped with a HP-5 MS (5% phenyl methylpolysiloxane, 30 m, 0.25 mm i.d., 0.1 μ m film thickness; J & W Scientific, Folsom) capillary column. The used temperature programme was as follows: 5 min at 60°C then 4°C/min up to 220 °C, then 11 °C/min up to 280°C, held for 15

min. Injector and detector temperatures: 280°C; carrier gas: He; flow rate: 1 mL/min; split ratio: 1:50; acquisition mass range: 29–400 m/z; mode: electron-impact (EI, 70 eV). The essential oil was diluted 1:100 in *n*-hexane and then 2 μ L of the solution were injected into the GC-MS system. For identification of essential oil components, co-injection with available analytical standards was used whenever possible, together with correspondence of retention indices and mass spectra with respect to those occurring in ADAMS, NIST 08, and FFNSC2 libraries. Semi-quantification of essential oil components was made by peak area normalisation considering the same response factor for all volatile components. Percentage values were the mean of three chromatographic analyses.

Total phenolic and flavonoid contents determination: The total phenolics content was determined by Folin-Ciocalteu method [23] with slight modification and expressed as gallic acid equivalents (GAEs/g sample). Total flavonoids content was determined according to AlCl₃ method [24] with some modifications and the results were expressed as rutin equivalents (REs/g sample).

Antioxidant assays: Several methods were used for measurement of antioxidant potential (DPPH and ABTS radical scavenging, ferric and copper reducing power (CUPRAC and FRAP), total antioxidant (phosphomolybdenum assay) and metal chelating activity (ferrozine method)) according to previously published procedures [25].

Enzyme inhibitory assays: Enzyme inhibitory properties of *P. gaubae* against α -glucosidase, α -amylase, cholinesterases (AChE and BChE), lipase, and tyrosinase were investigated using previously published methods [26].

Statistical analysis: All experiments were carried out in triplicate. The results are expressed as mean value \pm standard deviation (SD). Data analysis was performed using SPSS v.16.0. Differences between means were determined by one-way analysis of variance (ANOVA) followed by Duncan's post hoc test for multiple

comparisons with control. A value of $p < 0.05$ was considered as indicative of statistical significance.

Acknowledgments: This work was supported by the Urmia branch of the Islamic Azad University.

References

- [1] Lyskov DF, Kljuykov EV, Samigullin TH, Ukrainskaja UA, Khrustaleva IA. (2016) *Prangos multicostata* (Apiaceae), a new species from eastern Kazakhstan. *Phytotaxa*, **277**, 68-76.
- [2] Mozaffarian V, Assadi M, Maassoumi AAR, Khatamsaz M. (2007) *Flora of Iran: Umbelliferae*, Research Institute of Forests and Rangelands.
- [3] Geidarov I, Serkerov S. (2016) Coumarins from Roots of *Prangos Biebersteinii*. *Chemistry of Natural Compounds*, **52**, 700-701.
- [4] Gholivand MB, Yamini Y, Dayeni M, Shokoohinia Y. (2015) The influence of the extraction mode on three coumarin compounds yield from *Prangos ferulacea* (L.) Lindl roots. *Journal of the Iranian Chemical Society*, **12**, 707-714.
- [5] Razavi SM, Nazemiyeh H, Hajiboland R, Kumarasamy Y, Delazar A, Nahar L, Sarker SD. (2008) Coumarins from the aerial parts of *Prangos uloptera* (Apiaceae). *Revista Brasileira de Farmacognosia*, **18**, 1-5.
- [6] Razavi SM, Nazemiyeh H, Zarrini G, Asna-Ashari S, Dehghan G. (2010) Chemical composition and antimicrobial activity of essential oil of *Prangos ferulacea* (L.) Lindl from Iran. *Natural Product Research*, **24**, 530-533.
- [7] Shokoohinia Y, Sajjadi S-E, Gholamzadeh S, Fattahi A, Behbahani M. (2014) Antiviral and cytotoxic evaluation of coumarins from *Prangos ferulacea*. *Pharmaceutical Biology*, **52**, 1543-1549.
- [8] Razavi SM, Zarrini G, Zahri S, Mohammadi S. (2010) Biological activity of *Prangos uloptera* DC. roots, a medicinal plant from Iran. *Natural Product Research*, **24**, 797-803.
- [9] Kılıç CS, Coşkun M, Duman H, Demirci B, Başer KH. (2010) Comparison of the essential oils from fruits and roots of *Prangos denticulata* Fisch. et Mey. growing in Turkey. *Journal of Essential Oil Research*, **22**, 170-173.
- [10] Akbari M, Esmaili A, Zarea A, Saad N, Bagheri F. (2010) Chemical composition and antibacterial activity of essential oil from leaves, stems and flowers of *Prangos ferulacea* (L.) Lindl. grown in Iran. *Bulgarian Chemical Communications*, **42**, 36-39.
- [11] Meshkatsadat MH, Mirzaei HH. (2007) Chemical compositions of the essential oils of stems, leaves and flowers of *Prangos acaulis* (Dc) Bornm. *Pakistan Journal of Biological Sciences*, **10**, 2775-2777.
- [12] Moradalizadeh M, Salajegheh M, Mehrabpanah M. (2015) Chemical Characterization of the Essential Oil of *Prangos cheilanthifolia* from Iran. *Chemistry of Natural Compounds*, **51**, 573-574.
- [13] Razavi SM. (2012) Chemical and allelopathic analyses of essential oils of *Prangos pabularia* Lindl. from Iran. *Natural Product Research*, **26**, 2148-2151.
- [14] Ahmed J, Güvenç A, Küçükboyacı N, Baldemir A, Coşkun M. (2011) Total phenolic contents and antioxidant activities of *Prangos* Lindl. (Umbelliferae) species growing in Konya province (Turkey). *Turkish Journal of Biology*, **35**, 353-360.
- [15] Mai W, Chen D, Li X. (2012) Antioxidant activity of *Rhizoma cibotii* *in vitro*. *Advanced Pharmaceutical Bulletin*, **2**, 107-114.
- [16] López-Alarcón C, Denicola A. (2013) Evaluating the antioxidant capacity of natural products: A review on chemical and cellular-based assays. *Analytica Chimica Acta*, **763**, 1-10.
- [17] Bahadori MB, Asghari B, Dinparast L, Zengin G, Sarikurkcü C, Abbas-Mohammadi M, Bahadori S. (2017) *Salvia nemorosa* L.: A novel source of bioactive agents with functional connections. *LWT-Food Science and Technology*, **75**, 42-50.
- [18] Razavi SM, Zahri S, Nazemiyeh H, Zarrini G, Mohammadi S, Abolghassemi-Fakhri M-A. (2009) A furanocoumarin from *Prangos uloptera* roots, biological effects. *Natural Product Research*, **23**, 1522-1527.
- [19] Bahadori MB, Valizadeh H, Asghari B, Dinparast L, Bahadori S, Moridi Farimani M. (2016) Biological Activities of *Salvia santolinifolia* Boiss. A Multifunctional Medicinal Plant. *Current Bioactive Compounds*, **12**, 297-305.
- [20] Katanić J, Ceylan R, Matic S, Boroja T, Zengin G, Aktumsek A, Mihailović V, Stanić S. (2017) Novel perspectives on two *Digitalis* species: Phenolic profile, bioactivity, enzyme inhibition, and toxicological evaluation. *South African Journal of Botany*, **109**, 50-57.
- [21] Xie S-S, Wang X-B, Li J-Y, Yang L, Kong L-Y. (2013) Design, synthesis and evaluation of novel tacrine-coumarin hybrids as multifunctional cholinesterase inhibitors against Alzheimer's disease. *European Journal of Medicinal Chemistry*, **64**, 540-553.
- [22] Seo WD, Kim JY, Ryu HW, Kim JH, Han S-I, Ra J-E, Seo KH, Jang KC, Lee JH. (2013) Identification and characterisation of coumarins from the roots of *Angelica dahurica* and their inhibitory effects against cholinesterase. *Journal of Functional Foods*, **5**, 1421-1431.
- [23] Slinkard K, Singleton VL. (1977) Total phenol analysis: Automation and comparison with manual methods. *American Journal of Enology and Viticulture*, **28**, 49-55.
- [24] Zengin G, Uysal A, Gunes E, Aktumsek A. (2014) Survey of phytochemical composition and biological effects of three extracts from a wild plant (*Cotoneaster nummularia* Fisch. et Mey.): A potential source for functional food ingredients and drug formulations. *PLoS One*, **9**, e113527.
- [25] Zengin G, Locatelli M, Ceylan R, Aktumsek A. (2016) Anthraquinone profile, antioxidant and enzyme inhibitory effect of root extracts of eight *Asphodeline* taxa from Turkey: Can *Asphodeline* roots be considered as a new source of natural compounds? *Journal of Enzyme Inhibition and Medicinal Chemistry*, **31**, 754-759.
- [26] Movahhedini N, Zengin G, Bahadori MB, Sarikurkcü C, Bahadori S, Dinparast L. (2016) *Ajuga chamaecistus* subsp. *scoparia* (Boiss.) Rech. f.: A new source of phytochemicals for antidiabetic, skin-care, and neuroprotective uses. *Industrial Crops and Products*, **94**, 89-96.

A New Cytotoxic Polyacetylenic Alcohol from a Sponge <i>Callyspongia</i> sp. Walter Balansa, Agus Trianto, Nicole J. de Voogd and Junichi Tanaka	1909
Analysis of the Configuration of an Isolated Double Bond in Some Lipids by Selective Homonuclear Decoupling Elena A. Santalova and Vladimir A. Denisenko	1913
Structural Analysis of Two Bioactive Components of an Edible Mushroom, <i>Termitomyces microcarpus</i> Sunil Kumar Bhanja and Dilip Rout	1917
Exploring Co-fermentation of Glucose and Galactose using <i>Clostridium acetobutylicum</i> and <i>Clostridium beijerinckii</i> for Biofuels Mi Tang, Jiawen Liu, Zhuoliang Ye, Shumin Zhuo, Weiyang Zhang, Xiao Li and Dongyang Chen	1921
Ethanol Extract of <i>Rubus coreanus</i> Fruits Inhibits Bone Marrow-Derived Osteoclast Differentiation and Lipopolysaccharide-Induced Bone Loss Tae-Ho Kim, Chae Gyeong Jeong, Hyeong-U Son, Man-Il Huh, Shin-Yoon Kim, Hong Kyun Kim and Sang-Han Lee	1925
Volatile Chemical Constituents of the Chilean Bryophytes Jorge Cuvertino-Santoni, Yoshinori Asakawa, Mohammed Nour and Gloria Montenegro	1929
Volatile Compounds in the Aerial Parts of <i>Achillea collina</i> Collected in the Urban Area of Vienna (Austria) Remigius Chizzola	1933
Effect of Harvest and Drying on Composition of Volatile Profile of Elderflowers (<i>Sambucus nigra</i>) from Wild Tomáš Bajer, Petra Bajerová and Karel Ventura	1937
Chemical Composition of the Essential oil of <i>Syzygium kanarensis</i>: An Endemic and Rediscovered Species from the Western Ghats, India Rajesh K. Joshi, H. Sooryaprakash Shenoy and Ramakrishna Marati	1943
Chemical Composition of Essential Oil, Antioxidant, Antidiabetic, Anti-obesity, and Neuroprotective Properties of <i>Prangos gaubae</i> Mir Babak Bahadori, Gokhan Zengin, Shahram Bahadori, Filippo Maggi and Leila Dinparast	1945
Exploring the Effect of the Composition of Three Different Oregano Essential Oils on the Growth of Multidrug-Resistant Cystic Fibrosis <i>Pseudomonas aeruginosa</i> Strains Valentina Maggini, Giovanna Pesavento, Isabel Maida, Antonella Lo Nostro, Carmela Calónico, Chiara Sassoli, Elena Perrin, Marco Fondi, Alessio Mengoni, Carolina Chiellini, Alfredo Vannacci, Eugenia Gallo, Luigi Gori, Patrizia Bogani, Anna Rita Bilia, Silvia Campana, Novella Ravenni, Daniela Dolce, Fabio Firenzuoli and Renato Fani	1949

Accounts/Reviews

Antifungal Activity Based Studies of Amaryllidaceae Plant Extracts Jerald J. Nair and Johannes van Staden	1953
Herbal Therapy in Pregnancy - What to Expect When You Expect? Artur L. Belica, Nenad B. Četković, Nataša B. Milić and Nataša P. Milošević	1957

Natural Product Communications

2017

Volume 12, Number 12

Contents

<u>Original Paper</u>	<u>Page</u>
Bioactive Secondary Metabolites from the Aerial Parts of <i>Buddleja macrostachya</i> Truong Thi Thu Hien, Tran Hong Quang, Nguyen Xuan Nhiem, Bui Huu Tai, Pham Hai Yen, Duong Thi Hai Yen, Nguyen Thi Thanh Ngan, Youn-Chul Kim, Hyuncheol Oh, Chau Van Minh and Phan Van Kiem	1821
A New Picrotoxane Sesquiterpene Glucoside from <i>Dendrobium nobile</i> Nguyen Thi Viet Thanh, Giang Thi Phuong Ly, Le Huyen Tram, Bui Huu Tai, Vu Quoc Huy and Phan Van Kiem	1825
Antioxidant Sesquiterpenes from <i>Penicillium citreonigrum</i> Wei-Hua Yuan, Ying Zhang, Peng Zhang and Ru-Ru Ding	1827
Sessilifol A and B, Urease Inhibitory Pimarane-type Diterpenes from <i>Hymenocrater sessilifolius</i> Sadia Khan, Muhammad Shaiq Ali, Zeeshan Ahmed, Mehreen Lateef, Sammer Yousuf, Viqar Uddin Ahmad, Itrat Fatima and Rasool Bakhsh Tareen	1831
Rumphellolide J, an Ester of 4β,8β-Epoxyxycaryophyllan-5-ol and Rumphellaic acid A, from the Gorgonian <i>Rumphella antipathies</i> Chi-Cheng Lin, Hsu-Ming Chung, Yin-Di Su, Bo-Rong Peng, Wei-Hsien Wang, Tsong-Long Hwang, Yang-Chang Wu and Ping-Jyun Sung	1835
Determination of Oleanolic and Ursolic Acids in <i>Sambuci flos</i> Using HPLC with a New Reversed-phase Column Packed with Naphthalene Bounded Silica Michał Gleńsk and Maciej Włodarczyk	1839
Structural Analogues of Lanosterol from Marine Organisms of the Class <i>Asteroidea</i> as Potential Inhibitors of Human and <i>Candida albicans</i> Lanosterol 14α-demethylases Leonid A. Kaluzhskiy, Tatsiana V. Shkel, Natalia V. Ivanchina, Alla A. Kicha, Irina P. Grabovec, Andrei A. Gilep, Natallia V. Strushkevich, Mikhail A. Chernovetsky, Alexei E. Medvedev, Sergey A. Usanov and Alexis S. Ivanov	1843
Comparison of Anti-Inflammatory Activities of Structurally Similar Triterpenoids Isolated from Bitter Melon Hsueh-Ling Cheng, Ming-Hao Yang, Rista Anggriani and Chi-I Chang	1847
Xenocyloin Derivatives from Liquid Cultures of <i>Xenorhabdus bovienii</i> SN52 Feng Yu, Xiaomei Tian, Ying Sun, Yuhui Bi, Zhiguo Yu and Li Qin	1851
Cyclopiperettine, A New Amide from <i>Piper nigrum</i> Jie Ren, Ting Zeng, Zulfiqar Ali, Mei Wang, Jiyeong Bae, Amar G. Chittiboyina, Wei Wang, Shunxiang Li and Ikhlas A. Khan	1855
Phytochemical Profile and Antibacterial Activity of <i>Retama raetam</i> and <i>R. sphaerocarpa</i> cladodes from Algeria Nawal Hammouche-Mokrane, Antonio J. León-González, Inmaculada Navarro, Farida Boulila, Said Benallaoua and Carmen Martín-Cordero	1857
Pectolarigenin Suppresses Pancreatic Cancer Cell Growth by Inhibiting STAT3 Signaling Bin Zhou, Zhong Hong, Hailun Zheng, Min Chen, Lingyi Shi, Chengguang Zhao and Haixin Qian	1861
LC-MS/MS Analysis of Flavonoid Compounds from <i>Zanthoxylum zanthoxyloides</i> Extracts and Their Antioxidant Activities Yoro Tine, Yin Yang, Franck Renucci, Jean Costa, Alassane Wélé and Julien Paolini	1865
Microwave-assisted Acid Hydrolysis to Produce Vitexin from <i>Crataegus pinnatifida</i> Leaves and its Angiogenic Activity Meng Luo, Xin Ruan, Jiao-Yang Hu, Xuan Yang, Wen-Miao Xing, Yu-Jie Fu and Fan-Song Mu	1869
An Efficient Synthesis of Angelmarin and its Analogs Su-You Liu, Na Xu, Li-Jun Liu, Ying-Xiong Wang and Da-You Ma	1873
Three New Bibenzyls from the Twigs of <i>Smilax longifolia</i> Yuka Imura, Kenichi Harada, Miwa Kubo and Yoshiyasu Fukuyama	1877
High Anticancer Properties of Defatted <i>Jatropha Curcus</i> Seed Residue and its Active Compound, Isoamericanol A Ayako Katagi, Li Sui, Kazuyo Kamitori, Toshisada Suzuki, Takeshi Katayama, Akram Hossain, Chisato Noguchi, Youyi Dong, Fuminori Yamaguchi and Masaaki Tokuda	1881
Antioxidant Activity of 1'-Hydroxyethylnaphthazarins and their Derivatives Natalia K. Utkina and Natalia D. Pokhilo	1885
Antifungal Activity of the Extract and the Active Substances of Endophytic <i>Nigrospora</i> sp. from the Traditional Chinese Medicinal Plant <i>Stephania kwangsiensis</i> Haiyu Luo, Qiuyan Zhou, Yecheng Deng, Zhiyong Deng, Zhen Qing and Wenbin Sun	1889
A Rapid Determination and Quantification of Three Biologically Active Polyisoprenylated Benzophenones using Liquid Chromatography-Tandem Mass Spectrometry (MRM) Method in Five <i>Garcinia</i> species from Cameroon Bernadette Messi Bilou, Raimana Ho, Guillaume Marti, Alain Meli Lannang, Jean-Luc Wolfender and Kurt Hostettmann	1893
<i>In vitro</i> Anthelmintic Activity of Two Aloe-derived Active Principles against Sheep Gastrointestinal Nematodes Gianluca Fichi, Matteo Mattellini, Elisa Meloni, Guido Flamini and Stefania Perrucci	1897
Phytochemical Study and Antioxidant Activity of <i>Calligonum azel</i> and <i>C. comosum</i> Soumia Belaabed, Nouredine Beghidja, Khalfauoi Ayoub, Massimiliano D'Ambola, Marinella De Leo, Roberta Cotugno, Stefania Marzocco and Nunziatina De Tommasi	1901
Beneficial Effects of Curcumin on the Wound-healing Process after Tooth Extraction Aleksandar Mitic, Kosta Todorovic, Nenad Stojiljkovic, Nikola Stojanovic, Sonja Ilic, Ana Todorovic and Slavica Stojnev	1905

Continued inside backcover