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

Antioxidant and antimicrobial properties of traditional green and purple "Napoletano" basil cultivars (Ocimum basilicum L.) from Campania region (Italy)

Gian Carlo Tenore, Pietro Campiglia, Roberto Ciampaglia, Luana Izzo & Ettore Novellino

To cite this article: Gian Carlo Tenore, Pietro Campiglia, Roberto Ciampaglia, Luana Izzo & Ettore Novellino (2016): Antioxidant and antimicrobial properties of traditional green and purple "Napoletano" basil cultivars (Ocimum basilicum L.) from Campania region (Italy), Natural Product Research, DOI: 10.1080/14786419.2016.1269103

To link to this article: http://dx.doi.org/10.1080/14786419.2016.1269103

View supplementary material

Published online: 27 Dec 2016.

Submit your article to this journal

Article views: 40

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
http://www.tandfonline.com/action/journalInformation?journalCode=gnpl20

Download by: [University Napoli Federico II] **Date:** 26 June 2017, At: 06:49

NATURAL PRODUCT RESEARCH, 2016
http://dx.doi.org/10.1080/14786419.2016.1269103

Taylor & Francis
Taylor & Francis Group

SHORT COMMUNICATION

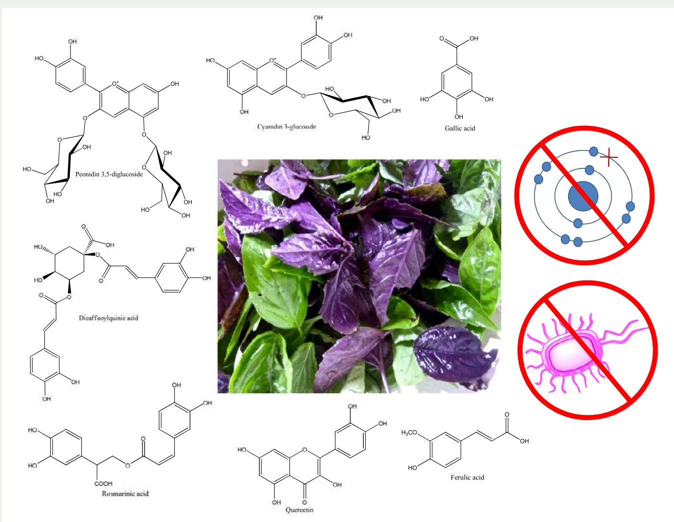
Antioxidant and antimicrobial properties of traditional green and purple "Napoletano" basil cultivars (*Ocimum basilicum* L.) from Campania region (Italy)

Gian Carlo Tenore[a], Pietro Campiglia[b], Roberto Ciampaglia[a], Luana Izzo[a] and Ettore Novellino[a]

[a]Department of Pharmacy, University of Naples "Federico II", Naples, Italy; [b]Department of Pharmaceutical and Biomedical Sciences, University of Salerno, Salerno, Italy

ABSTRACT

The present study is the first effort to a comprehensive evaluation of the antioxidant and antimicrobial activities of 'Napoletano' green and purple basil (*Ocimum basilicum* L.) varieties. The results obtained revealed that the basil sample extracts were characterised by a generally higher polyphenolic concentration than those reported elsewhere for other more conventional and geographically different basil varieties. Napoletano purple basil revealed higher radical-scavenging and ferric-reducing capacities than the green one probably due to its relevant anthocyanin content. As regards the antimicrobial properties, both basil varieties exhibited activity against a broad spectrum of food-borne and human pathogenic micro-organisms, revealing not only a moderate to high natural preserving capacity, but also potentially beneficial influence on human health. Results indicated Napoletano green and purple basils as a good source of antioxidants of potential nutraceutical interest.



ARTICLE HISTORY
Received 26 May 2016
Accepted 20 November 2016

KEYWORDS
'Napoletano' basils; polyphenolics; antioxidant; antimicrobial

CONTACT Gian Carlo Tenore giancarlo.tenore@unina.it

Supplemental data for this article can be accessed at http://dx.doi.org/10.1080/14786419.2016.1269103.

© 2016 Informa UK Limited, trading as Taylor & Francis Group

1. Introduction

Lamiaceae family is known to be a rich source of polyphenolic compounds, particularly phenolic acids and flavonoids. Among the 200 genera, basil (*Ocimum basilicum* L.) is definitely one of the most prominent for its considerable genetic diversity, with up to 150 species reported. Basil is a well-known medicinal plant used for thousands of years in the Indian traditional medicine (Mueller et al. 2010; Bora et al. 2011; Bharathi et al. 2012).

In spite of the very numerous data about the beneficial effects on human health of different basil varieties, very little is known in this sense about the variety Napoletano, also called 'basil lettuce leaves'. The purpose of this work was to evaluate the antioxidant and antimicrobial properties of Napoletano basil in order to assess the nutraceutical potential of this selected plant used as a typical flavouring spice in the Mediterranean area.

2. Results and discussion

The results obtained for the polyphenolic content of Napoletano basils (Table S1) were generally higher than those reported elsewhere for other basil varieties although equivalent analytical procedures for quantification were used (Lee & Scagel 2009, 2010; Aydemir & Becerik 2011). The main phenolic acid in green basil was gallic acid (40%), followed by rosmarinic acid (28.4%), ferulic acid (18%) and other minor compounds (11%), while purple basil mainly accounted for rosmarinic acid (34%), followed by ferulic acid (29%), gallic acid (18%) and other phenolic acids in trace (17%). 'Napoletano' green basil revealed very high content of gallic acid, only comparable to that of cloves (7835 mg/100 g dw) (Shan et al. 2005). Noteworthy, rosmarinic acid occurred in our basil samples in higher volumes than what on average reported for other common varieties, such as Sweet basil (112 mg/100 g fw), Thai basil (128 mg/100 g fw), Genovese Italiano (117 mg/100 g fw) and Purple Petra (352 mg/100 g fw) (Lee & Scagel 2009). Ferulic acid is present ubiquitously in plant tissues and also in many foods (Zhao & Moghadasian 2008). Ferulic acid is reported to be useful in the prevention and/or treatment of disorders linked to oxidative stress, including Alzheimer's disease, diabetes, cancers, hypertension and atherosclerosis; for example, sodium ferulate is already used in China for the treatment of cardiovascular and cerebrovascular diseases (Zhao & Moghadasian 2008). Napoletano green and purple basils possess an almost equal amount of ferulic acid when compared to many types of grain, fruits, vegetables and food products (Zhao & Moghadasian 2008). As regards phenolic acids occurring in the essential oils, the main constituents identified in our basil extracts were eugenol, carvacrol, epirosmanol

Table 1. Near equilibrium steady state antioxidant capacity of 'Napoletano' purple and green basil extracts *vs* antioxidant standards.[a]

Sample	DPPH	FRAP
Ngb	1288.0 ± 0.4	1159.0 ± 0.8
Npb	580.0 ± 0.5	1195.0 ± 0.6
Vit. E	8497.4 ± 0.3	8912.1 ± 0.2
BHT	7707.4 ± 0.3	7382.1 ± 0.0
$Na_2S_2O_5$	2267.8 ± 0.4	5267.1 ± 0.8
Vit. C	2157.3 ± 0.9	517.1 ± 0.5

Notes: Ngb: Napletano green basil; Npb: Napoletano purple basil. Standard solutions were of 1 mg/mL concentration.
[a]Values are expressed as TEs (μmol L^{-1}) of extract and standard solutions ± SD ($p < 0.001$) at the steady state (DPPH, 45 min; FRAP, 55 min). Vit. E: vitamin E; Vit. C: vitamin C; BHT: butylhydroxytoluene; $Na_2S_2O_5$: sodium metabisulfite.

Table 2. Antimicrobial activity of Napoletano basil polyphenolic extracts.[a]

Microorganism	Ngb	Npb	CTAX	PEN	TET	AMB	ECN
Gram (+) bacteria							
B. cereus (ATCC 11778)	64 ± 0.1	32 ± 0.0	R	7.5 ± 0.0	R	NT	NT
S. aureus (ATCC 13709)	64 ± 0.2	32 ± 0.2	2.0 ± 0.4	0.03 ± 0.0	2.0 ± 0.3	NT	NT
E. faecalis (ATCC 14428)	64 ± 0.1	32 ± 0.2	R	8.0 ± 0.0	2.0 ± 0.6	NT	NT
L. monocytogenes (ATCC 15313)	128 ± 0.4	64 ± 0.1	16 ± 0.0	R	R	NT	NT
Gram (−) bacteria							
E. coli (ATCC 25922)	128 ± 0.3	64 ± 0.2	32 ± 0.1	64 ± 0.4	32 ± 0.2	NT	NT
P. mirabilis (ATCC 7002)	128 ± 0.0	64 ± 0.4	0.03 ± 0.0	4.0 ± 0.0	32 ± 0.1	NT	NT
P. vulgaris (ATCC 12454)	128 ± 0.1	128 ± 0.2	2.0 ± 0.1	4.0 ± 0.3	R	NT	NT
P. aeruginosa (ATCC 27853)	128 ± 0.1	64 ± 0.0	16 ± 0.0	R	32 ± 0.1	NT	NT
S. typhi (ATCC 19430)	256 ± 0.0	128 ± 0.0	0.5 ± 0.1	4.0 ± 0.0	1.0 ± 0.3	NT	NT
E. cloaceae (ATCC 10699)	128 ± 0.0	64 ± 0.4	R	4.0 ± 0.0	R	NT	NT
E. aerogenes (ATCC 13048)	128 ± 0.4	128 ± 0.4	R	4.0 ± 0.0	R	NT	NT
Y. enterocolitica (ATCC 23715)	256 ± 0.3	128 ± 0.3	0.1 ± 0.0	18 ± 0.6	8.0 ± 0.0	NT	NT
K. pneumoniae (ATCC 27736)	128 ± 0.3	64 ± 0.2	0.1 ± 0.0	R	16 ± 0.1	NT	NT
Yeasts							
C. albicans (ATCC 10231)	128 ± 0.2	64 ± 0.3	NT	NT	NT	1 ± 0.0	NT
Rhizoctonia solani (ATCC 13048)	128 ± 0.4	64 ± 0.0	NT	NT	NT	1 ± 0.1	NT
Moulds							
F. oxysporum (ATCC 695)	256 ± 0.3	256 ± 0.2	NT	NT	NT	NT	4 ± 0.0
C. herbarum (ATCC 11281)	256 ± 0.4	128 ± 0.0	NT	NT	NT	NT	4 ± 0.1
B. cinerea (ATCC 11542)	256 ± 0.1	128 ± 0.0	NT	NT	NT	NT	4 ± 0.0
A. flavus (ATCC 15517)	256 ± 0.1	128 ± 0.0	NT	NT	NT	NT	3 ± 0.1

Notes: Ngb: Napoletano green basil; Npb: Napoletano purple basil; CTAX: cefotaxime; PEN: penicillin; TET: tetracycline; AMB: amphotericin B; ECN: econasol; NT: not tested; R: resistant.
[a]Values are expressed as minimum inhibitory concentration (MIC, µg/mL) and represent the average of three determinations ± SD.

and carnosol. It is well known that the essential oil from the basil leaves shows several bioactive properties, such as insect repellent, nematicide, anti-inflammatory, antibacterial and antifungal (Saggiorato et al. 2012) effects, in addition to their low contribution to the total antioxidant activity. Our data indicate green basil exhibited higher amounts (more than twice) of epirosmanol, carnosol and carvacrol than the purple one, whereas eugenol in purple basil is not detectable.

Napoletano purple basil exhibited higher amounts of non-anthocyanin flavonoids than the green one, and than what on average reported for other common basils and fresh herbs (Justesen & Knuthsen 2001). Quercetin was the most abundant in purple basil (62.5%). Green basil accounted for apigenin-7-O-rutinoside (34.9%). These data are of great interest, considering the well-known radical scavenging properties of plant flavonoids (Choudhary et al. 2011), and, thus, their potential beneficial effects on human health through diet.

Cyanidin-based p-coumaryl acids and cyanidin-based p-coumaril and malonil acids were the two most abundant anthocyanins (28.1% and 28.8%, respectively) in purple basil extract. These compounds have recently been shown to act as antioxidants, allowing for their use as medicinal agents (Phippen & Simon 1998). 'Napoletano' purple basil revealed a higher anthocyanin content than other commercial purple basil varieties, such as Purple Ruffles, Rubin and Dark Opal (Phippen & Simon 1998), and than other important natural anthocyanin fruit and leaf sources (Phippen & Simon 1998).

In contrast with their respective polyphenolic concentrations, Napoletano green basil revealed a higher total antioxidant capacity (DPPH + FRAP results) than purple one (Table 1). Nevertheless, the reason would be found in the higher concentrations of both rosmarinic and gallic acids in green basil than purple one. Specifically, Dorman et al. (2004) have observed that in basil, this capacity appear to be strongly dependent on rosmarinic and gallic acid contents, due to their vicinal –OH groups on the aromatic rings.

According to the MIC values reported in Table 2, both basil extracts revealed a broad antimicrobial spectrum by leading to an appreciable decrease in the growth of all of the human pathogenic and/or food spoilage bacteria, moulds and yeasts tested. On average, our samples showed better antimicrobial effects when compared to other different basil varieties (Bharathi et al. 2012). Generally, a significant correlation between the extract polyphenolic content and antioxidant capacity has been highlighted (Shan et al. 2005). Our studies confirmed that the most sensitive ones are Gram (+) pathogens. It is well known that phenolic acids are present in ionised form at the buffer pH value (7.0) and are too polar compounds to penetrate the semipermeable bacterial membrane and react with the cytoplasm or cellular proteins (Corrales et al. 2009). This is the same reason for which the lipidic wall of Gram (–) pathogens represent a great barrier for most polyphenols hence only a slight inhibition is achieved. Polyphenolics occurring in green basil extract were represented mainly by phenolic acids while those in purple variety were mainly flavonoids, more lipophilic compounds. Our results are of great interest because they would explain the more appreciable effects exerted by purple basil on Gram (–) bacteria in comparison to those of green variety. Interestingly, the activity of both samples resulted appreciable also against the fungal microorganisms tested, with higher values for yeasts than moulds.

3. Conclusions

Napoletano purple basil extract showed a higher reducing capacity and radical scavenging activity than the green one revealing a good correlation between anthocyanin content and extract antioxidant activity. A broad antimicrobial spectrum was exerted by basil varieties extracts. Particularly, our results pointed out the attention on the leading role in purple basil sample tested of the anthocyanin fraction in terms of antioxidant and antimicrobial properties. Overall, Napoletano green and purple basils may be reasonably regarded as responsible for an appreciable food-preserving capacity and potentially healthy effects through diet.

Supplementary material

Table 1 and the experimental section is available in the supplementary data.

Acknowledgements

Antimicrobial activity was tested by Dr. Francesco Napolitano, Department of Pharmacy, University "Federico II", Naples, Italy. The assistance of the staff is gratefully appreciated.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Aydemir T, Becerik S. 2011. Phenolic content and antioxidant activity of different extracts from ocimum basilicum, apium graveolens and *Lepidium sativum* seeds. J Food Biochem. 35:62–79.

Barry AL, Hoeprich PD, Saubolle MA. 1976. The antimicrobic susceptibility test: principles and practices. Philadelphia, PA: Lea and Febiger.

Benzie IFF, Strain JJ. 1996. The ferric reducing ability of plasma (frap) as a measure of "antioxidant power": the frap assay. Anal Biochem. 239:70–76.

Bharathi V, Shanmuga Priya A, Firdous SJ. 2012. Antibacterial activity of stem extracts of *Ocimum basilicum*. J Chem Biol Phys Sci. 2:298–301.

Bora KS, Arora S, Shri R. 2011. Role of *Ocimum basilicum* L. in prevention of ischemia and reperfusion-induced cerebral damage, and motor dysfunctions in mice brain. J Ethnopharmacol. 137:1360–1365.

Brand-Williams W, Cuvelier ME, Berset C. 1995. Use of a free radical method to evaluate antioxidant activity. Lebensm-Wiss Technol. 28:25–30.

Choudhary RK, Saroha AE, Swarnkar PL. 2011. Radical scavenging activity of phenolics and flavonoids in some medicinal plants of India. J Pharm Res. 4:712–713.

Corrales M, Han JH, Tauscher B. 2009. Antimicrobial properties of grape seed extracts and their effectiveness after incorporation into pea starch films. Int J Food Sci Techn. 44:425–433.

Dorman HJD, Bachmayer O, Kosar M, Hiltunen R. 2004. Antioxidant properties of aqueous extracts from selected Lamiaceae species grown in Turkey. J Agric Food Chem. 52:762–770.

Justesen U, Knuthsen P. 2001. Composition of flavonoids in fresh herbs and calculation of flavonoid intake by use of herbs in traditional Danish dishes. Food Chem. 73:245–250.

Lee J, Scagel CF. 2009. Chicoric acid found in basil (*Ocimum basilicum* L.) leaves. Food Chem. 115:650–656.

Lee J, Scagel CF. 2010. Chicoric acid levels in commercial basil (*Ocimum basilicum*) and Echinacea purpurea products. J Funct Food. 2:77–84.

Mueller M, Hobiger S, Jungbauer A. 2010. Anti-inflammatory activity of extracts from fruits, herbs and spices. Food Chem. 122:987–996.

Phippen WB, Simon JE. 1998. Antocyanins in basil (*Ocimum basilicum* L.). J Agric Food Chem. 46:1734–1738.

Saggiorato AG, Gaio I, Treichel H, de Oliveira D, Cichoski AJ, Cansian RL. 2012. Antifungal activity of Basil essential oil: evaluation *in vitro* and on an Italian-type sausage surface. Food Bioproc Technol. 5:378–384.

Shan B, Cai YZ, Sun M, Corke H. 2005. Antioxidant capacity of 26 spice extracts and characterization of their phenolic constituents. J Agric Food Chem. 53:7749–7759.

Zhao Z, Moghadasian MH. 2008. Chemistry, natural sources, dietary intake and pharmacokinetic properties of ferulic acid: A review. Food Chem. 109:691–702.