

## Review

# ***Acinos* species: Chemical composition, antimicrobial and antioxidative activity**

**Gordana Stojanović<sup>1\*</sup>, Tatjana Golubović<sup>2</sup>, Dušanka Kitić<sup>3</sup> and Radosav Palić<sup>1</sup>**

<sup>1</sup>Department of Chemistry, Faculty of Science and Mathematics, University of Niš, Višegradska 33, 18000 Niš, Serbia.

<sup>2</sup>Faculty of Occupational Safety, Čarnojevica 10 a, University of Niš, 18000 Niš, Serbia.

<sup>3</sup>Faculty of Medicine, Department of Pharmacy, Bulevar Zorana Đinđića 81, 18000 Niš, Serbia.

Accepted 16 December, 2009

**Published papers considering composition, antimicrobial and antioxidant activity of *Acinos* Miller species were reviewed. Main volatile constituents are pulegone, menthone and germacrene D. Alcoholic and water extracts contain a number of flavonoids. Reported chemical composition suggest potential use of *Acinos* species as phyto-therapeutic and food preservative agents. The investigation of biological activity of *Acinos* species has rarely been reported so further research should be carried out to determine whether the extract components posses activity both, *in vitro* and *in vivo* and ultimately are safe for human consumption.**

**Key words:** *Acinos*, Lamiaceae, essential oil, antibacterial activity, antioxidant activity, composition.

## INTRODUCTION

*Acinos* Miller is one of the smaller genera of the Lamiaceae family native to Europe, Mediterranean, central Asia, northern Africa and North America. The name *Acinos* comes from the Greek word *akinos* meaning a small aromatic plant. *Acinos* species are annual and short-lived evergreen perennial woody plants. They are small, tufted, bushy or spreading plants growing to 10 - 45 cm tall which propagate by division, softwood cuttings or from seed in spring (Bonnier, 1927; Bown, 1995). Among botanists there is no agreement about the list of accepted species. According to The International Organization for Plant Information (IOPI), genus *Acinos* Miller comprises 11 species (names and synonyms from different sources are given in Table 1). Even small *Acinos* is important genus within the Lamiaceae family from the economic point of view. A number of *Acinos* species are being traded in the herbal market, as the herbs of "mint" group, mainly in the Mediterranean countries (Table 2). Traditional applications of *Acinos* species in folk medicine has not been justified enough through biochemical researches. This review presents published results of chemical composition, antibacterial and antioxidant activity of *Acinos* species in order to point out which species could be considered as possible phyto-therapeutics.

Reviewing the available literature (SciFinder), 47 references were found concerning *Acinos* species. Majority of the papers dealt with essential oil composition. There are only two papers devoted to the antibacterial activity, one to antioxidant properties and one to fatty acids. *A. suaveolens* is the most examined species and also has the greatest number of uses in traditional medicine while some of the species weren't examined at all.

## CHEMICAL COMPOSITION

Published data of chemical composition of *Acinos* species are summarized in the Table 3. Presented results (Table 3) suggest a number of observations:

1. According to essential oil yield and composition two group of *Acinos* species could be recognized: one which produce essential oil in great quantity than other examined *Acinos* species (2.3 - 0.64) with monoterpenes as main constituents, pulegone, menthone and isomenthone (Figure 1): *A. majoranifolius* and *A. suaveolens* and the other group which was characterize with low yield of oil (0.01 - 0.08) and sesquiterpenes as dominant constituents. There is one exception: for *A. arvensis* oil from Greece was reported that it consist of pulegone, menthone and isomenthone, (Souleles et al. (1988). Misidentification of the species may be hypothesized.

\*Corresponding author. E-mail: [stgocaus@yahoo.com](mailto:stgocaus@yahoo.com) or [gocast@pmf.ni.ac.rs](mailto:gocast@pmf.ni.ac.rs). Fax/Tel: +38118533014.

**Table 1.** Names and synonyms of *Acinos* species from different literature sources.

Greuter et al. (1984, 1986)	Czerepanov (2007)	Database of European Plants (ESFEDS). Edinburgh ( <a href="http://www.helsinki.fi/kmus/botflor.html">http://www.helsinki.fi/kmus/botflor.html</a> )
<i>Acinos alpinus</i> (L.) Moench Synonyms: <i>Satureja alpina</i> (L.) Scheele	<i>Acinos alpinus</i> (L.) Moench Synonyms: <i>Acinos baumgartenii</i> (Simonk.) Klokov, <i>Melissa baumgartenii</i> Simonk., <i>Acinos alpinus</i> subsp. <i>baumgartenii</i> (Simonk.) Pawl>l.	<i>Acinos alpinus</i> (L.) Moench Synonyms: <i>Calamintha alpina</i> (L.) Lam., <i>Clinopodium alpinum</i> (L.) Merino, <i>Satureja alpina</i> (L.) Scheele, <i>Calamintha alpina</i> (L.) Lam. subsp. <i>alpina</i>
<i>Acinos arvensis</i> (Lam.) Dandy Synonyms: <i>Satureja acinos</i> (L.) Scheele	<i>Acinos arvensis</i> (Lam.) Dandy Synonyms: <i>Acinos schizodontus</i> Klokov, <i>Acinos thymoides</i> Moench	<i>Acinos arvensis</i> (Lam.) Dandy Synonyms: <i>Acinos thymoides</i> Moench, <i>Calamintha acinos</i> (L.) Clairv., <i>Satureja acinos</i> (L.) Scheele <i>Acinos corsicus</i> (Pers.) Getliffe
<i>Acinos corsicus</i> (Pers.) Getliffe Synonyms: <i>Satureja corsica</i> (Pers.) Caruel	-	<i>Acinos corsicus</i> (Pers.) Getliffe Synonyms: <i>Calamintha corsica</i> (Pers.) Bentham, <i>Satureja corsica</i> (Pers.) Caruel, <i>Thymus corsicus</i> Pers.
<i>Acinos graveolens</i> Synonyms: <i>Satureja graveolens</i> (MB.) Caruel	<i>Acinos graveolens</i> (M. Bieb.) Synonyms: <i>Acinos rotundifolius</i> Jim.Perss.	<i>Acinos graveolens</i> (Bieb.) Link <b>Synonyms:</b> Synonyms: <i>Acinos rotundifolius</i> Pers.
<i>Acinos hungaricus</i> (Simonkai) Synonyms: <i>Satureja hungarica</i> (Simonkai) Hayek	-	-
<i>Acinos majoranifolius</i> (Miller) Synonyms: <i>Satureja majoranifolia</i> (Miller) K. Mal'y	-	-
<i>Acinos orontius</i> (K. Mal'y) Synonyms: <i>Satureja orontia</i> K. Mal'y	-	-
<i>Acinos rotundifolius</i> Pers. Synonyms: <i>Satureja rotundifolia</i> (Pers.).	<i>Acinos rotundifolius</i> Jim.Perss. Synonyms: <i>Acinos fominii</i> Des.-Shost., <i>Acinos graveolens</i> (M.Bieb.), <i>Acinos infectus</i> Klokov, <i>Acinos subcrispus</i> , Klokov <i>Acinos thubcrispus</i> Klokov	<i>Acinos rotundifolius</i> Pers. Synonyms: <i>Acinos fominii</i> Roussine <i>Acinos graveolens</i> (Bieb.) Link, <i>Calamintha exigua</i> (Sibth. & Sm.) Hayek, <i>Calamintha graveolens</i> (Bieb.) Bentham, <i>Calamintha maritima</i> Bentham, <i>Calamintha rotundifolia</i> (Pers.) Bentham, <i>Satureja rotundifolia</i> (Pers.) Briq.

Table 1. Contd.

<i>Acinos suaveolens</i> (Sm.) Synonyms: <i>Satureja suaveolens</i> (Sm.) Watzl-Zeman	-	<i>Acinos suaveolens</i> (Sibth. & Sm.) G. Don fil. Synonyms: <i>Calamintha suaveolens</i> (Sibth. & Sm.) Boiss.
<i>Acinos troodi</i> (Post) Leblebici Synonyms: <i>Satureja troodi</i> (Post) Holmboe	-	-
-	-	<i>Acinos villosus</i> Jim.Perss. Synonyms: <i>Acinos eglandulosus</i> Klokov, <i>Acinos arvensis</i> subsp. eglandulosus (Klokov) Tzvelev, <i>Acinos arvensis</i> subsp. villosus (Pers.) Soják

Table 2. Reported medicinal uses of *Acinos* Miller species.

Species	Medicinal use	References
<i>A. alpinus</i> Folk names: Rock thyme, mint	Antiemetic, anti-inflammatory, diuretic, for cholesterol, diarrhea, digestion, obesity and respiratory ailments	Karousou et al. (2007)
<i>A. arvensis</i> Folk name: Basil Thyme	Antiseptic, stimulant tonic, for shortness of breath, improving digestion, to treat bruises, toothache, Sciatica and neuralgia	Bown (1995)
<i>A. suaveolens</i> Folk name: mint	Anticlipusive, antiseptic, aphrodisiac, blood purification, dizziness-nausea-sea sickness, dysmenorrhoea, fever gall disorders, headache-migraine influenza mouth and throat hygiene, rheumatism, sedative, spasmolytic, tonic-stimulant, tonsillitis, diabetes, stomach ailments.	Karousou et al. (2007)

2. Germacrene D is widespread main sesquiterpene among examined *Acinos* species. However, there are two exceptions: Jovanović et al. (2002) reported caryophyllene oxide as the dominant constituent for *A. hungaricus* oil and Skaltsa et al. (1999) found germacrene A as major compound in *A. alpinus* oil. Possible reason could be the cause of the existence of different chemotypes or wrong constituent identification.

3. There is the variability in quantity and composition of essential oils among populations of the same species suggesting different chemical types within it (Kaya et al. 1999a,b,c).

4. Linolenic acid is the main constituent in *A. alpinus* and *A. hungaricus* chloroform-methanolic extract (Jovanović et al. (2008). Studies have found evidence that  $\alpha$ -linolenic acid, an  $n-3$  essential fatty acid, is related to a lower risk of cardiovascular disease (Kris-Etherton et al., 2002). Research has also suggested a major neuroprotective effect of  $\alpha$ -linolenic acid in in-vivo models of both global

ischemia and epilepsy (Lauritzen et al., 2000).

5. Plenty of flavonoids and flavonoids glycosides were isolated from *A. alpinus*, *A. suaveolens* and *A. hungaricus* (Figures 2 and 3). Flavones (apigenin, luteolin, chrysoeriol) and their glycosides (luteolin-7-*O*-rutinoside, cynaroside, linarin, fortunalin) are the most frequent flavonoids in methanol extracts of examined *Acinos* species. Flavonols such as kaempferol and quercetin are less frequent. Glycosidic form of flavanones (narirutin, hesperidin, neoponcirin, paucerin, portsirin) also occur in the *Acinos* species. Majority of flavonoids are linked with sugars in position 7. The most frequent monoglycoside is *O*-glucosides. Among diglycosides it is true for rutinosides. Both, flavonoids and their glycosides, have been used as a nutritional supplement due to positive effects in combating or helping to prevent cancer, prostatitis, heart disease, cataracts, allergies/inflammations, and respiratory diseases such as bronchitis and asthma. In an eight year long study it was found that the presence of three flavonols (kaempferol, quercetin, and myricetin) in a diet

**Table 3.** Chemical composition of *Acinos* species

<b>Acinos species</b>	<b>Essential oil main constituents* (%)</b>	<b>Other constituents**</b>	<b>References</b>
<i>A. alpinus</i>	Germacrene D (3.5-39.8), hexadecanoic acid (3.7-24.3), thymol (10.9-15.3)	-	Kaya et al. (1999a)
	germacrene A (32.3), epi-bicyclosesquiphellandrene (15.8), $\beta$ -elemene (12.5) and $\beta$ -caryophyllene (12.2)	-	Skaltsa et al. (1999)
	Germacrene D (56.8; 43.2), $\beta$ -caryophyllene (6.2; 15.4), bicyclogermacrene (5.9; 11.7)	-	Velasco-Negueruela et al. (1993)
	-	Aurapin, naringenin, taxifolin, neoponcirin	Venturella et al. (1980)
	-	Linolenic acid 35.2% palmitic acid 23.0%; linoleic acid 15.1%	Jovanović et al. (2008)
<i>A. arvensis</i>	Germacrene D (47.0) $\beta$ -bourbonene (7.7)	-	Jovanović et al. (2005)
	Germacrene D (14.3) hexadecanoic acid (14.0) $\beta$ -bourbonene (7.0)	-	Kaya et al. (1999b)
	Germacrene D (51.4) $\beta$ -caryophyllene (7.9) $\beta$ -bourbonene (4.8)	-	Kaya et al. (1999b)
	pulegone (51.3) izomenthone (18.1)	-	Souleles et al. (1988)
	-	Linarin (acacetin 7-O-rutinoside)	Marin et al. (2001)
	-	phytol (0.04-0.1%), $\beta$ -sitosterol (0.06-0.08%), ursolic acid (0.4- 1.4%), betulin (0.05%)	Popa and Pasechnik (1974)
	-	Atsinoside (didymine, neoponcirin)	Wagner et al. (1974)
	-	Fortunallin (acacetin 7-(2-O- $\alpha$ -L- rhamnopyranosyl - $\beta$ -D - glucopyranoside)	Sergienko et al. (1968)
	-	paucerin (5-hydroxy-4-methoxyflavanone 7 $\beta$ -D-glucopyranoside-2- $\alpha$ -L- rhamnopyranoside)	Sergienko et al. (1967)

Table 3. Contd.

	-	Portsirin (5,7-dihydroxy-4'-methoxyflavanone 7- (β -D-glucopyranosyl-2- α -L-rhamnopyranoside), atsinoside (didymine, neoponcirin)	Sergienko et al. (1966)
<i>A. hungaricus</i>	germacrene D (46.7), β-bourbonene (6.6)	-	Chalchat et al. (2004)
	caryophyllene oxide (16.8), geraniol (9.7), β-bourbonene (5.7), globulol (5.6)	-	Jovanović et al. (2002)
		linolenic acid 26.7% palmitic acid 21.8%; linoleic acid 11.7%; Linarin (acacetin 7-O-rutinoside)	Jovanović et al. (2008)
<i>A. majoranifolius</i>	pulegone (97), menthone (3)	-	Marin et al. (2001) Pavlović et al. (1984b)
<i>A. rotundifolius</i>	germacrene-D (14.4-73.1), hexadecanoic acid (17.5-30.2)	-	Kaya et al. (1999b)
	pulegone (67.7; 77.7), isomenthone (4.9; 6.8)	-	Couladis et al. (2002)
<i>A. suaveolens</i>	pulegone (23.2-80.7), isomenthone (1.1-54.1)	-	Kaya et al. (1999b)
	isomenthone (50.86), pulegone (33.22)	-	Tumen (1991)
	pulegone (69.04), isomenthone (17.04) pulegone (96.9)	-	Kokkalou (1988a) Pavlović et al. (1984a)
	-	apigenin, kaempferol, chrysoeriol, luteolin, quercetin, didymin, narirutin, cosmosiin, cynaroside, isoquercitrin, hesperidine, luteolin-7-O-rutinoside	Kokkalou and Kapetanidis (1988b)
<i>A. troodi</i>	hexadecanoic acid (7.5-18.2 and 15.2-22.3), germacrene D (10.2-14.5 and 14.1-29.7)	-	Kaya et al. (1999c)

\*Essential oils obtained by hydrodistillation using a Clevenger-type apparatus.

\*\*Maceration in methanol was used as extraction method in references: Venturela et al. (1980), Wagner et al. (1974), Sergienko et al. (1967, 1968 and 1966), and Kokkalou and Kapetanidis (1988b). Popa and Pasechnik (1974) used acetone as solvent for extraction. Marin et al. (2001) extracted plant material by aqua's methanol (H<sub>2</sub>O:CH<sub>3</sub>OH, 20:80). Fatty acids were extracted by maceration in chloroform: methanol, 2:1.

were associated with a reduced risk of pancreatic cancer in current tobacco smokers (Nöthlings et al., 2007).

## ANTIOXIDANT AND ANTIMICROBIAL ACTIVITIES

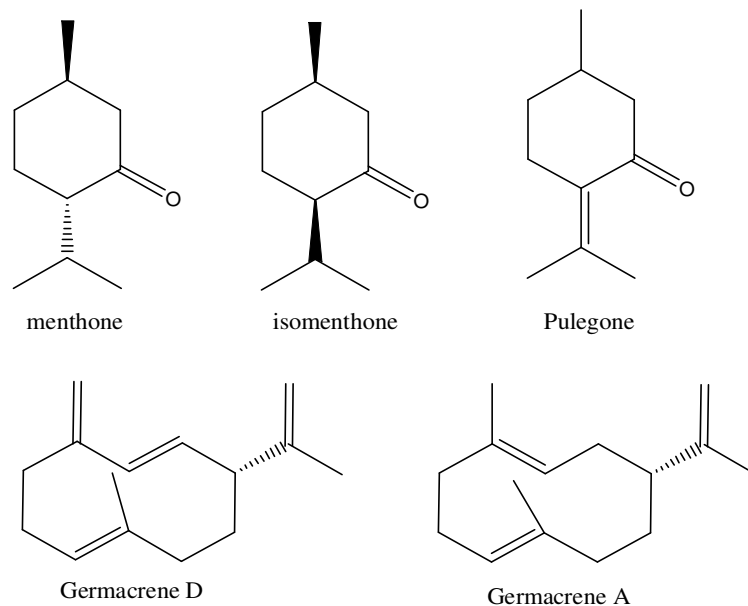
There is only one paper that stated the antioxidant activity of water extract of *A. suaveolens* (Triantaphyllou et al., 2001). Results of this work indicate that water extract of *A. suaveolens* (mint) have a protective effect against lipid oxidation but it is less active than the water extract of sage (*Salvia officinalis*).

*A. arvensis* essential oil is active against *Escherichia coli*, *Staphylococcus aureus* and *Klebsiella pneumonia* but not against *Pseudomonas aeruginosa* (Jovanović et al. (2005). Couladis et al. (2002) found that *E. coli*, *S. aureus*, *S. epidermidis*, *S. hominis* and *K. pneumonia*

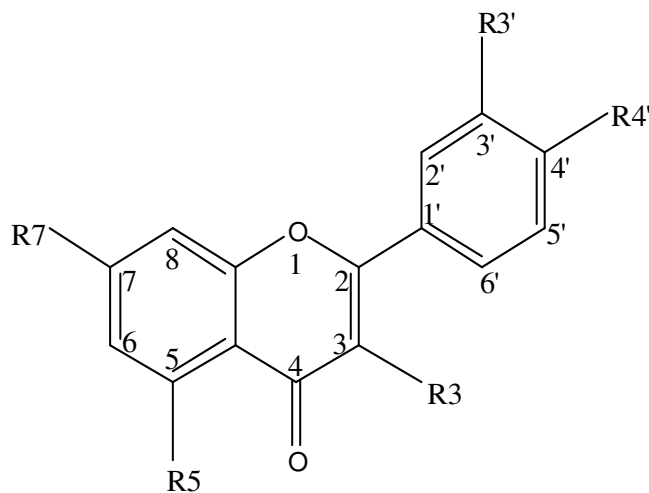
were susceptible to the *A. suaveolens* oil.

## CONCLUSION

Activity of the plant extracts would be expected to relate to their composition, the structural configuration of the components, their functional groups and possible synergistic or antagonistic interactions between components. There are a lot of papers that connect particular extract component with observed extract bioactivity (Misra, 2009). It is known that *p*-menthane ketones are effective towards a number of microorganisms (Dorman, 2000). Pulegone exhibited high antimicrobial activity, especially on *Salmonella typhimurium* and *S. aureus* (Duru, 2004). β-Caryophyllene have moderate antimicrobial activity (Blagojević, 2006). One may conclude that the composi-

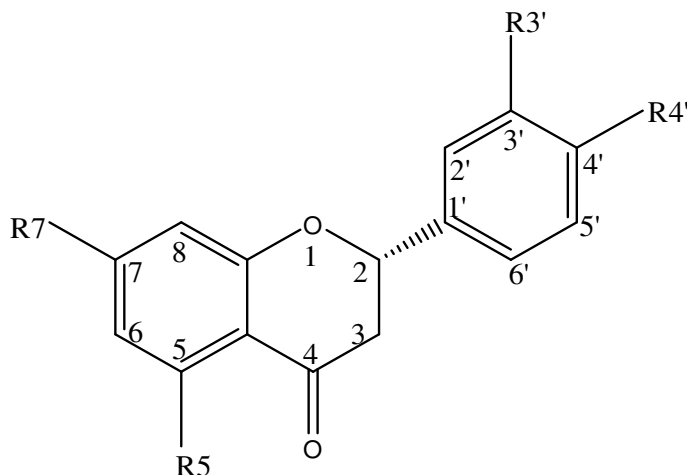


**Figure 1.** Main constituents of *Acinos* species essential oils.



Compound	R3	R5	R7	R3'	R4'
Apigenin	H	OH	OH	H	OH
Luteolin	H	OH	OH	OH	OH
Kaempferol	OH	OH	OH	H	OH
Quercetin	OH	OH	OH	OH	OH
Chrysoeriol	H	OH	OH	OCH <sub>3</sub>	OH
Cosmosiin (apigetrin)	H	OH	<i>O</i> -glucoside	H	OH
Isoquercitrin	<i>O</i> -glucoside	OH	OH	OH	OH
Luteolin-7- <i>O</i> -rutinoside	H	OH	<i>O</i> -rutinoside	OH	OH
Cynaroside	H	OH	<i>O</i> -glucoside	OH	OH
Linarin	H	OH	<i>O</i> -rutinoside	H	OCH <sub>3</sub>
fFortunalin	H	OH	<i>O</i> -(2- <i>O</i> - $\alpha$ -L-rhamnopyranosyl - $\beta$ -D - glucopyranoside)	H	OCH <sub>3</sub>

**Figure 2.** Common flavones, flavonols and their glycosides of *Acinos* species



Compound	R5	R7	R3'	R4'
Narirutin	OH	O-rutinoside	H	OH
Hesperidin	OH	O-rutinoside	OH	OCH <sub>3</sub>
Didymin (neoponcirin, atsinoside)	OH	O-rutinoside	H	OCH <sub>3</sub>

**Figure 3.** Common flavanone glycosides of *Acinos* species

tion of essential oils of *Acinos* species promises exploitable *in vitro* antimicrobial activity.

In addition, *Acinos* species are promising source of natural antioxidants because of high content of flavonoids and linolenic acid in their extracts (Table 3). Flavonoids are known as high-level antioxidants because of their ability to scavenge free radicals and reactive oxygen species such as singlet oxygen, superoxide anion radical and hydroxyl radicals.

## ACKNOWLEDGMENT

This work was funded by the Ministry of Science and Technological Development of Serbia (Project 142054).

## REFERENCES

- Blagojević P, Radulović N, Palić R, Stojanović G (2006) Chemical composition of the essential oils of Serbian wild-growing *Artemisia absinthium* and *Artemisia vulgaris*. J. Agric. Food Chem. 54: 4780-4789.
- Bonnier G (1927). *Flora Complete Illustrée en Couleurs de France Suisse et Belgique*, Tome 9, Brussels.
- Bown D (1995). Encyclopedia of Herbs & Their Uses, The Herb Society of America, Dorling Kindersley, New York.
- Chalchat J, Maksimović Z, Petrović S, Gorunović M (2004). Essential oil of *Acinos hungaricus* (Simonkai) Silic, Lamiaceae. J. Essent. Oil Res. 16: 38-39.
- Couladis M, Tzakou O, Demetzos C, Perdetzoglou D (2002). Chemical composition and antibacterial activity of the oil of *Acinos suaveolens* (Sibth. et Sm.) G. Don f. from Greece. J. Essent. Oil Res. 14: 139-140.
- Czerepanov SK (2007). Vascular Plants Of Russia And Adjacent States (the Former Ussr). Cambridge University Press.
- Dorman H, Deans S (2000) Antimicrobial agents from plants: antibacterial activity of plant volatile oils. J. Appl. Microbiol. 88: 308-316.
- Duru ME, Ozturk M, Ugur A, Ceylan O (2004). The constituents of essential oil and *in vitro* antimicrobial activity of *Micromeria cilicica* from Turkey. J. Ethnopharmacol. 94: 43-48.
- Greuter W, Burdet, HM, Long G (1984). Med-Checklist. 1. Genève and Berlin.
- Greuter W, Burdet, HM, Long G (1986). Med-Checklist. 3. Genève and Berlin.
- Jovanović T, Kitić D, Palić R, Stojanović G, Ristić M (2002). Chemical composition of the essential oil of *Acinos hungaricus* (Simonkai) Silic. J. Essent. Oil Res. 14: 29-30.
- Jovanović T, Kitić D, Palić R, Stojanović G, Ristić M (2005). Chemical composition and antimicrobial activity of the essential oil of *Acinos arvensis* (Lam.) Dandy from Serbia. Flavour Frag. J. 20:288-290.
- Jovanović T, Palić R, Kitić D, Ristić M, Zlatković B (2008). Fatty acids of *Acinos alpinus* and *A. hungaricus*. Chem. Nat. Compd. 44:231-233.
- Karousou R, Balta M, Hanlidou E, Kokkini S (2007). "Mints", smells and traditional uses in Thessaloniki (Greece) and other Mediterranean countries. J. Ethnopharm. 109(2): 248-257.
- Kaya A, Baser KHC, Demirci B, Koca F (1999a) The essential oil of *Acinos alpinus* (L.) Moench growing in Turkey. Flavour Frag. J. 14: 55-59.
- Kaya A, Baser KHC, Koca F (1999c). Essential oils of *Acinos troodi* (Post) Leblebici subsp. vardaranus Leblebici and subsp. grandiflorus Hartvig & Strid. Flavour Frag. J. 14: 50-54.
- Kaya A, Baser KHC, Tumen G, Koca F (1999b). The essential oil of *Acinos suaveolens* (Sm.) G. Don fil., *Acinos arvensis* (Lam.) Dandy and *Acinos rotundifolius* Pers. growing wild in Turkey. Flavour Frag. J. 14: 60-64.
- Kokkalou E (1988). Composition of the volatile oil from *Acinos suaveolens*. Planta Med. 54: 340-2.
- Kokkalou E, Kapetanidis (1988). Flavonoids of the aerial parts of *Acinos suaveolens* (Sibth. et Smith) G. Don Fil. (Lamiaceae). Pharm. Acta Helv. 63: 170-173.
- Kris-Etherton P, Harris W, Appel L (2002). Fish Consumption, Fish Oil, Omega-3 Fatty Acids, and Cardiovascular Disease. Circulation 106 (21): 2747-2757.
- Lauritzen I, Blondeau N, Heurteaux C, Widmann C, Romey G, Lazdunski M (2000). Polyunsaturated fatty acids are potent neuro-

- protectors. *EMBO J.* 19 (8): 1784–1793.
- Marin P, Grayer R, Veitch N, Kite, G, Harborne J (2001). Acacetin glycosides as taxonomic markers in *Calamintha* and *Micromeria*. *Phytochemistry* 58: 943-947.
- Misra M (2009). The key to medicinal plants research revolves around the detection, isolation, and characterization of antioxidants as therapeutic agents. *J. Med. Plants Res.* 3(10) Editorials.
- Nöthlings U, Murphy S, Wilkens L, Henderson B, Kolonel L (2007). Flavonols and Pancreatic Cancer Risk. *Am. J. Epidemiol.* 166 (8): 924–931.
- Pavlovic S, Kuznetsova G, Zivanovic P, Shevarda A, Jancic R, Vujcic S (1984). Content and composition of essential oil and some anatomical characteristics of plants of the species *Acinos suaveolens* (Sibth and SM) G. Don fil. *Arhiv za Farmaciju* 34: 65-71.
- Pavlovic S, Zivanovic P, Jancic R, Kuznetsova G, Vujcic S, Shevarda A (1984). Study of the species *Acinos majoranifolius* (Mill.) Silic (Lamiaceae) from Orjen Mountain, as a new source of essential oils. *Arhiv za Farmaciju* 34: 27-33.
- Popa DP, Pasechnik GS (1974). Higher terpenoids of some species of Labiatae. *Khim. Prir. Soedin.* 4: 529-30.
- Sergienko T, Kazarnovskii L, Litvinenko VIS (1967). Flavonoids from *Acinos thymoides*. *Farmatsiya* 16:34-8.
- Sergienko T, Kazarnovskii L, Litvinenko VIS (1966). Flavonoid biosides of *Acinos thymoides*. *Khim. Prir. Soedin.* 2: 166-72.
- Sergienko T, Litvinenko VI, Kazarnovskii LS (1968). Fortunallin from *Acinos thimoides*. *Khim. Prir. Soedin.* 4: 320.
- Skaltsa H, Lazaris D, Loukis A (1999). Composition of the essential oil of *Acinos alpinus* (L.) Moench. from Greece. *J. Essent. Oil Res.* 11: 35-37.
- Souleles C, Katsiotis S (1988). Study on the essential oil of *Acinos arvensis* (Lam.) Dandy. *Plantes Medic. Phytother.* 22: 180-3.
- Tomas-Barberan F, Husain S, Gil M (1987). The distribution of methylated flavones in the Lamiaceae. *Biochem. Syst. Ecol.* 16: 43-6.
- Triantaphyllou K, Blekas G, Boskou D (2001). Antioxidative properties of water extracts obtained from herbs of the species Lamiaceae. *Int. J. Food Sci. Nutr.* 52: 313-317.
- Tumen G (1991). The volatile constituents of *Acinos suaveolens* (Sibt. et Smith) G. Don fil. growing in Turkey. *J. Essent. Oil Res.* 3: 191-2.
- Velasco–Negueruela A, Perez–Alonso M J, Jimenez SM, Garcia F (1993). The volatile constituents of *Acinus alpinus* (L.) Moench ssp. *meridionalis* (Nyman) P. W. Ball growing in Spain. *Flavour Frag. J.* 8: 127-130.
- Venturella, P, Bellino A, Marino ML, Sorrentino M (1980) Aurapin, a new dihydroflavonol glycoside and other flavonoids from *Acinos alpinus*. *Heterocycles* 14: 1979-82.
- Wagner H, Aurnhammer G, Hoerhammer L, Farkas L (1969). Identification of atsinoside as the isosakuranetin 7-rutinoside, didymine. *Chem. Ber.* 102: 3605.