



Natural Product Research

Formerly Natural Product Letters

ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/gnpl20>


The comparison of the phytochemical composition, antioxidant and enzyme inhibition activity of two moss species: *Plagiomnium ellipticum* (Brid.) T. Kop. and *Antitrichia californica* Sull., from southwest ecological region in Turkey

Alev Onder, Aybala Yıldız, Ahsen Sevde Cinar, Gokhan Zengin, Gunes Ak & Hatice Ozenoğlu


To cite this article: Alev Onder, Aybala Yıldız, Ahsen Sevde Cinar, Gokhan Zengin, Gunes Ak & Hatice Ozenoğlu (2021): The comparison of the phytochemical composition, antioxidant and enzyme inhibition activity of two moss species: *Plagiomnium ellipticum* (Brid.) T. Kop. and *Antitrichia californica* Sull., from southwest ecological region in Turkey, *Natural Product Research*, DOI: [10.1080/14786419.2021.1916745](https://doi.org/10.1080/14786419.2021.1916745)



To link to this article: <https://doi.org/10.1080/14786419.2021.1916745>

 View supplementary material 

 Published online: 05 May 2021.

 Submit your article to this journal 

 Article views: 38

 View related articles 

 View Crossmark data 

SHORT COMMUNICATION



The comparison of the phytochemical composition, antioxidant and enzyme inhibition activity of two moss species: *Plagiomnium ellipticum* (Brid.) T. Kop. and *Antitrichia californica* Sull., from southwest ecological region in Turkey

Alev Onder^a , Aybala Yıldız^a , Ahsen Sevde Cinar^{a,b} , Gokhan Zengin^c , Gunes Ak^c  and Hatice Ozenoğlu^d 

^aDepartment of Pharmacognosy, Faculty of Pharmacy, Ankara University, Ankara, Turkey;

^bDepartment of Pharmaceutical Botany and Pharmacognosy, Faculty of Pharmacy, Lokman Hekim University, Ankara, Turkey; ^cDepartment of Biology, Physiology, and Biochemistry Research Laboratory, Science Faculty, Selcuk University, Konya, Turkey; ^dDepartment Science Education, Adnan Menderes University, Faculty of Education Mathematics and Science Education, Aydın, Turkey

ABSTRACT

A limited number of mosses have been studied regarding antioxidant activity and enzyme inhibition effects. In the present study, the phytochemical content, antioxidant, and enzyme inhibition properties of the ether extracts from T.J.Kop.. were investigated as promising bryophyte sources. The ether extracts of *P. ellipticum* had the highest flavonoid content (52.41 ± 0.52 , Rutin equivalent), and *A. californica* had the highest total phenolic content (25.84 ± 0.23 , Gallic acid equivalent). While the *P. ellipticum* had the highest ABTS (mg TE/g extract) 6.60 ± 0.4 ; *A. californica* showed the highest metal chelating capacity (mg EDTA/g extract) with the values of 51.46 ± 0.26 . In the enzyme activity tests, almost all values of the species were closed the each other, but *P. ellipticum* was exhibited higher tyrosinase activity (mg/KAE/g extract) with 48.64 ± 1.02 . The results have indicated for the first time the potential importance of the selected mosses.


ARTICLE HISTORY

Received 21 February 2021
Accepted 9 April 2021

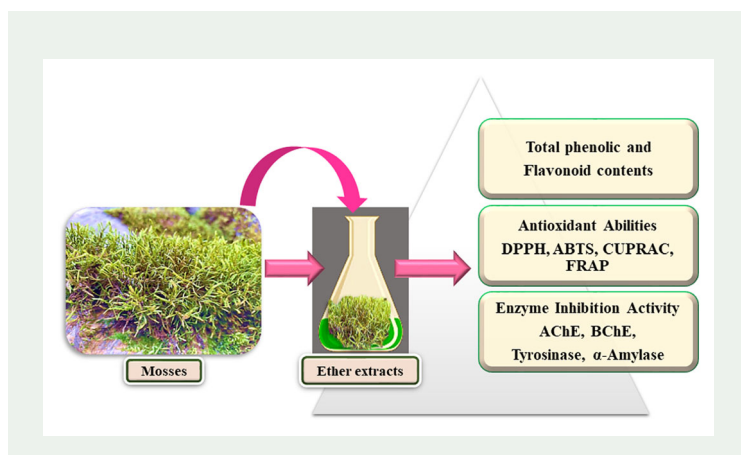
KEYWORDS

Bryophyte; antioxidant; enzyme inhibition; moss; *Antitrichia californica*; *Plagiomnium ellipticum*

CONTACT Alev Onder  pharmacogalev@gmail.com

 Supplemental data for this article can be accessed online at <https://dx.doi.org/10.1080/14786419.2021.1916745>.

© 2021 Informa UK Limited, trading as Taylor & Francis Group



1. Introduction

Bryophytes are the second largest group in the plant kingdom with 25,000 species, separated into three classes as mosses (Bryophyta), liverworts (Marchantiophyta), and hornworts (Anthocerotophyta) (Asakawa et al. 2013). The bryophytes are recognised as the oldest terrestrial plants but were not used in nutrition for humans. However, the bryophytes have been used for medicinal purposes in many countries (Karim et al. 2014; Klavina et al. 2015; Glime 2017). On the other hand, the chemistry of bryophytes is little known due to the difficulties in their process (Adebisi et al. 2012). Mosses (or *Musci* ~ 8000 species) from Bryophyta mostly grown in the Northern Hemisphere as the second-largest division, are small non-woody, and the simplest land plants (Asakawa et al. 2013). Also, liverworts and mosses have a great interest as a source of medicinal and cosmetic use, due to their antioxidant properties (Pejin et al. 2013; Aslanbaba et al. 2017). In the present study, the phytochemical contents (total phenolic and flavonoid content), was investigated of the selected mosses which are widely growing in the southwestern side of Turkey. The antioxidant capacity [the free radical scavenging (DPPH, ABTS), reducing power (FRAP, CUPRAC), phosphomolybdenum (total antioxidant capacity), and metal chelating (ferrous ion chelation)] and the possible enzyme inhibition capacity of all the concentrates against acetylcholinesterase (AChE), butyrylcholinesterase (BChE), tyrosinase, and α -amylase were investigated utilising earlier standard *in vitro* bio-assays on two moss species, called *Plagiomnium ellipticum* (Brid.) T.J.Kop. and *Antitrichia californica* Sull. in Lesq. Therefore, this study aimed to give the first detailed investigation on these moss species and our findings could open new windows on the utilisation of these mosses.

2. Results and discussion

Bryophytes are traditionally used for many health problems (Singh et al. 2011) due to important phytochemicals (Aruna and Krishnappa 2015, 2018). In Malaysia and Egypt, the mosses have been used as a medicinal tea for treating colds (Glime 2017); in

Germany as a remedy for fungal infections of horses besides anti-leukemic and anti-cancer effects (Aslanbaba et al. 2017; Glime 2017); in China for the treatment of fever, hemostatic, uterine prolapse, and lymphocytic leukemia (Cheng et al. 2012). Moreover, there are previous studies conducted on the antimicrobial and antifungal activities (Dulger et al. 2005; Wang et al. 2005; Sabovljevic et al. 2006; Singh et al. 2007; Singh et al. 2011; Cheng et al. 2012), besides cytotoxic (Wei et al. 2015) and antiproliferative effects (Vollár et al. 2018). In addition, to prove the uses of the mosses as traditional plant, the fatty acid content had been investigated in some mosses that also can help to treat cardiovascular diseases (Pejin et al. 2012a), besides the sugar composition was determined as may use natural sweetener (Pejin et al. 2012b). Since some mosses (exp: *Rhodobryum* sp.) have been suggested to treat cardiovascular diseases as a medicinal tea in Traditional Chinese Medicine, a study has been conducted to determine the heavy metals aiming for safe use (Pejin et al. 2012c). However, the determination of the phenolic level is an important parameter in managing oxidative stress and related disorders (Rani 2017), and to evaluate the quality of plant extracts. In the present study, the total phenolic and flavonoid contents of two mosses were determined by colorimetric methods, and the results are shown in supplemental material Table S1. *A. californica* (25.84 mg GAE/g) had a higher level of total phenolics when compared with *P. ellipticum* (18.36 mg GAE/g). However, the total flavonoid level of *P. ellipticum* (52.41 mg RE/g) was higher than *A. californica* (25.80 mg RE/g). These contradictory results could be explained by the limitations of the spectrophotometric methods (Sánchez-Rangel et al. 2013; Margraf et al. 2015; Granato et al. 2018). In this context, the antioxidant abilities of the moss species were investigated by different chemical assays, including radical quenching (ABTS and DPPH), reducing power (CUPRAC and FRAP), metal chelating and total antioxidant (phosphomolybdenum) assays. The results are given in supplemental material Table S2. In DPPH radical scavenging assay, the moss extracts exhibited similar abilities, but *A. californica* was not active on ABTS radical. The results could be linked with the nature of these radicals, and similar findings were also reported in earlier studies (Kim et al. 2002). CUPRAC and FRAP assays were performed to detect the electron-donating abilities of the tested extracts. As can be seen in supplemental material Table S2, *P. ellipticum* exhibited the highest activity in CUPRAC assay while *A. californica* was more active than *P. ellipticum* in FRAP assay. Obtained results from reducing power assays could be linked with the structure of phenolics in the extracts. The reducing abilities of phenolics could be affected by the presence of hydroxyl group numbers or their positions in the phenolic rings (Chen et al. 2020). Chelation of transition metal is one important mechanism, and thus, the hydroxyl radicals formation in the Fenton reaction could be prevented (Santos et al. 2017). In the present study, the metal chelation ability was investigated by the ferrozine method. *A. californica* (51.46 mg EDTAE/g) had a higher metal chelation capacity than *P. ellipticum* (38.34 mg EDTAE/g). Phosphomolybdenum assay reflects the reduction of Mo (VI) to Mo (V) by antioxidant compounds in acidic pH, and this method is known as the total antioxidant method. In the study, the moss extracts exhibited similar abilities in phosphomolybdenum assay. The prevalence of diseases arising from oxidative stress is increasing by the day and should be taken with urgent precautions (Rauf and Jehan 2017). In this sense, several therapeutic strategies have been

developed including enzyme inhibition theory (Alagesan et al. 2012; Sharma 2019; Zolghadri et al. 2019). In the present study, the enzyme inhibitory properties of the mosses were detected against cholinesterases (AChE and BChE), tyrosinase, and α -amylase. The results are depicted in supplemental material Table S3. Regarding cholinesterase inhibition, the best AChE inhibition was provided by *P. ellipticum*, while *A. californica* exhibited stronger BChE inhibition ability than *P. ellipticum*. *P. ellipticum* was also more active on tyrosinase than *A. californica*. In the amylase inhibition assay, the moss extracts exhibited similar actions. To the best of our knowledge, the current work is the first report on the moss samples and thus, our findings could light to design novel products from moss species.

3. Experimental

The experimental sections were given as supplemental material.

4. Conclusion

This work is a preliminary screening on antioxidant, and enzyme inhibition of the moss extracts obtained from *P. ellipticum* and *A. californica*. The extracts exhibited appropriate effects correlated with the phytochemical profile. The results from the present work provided a new framework for the utilisation of the *P. ellipticum* and *A. californica* as a natural source of bioactive agents, such as antioxidants and enzyme inhibitors.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Alev Onder  <http://orcid.org/0000-0002-9088-1045>

Aybala Yıldız  <http://orcid.org/0000-0003-3240-7481>

Ahsen Sevde Cinar  <http://orcid.org/0000-0001-6030-6931>

Gokhan Zengin  <http://orcid.org/0000-0001-6548-7823>

Gunes Ak  <http://orcid.org/0000-0002-9539-0763>

Hatice Ozenoğlu  <http://orcid.org/0000-0002-2600-7353>

References

- Adebisi AO, Oyediji AA, Chikwendu EE, Fatoke OA. 2012. Phytochemical screening of two tropical moss plants: *Thuidium gratum* P. Beauv and *Barbula indica* Brid grown in southwestern ecological zone of Nigeria. *Am J Analyt Chem.* 3:836–839.
- Alagesan K, Raghupathi PK, Sankarnarayanan S. 2012. Amylase inhibitors: potential source of anti-diabetic drug discovery from medicinal plants. *Int J Pharm Life Sci.* 3:1407–1412.
- Aruna KB, Krishnappa M. 2015. Phytochemical screening of lawn-forming moss *Hyophila involuta* in Kuvempu University Campus, Shivamogga District, Karnataka. *Int. J. Res. Pharm, L. Sci.* 3: 825–828.

- Aruna KB, Krishnappa M. 2018. Phytochemistry and antimicrobial activities of *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid. (Bryophyta; Musci: Polytrichaceae). *Int J Botany Stud.* 3: 120–125.
- Asakawa Y, Ludwiczuk A, Nagashima F. 2013. Phytochemical and biological studies of bryophytes. *Phytochemistry.* 91:52–80.
- Aslanbaba B, Yilmaz S, Tonguç YÖ, Özyurt D, Öztürk BD. 2017. Total phenol content and antioxidant activity of mosses from the Yenice forest (İda mountain). *J Sci Perspect.* 1:1–12.
- Chen J, Yang J, Ma L, Li J, Shahzad N, Kim CK. 2020. Structure-antioxidant activity relationship of methoxy, phenolic hydroxyl, and carboxylic acid groups of phenolic acids. *Sci Rep.* 10:1–9.
- Cheng X, Xiao Y, Wang X, Wang P, Li H, Yan H, Liu Q. 2012. Anti-tumor and pro-apoptotic activity of ethanolic extract and its various fractions from *Polytrichum commune* L. ex Hedwin L1210cells. *J Ethnopharmacol.* 143:49–56.
- Dulger B, Tonguc YO, Gonuz A. 2005. Antimicrobial activity of some mosses from Turkey. *Fitoterapia.* 76:730–732.
- Glime JM. 2017. Medical uses: biologically active substances. Chapter. 2-2. In: Glime JM, editor. *Bryophyte ecology.* Vol. 5. Michigan-USA: E-book sponsored by Michigan Technological University and the International Association of Bryologists.
- Granato D, Shahidi F, Wrolstad R, Kilmartin P, Melton LD, Hidalgo FJ, Elmore S. 2018. Antioxidant activity, total phenolics and flavonoids contents: Should we ban *in vitro* screening methods? *Food Chem.* 264:471–475.
- Karim FA, Suleiman M, Rahmat A, Abu BM. 2014. Phytochemicals, antioxidant and antiproliferative properties of five moss species from Sabah, Malaysia. *Int J Pharm Pharm Sci.* 6:292–297.
- Kim DO, Lee KW, Lee HJ, Lee CY. 2002. Vitamin C equivalent antioxidant capacity (VCEAC) of phenolic phytochemicals. *J Agric Food Chem.* 50:3713–3717.
- Klavina L, Springe G, Nikolajeva V, Martsinkevich I, Nakurte I, Dzabijeva D, Steinberga I. 2015. Chemical composition analysis, antimicrobial activity and cytotoxicity screening of moss extracts (Moss Phytochemistry). *Molecules.* 20:17221–17243.
- Margraf T, Karnopp AR, Rosso ND, Granato D. 2015. Comparison between Folin-Ciocalteu and Prussian Blue assays to estimate the total phenolic content of juices and teas using 96-well microplates. *J Food Sci.* 80:C2397–C2403.
- Pejin B, Bianco A, Newmaster S, Sabovljevic M, Vujisic L, Tesevica V, Vajsf V, De Rosa S. 2012a. Fatty acids of *Rhodobryum ontariense* (Bryaceae). *Nat Prod Res.* 26(8):696–702.
- Pejin B, Bogdanovic-Pristov J, Pejin I, Marko SM. 2013. Potential antioxidant activity of the moss *Bryum moravicum*. *Nat Prod Res.* 27(10):900–902.
- Pejin B, Iodice C, Tommonaro G, Sabovljevic M, Bianco A, Tesevic V, Vajse V, De RS. 2012b. Sugar composition of the moss *Rhodobryum ontariense* (Kindb.) Kindb. *Nat Prod Res.* 26(3): 209–215.
- Pejin B, Kien-Thai Y, Stanimirovic B, Gordana VG, Belic D, Sabovljevic M. 2012c. Heavy metal content of a medicinal moss tea for hypertension. *Nat Prod Res.* 26(23):2239–2242.
- Rani K. 2017. Role of antioxidants in prevention of diseases. *J Appl Biotechnol Bioeng.* 4:495–496.
- Rauf A, Jehan N. 2017. Natural products as potential enzyme inhibitors from medicinal plants. In: *Enzyme inhibitors and activators.* Rijeka: InTech; p. 165–177.
- Sabovljevic A, Sokovic M, Sabovljevic M, Grubisic D. 2006. Antimicrobial activity of *Bryum argenteum*. *Fitoterapia.* 77:144–145.
- Sánchez-Rangel JC, Benavides J, Heredia JB, Cisneros-Zevallos L, Jacobo-Velázquez DA. 2013. The Folin–Ciocalteu assay revisited: improvement of its specificity for total phenolic content determination. *Anal Methods.* 5:5990–5999.
- Santos JS, Brizola VRA, Granato D. 2017. High-throughput assay comparison and standardization for metal chelating capacity screening: A proposal and application. *Food Chem.* 214:515–522.
- Sharma K. 2019. Cholinesterase inhibitors as Alzheimer’s therapeutics. *Mol Med Rep.* 20: 1479–1487.
- Singh M, Rawat AKS, Govindarajan R. 2007. Antimicrobial activity of some Indian mosses. *Fitoterapia.* 78:156–158.

- Singh M, Singh S, Nath V, Sahu V, Singh RA. 2011. Antibacterial activity of some bryophytes used traditionally for the treatment of burn infections. *Pharm Biol.* 49:526–530.
- Vollár M, Gyovai A, Szucs P, Zupkó I, IDMarschall M, Csupor-Löffler B, Bérdi P, Vecsernyés A, Csorba A, Liktör-Busa E, et al. 2018. Antiproliferative and antimicrobial activities of selected Bryophytes. *Molecules.* 23:1520.
- Wang X-N, Yu W-T, Lou H-X. 2005. Antifungal constituents from the Chinese moss *Homalia trichomanoides*. *Chem. Biodivers.* 2:139–145.
- Wei H, Xu Y-M, Espinosa-Artiles P, Liu MX, Jiang-Guang Luo J-G, U'Ren JM, Elizabeth AA, Leslie GAA. 2015. Sesquiterpenes and other constituents of *Xylaria* sp. NC1214, a fungal endophyte of the moss *Hypnum* sp. *Phytochemistry.* 118:102–108.
- Zolghadri S, Bahrami A, Hassan KM, Munoz-Munoz J, Garcia-Molina F, Garcia-Canovas F, Saboury AA. 2019. A comprehensive review on tyrosinase inhibitors. *J Enzyme Inhib Med Chem.* 34: 279–309.