Taylor & Francis
Taylor & Francis Group

Natural Product Research

Formerly Natural Product Letters

ISSN: 1478-6419 (Print) 1478-6427 (Online) Journal homepage: http://www.tandfonline.com/loi/gnpl20

Bioactive compounds and antioxidants from a Mediterranean garland harvested at two stages of maturity

Leonardo Sulas, Giacomo L. Petretto, Giorgio Pintore & Giovanna Piluzza

NATURAL PRODUCT RESEARCH, 2017
http://dx.doi.org/10.1080/14786419.2017.1305384

Taylor & Francis
Taylor & Francis Group

SHORT COMMUNICATION

Check for updates

Bioactive compounds and antioxidants from a Mediterranean garland harvested at two stages of maturity

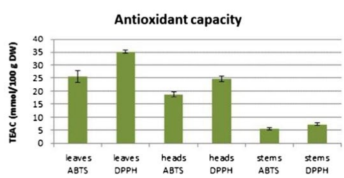
Leonardo Sulas[a], Giacomo L. Petretto[b], Giorgio Pintore[b] and Giovanna Piluzza[a]

[a]National Research Council, Institute for the Animal Production System in Mediterranean Environment, Sassari, Italy; [b]Department of Chemistry and Pharmacy, University of Sassari, Sassari, Italy

ABSTRACT

Chrysanthemum coronarium L. (garland) is an herbaceous plant rich in bioactive compounds. The chemical composition, bioactive compounds and antioxidant properties of a Mediterranean garland population were investigated in different organs at two phenological stages. Antioxidant capacity varied from 7.9 (vegetative) to 14.4 (flowering) mmol Trolox equivalent antioxidant capacity 100 g^{-1} dry weight (DW). A significant correlation between antioxidant capacity and total phenolics and total flavonoids was found at flowering stage. LC-MS/MS analysis revealed that chlorogenic acid reached a maximum of 4.7 μg g^{-1} DW in leaves; flowers were high in luteolin (2.37 μg g^{-1} DW), whereas leaves showed a remarkable content of rutin (1.78 μg g^{-1} DW). Results highlight differences in bioactive compound levels and antioxidant capacity related to plant stages and organs. This research provides new insights into antioxidant activities and chemistry of garland, in view of its exploitation in areas of fodder resources, functional foods and natural antioxidants.


Chrysanthemum coronarium L.



ARTICLE HISTORY
Received 5 January 2017
Accepted 6 March 2017

KEYWORDS
Chrysanthemum coronarium; plant organs; multipurpose species; chlorogenic acid; secondary metabolites

1. Introduction

Chrysanthemum coronarium L. (garland) is an herbaceous annual species, belonging to the Asteraceae family, native to Mediterranean regions, but naturalised throughout the world. In southern Europe, it could be grown, in combination with traditional forage crops, to produce high amount of biomass for feeding livestock, suggesting its introduction in forage systems (Valente et al. 2003). Based on its rich source of bioactive compounds, a plenty of

CONTACT Leonardo Sulas l.sulas@cspm.ss.cnr.it
Supplemental data for this article can be accessed at http://dx.doi.org/10.1080/14786419.2017.1305384.

ethnobotanical studies document several garland uses, as multipurpose plant. Essential oils from flowerheads have been evaluated for their activity against insects, nematodes and plant fungal pathogens (Bar-Eyal et al. 2006).

Pharmacological activity, medicinal uses and human consumption of garland are reported in Jordan, Egypt and Italy (Marongiu et al. 2009) and it has been suggested that garland extracts might be useful for prevention of infectious, cancer and allergic diseases. The secondary metabolites are isolated from garland and related biological activities were reviewed by Wan et al. (2014) and Dokuparthi and Manikanta (2015), who suggested the development of anticancer drugs from the plant. There is growing interest in using natural antioxidants from phytochemical-rich plants to replace synthetic antioxidants in foods and pharmaceutical preparations. Our specific objectives were (i) to evaluate variations in chemical composition, antioxidant properties and bioactive compounds of garland plant and organs at different phenological stages and, (ii) to quantify, by liquid-chromatography–tandem mass spectrometry analysis, selected phenolic compounds in its biomass.

2. Results and discussion

2.1. Chemical composition of dry matter

Total plant crude protein (CP) concentration decreased from 225 in early spring to about 100 g kg^{-1} DM in late spring, whereas neutral detergent fibre (NDF) content increased in late spring (Table S2). The NDF reached 560 g kg^{-1} DM in stems and differed in heads and leaves. Acid detergent fibre values showed a similar trend. Tagliapietra et al. (2015) reported higher values in NDF and ADF and lower in CP for the same garland population under study, but on plants that were harvested at a later stage than in the current experiment.

2.2. Antioxidant capacity and bioactive compounds

The content of phenolics and antioxidant activities of garland significantly varied according to phenological stage (Table S3). Moreover, high Trolox antioxidant capacity (TEAC) values corresponded to high total phenolic contents (TPC) and low TEAC values to lower TPC contents. In wild garland plants growing in Jordan, Tawaha et al. (2007) found an antioxidant capacity of 143 and 224 µmol g^{-1} of TEAC and polyphenol contents of 27.4 and 59.6 g gallic acid equivalent (GAE) kg^{-1} in aqueous and methanolic extracts, respectively. Alzoreky and Nakahara (2001) reported, for garland plants traditionally eaten in Yemen, an antioxidant capacity and TPC of 4 µmol TEAC g^{-1} DW and 23.2 mg GAE g^{-1} DW, respectively, but without indication of plant phenological stage. Lee et al. (2013) studied the influence of air temperature on phytochemical content of garland and found that the content of polyphenols and flavonoids was the greatest in plants grown at 25 °C. Moreover, the total flavonoid content (TFC) (10 mg CE g^{-1}) was similar to our results. A significant linear correlation between antioxidant activity and TPC and TFC was found at flowering, but not at vegetative stage (Table S4). In accordance with our findings, other authors (Alzoreky & Nakahara 2001; Tawaha et al. 2007; Petretto et al. 2015; Sulas et al. 2016) also reported a linear relationship between antioxidant activity and TPC. The antioxidant capacity in garland organs evidenced a high TEAC value in leaves compared to heads and stems (Figure S1). At flowering, TPC, NTP (Non-Tannic Phenolics) and TP (Tannic Phenolics) concentrations in leaves were higher than in the other examined plant organs (Figure S2). The average flavonoid contents for each plant organ indicate higher contents in leaves compared to heads and stems (Data not shown). Polyphenols are recognised to have a variety of roles in plant life and its interaction with environment. As for other plant species (Rugna et al. 2013; Valares Masa et al. 2016), the abovementioned organ-specific variations in polyphenol contents and antioxidant activity of garland are, presumably, linked to a defence mechanism of different plant organs to environmental stresses caused by UV radiation, drought, pathogens, attack from herbivore insects, etc. Unfortunately, to our knowledge, this important information is not available for garland organs so far. Therefore, future studies are required for elucidating that important issue.

2.3. Liquid-chromatography–tandem mass spectrometry analysis

Six main selected compounds were quantified (Table S5). Chlorogenic acid was the major compound found in garland reaching a maximum of 4.70 μg g^{-1} DW in leaves, whereas it was 1.41 μg g^{-1}in stems. Previous studies evidenced the presence of several chlorogenic acid isomers on garland plant (Murayama et al. 2002). Chlorogenic acid, is an ester of caffeic acid with quinic acid, occurs in many plants and fruits and exerts antioxidant capacity (Clifford et al. 2007). Flowers were also characterised by high amount of luteolin (2.37 μg g^{-1} DW), whereas leaves showed a remarkable amount of rutin (1.78 μg g^{-1} DW). Farag et al. (2015) provided a detailed characterisation of secondary metabolites profiles in *Chrysanthemum pacificum* Nakai and indicated that flowers were mainly enriched in luteolin conjugates.

Previous investigations (Clifford et al. 2007; Lai et al. 2007; Hosni et al. 2013) on the garland polar fraction were limited to the qualitative analysis, whereas, to the best of our knowledge, this is the first report on the quantitative data of polyphenols for garland.

3. Conclusions

Results highlight differences in bioactive compound levels and antioxidant capacity related to plant stages and organs in garland. A highly significant linear correlation between antioxidant capacity and TPC and TFC was found at flowering stage.

The quantification of selected compounds evidenced the important contribution of chlorogenic acid. This study provides new insights into antioxidant activities and chemistry of Mediterranean garland that could be useful in its exploitation as fodder resource and functional food.

Acknowledgements

Authors thank Maddalena Sassu and Dr Simone Canu for their laboratory assistance at CNR. The authors gratefully acknowledge useful discussions for LC-MS analysis with Dr Lucia Burrai, Department of Chemistry and Pharmacy, University of Sassari.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Alzoreky N, Nakahara K. 2001. Antioxidant activity of some edible Yemeni plants evaluated by ferrylmyoglobin/ABTS*+ assay. Food Sci Technol Res. 7:141–144.

Bar-Eyal M, Sharon E, Spiegel Y. 2006. Nematicidal activity of *Chrysanthemum coronarium*. Europ J Plant Pathol. 114:427–433.

Clifford MN, Wu W, Kirkpatrick J, Kuhnert N. 2007. Profiling the chlorogenic acids and other caffeic acid derivatives of herbal *Chrysanthemum* by LC–MS n. J Agric Food Chem. 55:929–936.

Dokuparthi SK, Manikanta P. 2015. Phytochemical and pharmacological studies on *Chrysanthemum coronarium* L.: a review. J Drug Discov Ther. 3:11–16.

Farag NF, Farag MA, Abdelrahman EH, Azzam SM, El-Kashoury EA. 2015. Metabolites profiling of *Chrysanthemum pacificum* Nakai parts using UPLC-PDA-MS coupled to chemometrics. Nat Prod Res. 29:1342–1349.

Hosni K, Hassen I, Sebei H, Casabianca H. 2013. Secondary metabolites from *Chrysanthemum coronarium* (Garland) flowerheads: chemical composition and biological activities. Ind Crop Prod. 44:263–271.

Lai JP, Lim YH, Su J, Shen HM, Ong CN. 2007. Identificaton and characterization of major flavonoids and caffeoylquinic acids in three compositae plants by LC/DAD-APCI/MS. J Chromatogr B. 848:215–225.

Lee SG, Choi CS, Lee JG, Jang YA, Lee HJ, Lee HJ, Chae WB, Um YC. 2013. Influence of air temperature on yield and phytochemical content of red chicory and garland *Chrysanthemum* grown in plant factory. Hortic Environ Biotec. 54:399–404.

Marongiu B, Piras A, Porcedda S, Tuveri E, Laconi S, Deidda D, Maxia A. 2009. Chemical and biological comparisons on supercritical extracts of *Tanacetum cinerariifolium* (Trevir) Sch. Bip. with three related species of *Chrysanthemums* of Sardinia (Italy). Nat Prod Res. 23:190–199.

Murayama T, Yada H, Kobori M, Shinmoto H, Tsushida T. 2002. Evaluation of three antioxidant and their identification and radical scavenging activities in edible *Chrysanthemums*. J Soc Horticol Sci. 71:36–242.

Petretto GL, Cossu M, Alamanni MC. 2015. Phenolic content, antioxidant and physico-chemical properties of Sardinian monofloral honeys. Int J Food Sci Technol. 50:482–491.

Rugna AZ, Gurni AA, Wagner ML. 2013. Phenological variations of polyphenols in *Smilax campestris* (Smilacaceae). Turk J Bot. 37:350–354.

Sulas L, Re GA, Bullitta S, Piluzza G. 2016. Chemical and productive properties of two Sardinian milk thistle (*Silybum marianum* (L.) Gaertn.) populations as sources of nutrients and antioxidants. Genet Resour Crop Evol. 63:315–326.

Tagliapietra F, Cattani M, Guadagnin M, Haddi ML, Sulas L, Muresu R, Squartini A, Schiavona S, Bailoni L. 2015. Associative effects of poor-quality forages combined with food industry byproducts determined *in vitro* with an automated gas-production system. Anim Prod Sci. 55:1117–1122.

Tawaha K, Alali FQ, Gharaibeh M, Mohammad M, Elelimat T. 2007. Antioxidant activity and total phenolic content of selected Jordanian plant species. Food Chem. 104:1372–1378.

Valares Masa C, Sosa Díaz T, Alías Gallego JC, Chaves Lobón Natividad. 2016. Quantitative variation of flavonoids and diterpenes in leaves and stems of *Cistus ladanifer* L. at different ages. Molecules. 21:275.

Valente ME, Borreani G, Caredda S, Cavallarin L, Sulas L. 2003. Ensiling forage garland (*Chrysanthemum coronarium* L.) at two stages of maturity and at different wilting levels. Anim Feed Sci Technol. 108:181–190.

Wan CP, Liu Q, Zhang XL, Fan SY. 2014. A review of the chemical composition and biological activities of the edible and medicinal plant *Chrysanthemum coronarium* L. Mod Food Sci Technol. 30:282–288.