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Antioxidant and antimicrobial activities of *Gynura procumbens* (Merr.) leave: A review

Kezia Eggiova Ananda, Ika Rahayu and Kris Herawan Timotius

Abstract
The accentuated increase in the use of *Gynura procumbens* leave as edible leave, and herbal medicine to treat diseases makes it is necessary to evaluate information available on its antioxidant and antimicrobial activities. This review aims to compile a comprehensive report on total phenolics and flavonoids compounds in the various extract of *Gynura procumbens* leave; understand their antioxidant and antimicrobial activities; and its administration. Articles were searched via PubMed and Google scholar, and screened according to the criteria. The highest TPC is ethyl acetate extract, but the most TFC is ethanol extract. As concentrated extracts, ethyl acetate extracts have the highest antioxidant activity, followed by ethanol extract. Both inhibit the growth of Gram-positive and gram-negative bacteria, yeast, and fungi. As a diluted extract, the aqueous extract has lower antioxidant and antimicrobial activity than ethyl acetate and ethanol extracts. Commercial preparation of *Gynura procumbens* is available in the market. Herbal medicine delivery for *Gynura procumbens* leaves can be prepared as herbal drink, concentrated capsule/tablet, and topical medicine. The high TPC and TFC, antioxidant and antimicrobial activities are found mainly in concentrated ethyl acetate and ethanol extract that can be administrated as tablet/capsule and topical preparation. The aqueous extract should be considered as diluted preparation that good as a herbal drink or as capsule containing concentrated extract.

Keywords: Antioxidant, antimicrobial, flavonoid, *Gynura procumbens*, phenolic, sambungnyawa

1. Introduction
Gynura procumbens (GP), locally known as sambungnyawa, is used in traditional medicine to treat skin rashes, infections, rheumatism, inflammation, kidney disease, migraine, constipation, hypertension, diabetic mellitus and cancer [1-2]. GP-leave is safe for everyday consumption, either served as raw or cooked [3]. GP-leave contains high amounts of phenolic and flavonoids essential oils saponins, tannins, terpenoids sterol glycosides. It has astragalin, kaempferol-3-O-rutinoside, kaempferol, and rutin [4]. Therefore, GP-leave is obtained effectively as an antioxidant [5]. Antioxidants, including extract of GP-leave, are used as pharmaceutical agents to prevent the deposits of the oxidative process in the body [6]. Or free radicals primarily Reactive Oxygen Species (ROS) that cause damage in a variety of biomolecule including DNA, proteins and lipid. It may cause chronic diseases such as atherosclerosis, cancer, diabetic, hypertension and many more infection diseases [7].
Antimicrobial substances are still needed to eradicate pathogenic bacteria due to the increase of their resistance to antimicrobials. Polyphenol compounds are considered responsible for the critical role of antimicrobials against pathogenic microorganisms [8]. GP-leave is known for its richness in phenolic and flavonoid. Therefore, it is necessary to evaluate the potential of GP-leave extracts as antioxidant and antimicrobial agents [9].
The objectives of this review were to collect information on total phenolics and flavonoids compounds in various extract of GP-leave; to get knowledge on their antioxidant and antimicrobial activities; and the administration of GP-leave extracts.

2. Method
Articles review was used to be the method of this study. Articles were searched via PubMed and Google scholar, it was obtained about 38 articles from Pubmed and 293 from Google Scholar with keyword "*Gynura procumbens*" then the articles were filtered according to the needs of topics that will be reviewed. Some articles were eliminated due to its unrelated to the topics. As result, There were 13 articles from PubMed and 19 articles from Google Scholar with total of 32 articles that meet the criteria of this study.

3. Total phenolics and total flavonoids compounds of Gynura procumbens leave
Data are available from previous literatures on the total phenolic compounds (TPC) and total flavonoids compounds (TFC) of the GP-leave extracts, but it is not easy to compare and to

combine the data due to the different units used by each literature. Most of the data need to be recalculated and to reinterpreted. As seen in Table 1 and 2, the data of TPC and TFC are varied and recalculated into the same unit, so that they are easier to be interpreted than the original data.

Phenolic compounds are essential compounds which function as potent antioxidant to prevent disease [10]. Phenolic compounds provide the necessary components as anantioxidants [11]. Extracts and fractions of GP-leave show variations of TPC and TFC (Table 1 and 2). The ethyl acetate extract or fraction is the best extract in TPC. The ethanol extract is the best for TFC.

4. Antioxidant activity of the leave of *Gynura procumbens*

The GP-leave extract is a good source for an antioxidant agent. Antioxidants from GP-leave can be extracted with various solvents, either water, polar and semi-polar [2]. Antioxidant activities of the aqueous extract of the GP-leave either by infusate or cognation are weak compared with the concentrated organic solvent. The use of deionized water results in the diluted extract, but it can be consumed as herbal drink or tea. If a glass of herbal drink consumed, the end amount of the consumed bioactive compounds is comparable with the concentrated extracts [2].

Polar and semi-polar solvents produce concentrated extracts, especially ethyl acetate and ethanol. Antioxidant activities of the semi-polar extract of GP leave are detected in Methanol and various variation of Ethanol extracts. Fractionation of the Methanol or Ethanol crude extracts showed that ethyl acetate fraction has the highest antioxidant potencythat measured *in vitro* systems. The substantial antioxidant activity depends on the TPC. *In vivo* study with an animal model, shows that using ethanol and methanol extract of GP-leave can inhibit the levels of peroxidation lipid [12]. But the best antioxidant activity is found in the ethyl acetate extract or fraction that contains a high amount of phenolic compounds [13].

Phenolic compounds are considered an important antioxidant compounds, such as caffeic, chlorogenic, p-coumaric, ferulic, gallic, p-hydroxybenzoic, protocatechuic,sinapic, syringic, and vanillic acid. Chlorogenic, ferulic and sinapic acid have the highest antioxidant levels of other components [7]. And can be extracted from GP-leave. Many of the phenolic compounds that have the ability to increase antioxidant activity can be fully absorbed during the gastro-intestinal digestive processes [1].

GP-leave extracts also source of flavonoid that contain such asrutin, myricetin, quercetin, apigenin and kaempferol are found. Beside phenolic compounds, these flavonoids are considered to be the most important antioxidant compounds [7]. Astragalin and kaempferol-3- O-rutinoside are considered as a good antioxidant [13].

Other antioxidant compounds lipophilic compounds are carotenoids including carotene, lutein, and zeaxanthin, that synergistically with other antioxidants scavenge reactive oxygen species, singlet molecular oxygen, and peroxyl radicals[2].Several polysaccharides are extracted from GP-leave and identified as an antioxidant, such as GPP-20, GPP-40, GPP-60 and GPP-80 [14].

The antioxidant studies of GP-leave were carried out mostly *in vitro* assays. The most popular antioxidant assay is the DPPH assay [15-16]. Other assays, such asferric reducing assay, trolox equivalent, β-carotene-linoleic acid, and xanthine oxidase inhibitory assays are not used in all reports. As listed in Table 1, GP-leave is found to display substantial antioxidant activity, especially the ethyl acetate extract.

The antioxidative effect of GP in animal model is revealed when inhibiting lipid peroxidation as a common result of oxidative stress. Reportson *in vivo* with the animal model is limited. The effect of methanol extract of GP-leave that administrated prior to oxidative stress induction is able to reverse the elevation of plasma lipid peroxidation in tested animals [17].

5. Antimicrobial activity of the leave of *Gynura procumbens*

Antimicrobial activities of the GP-leave are reported either as an aqueous extract, polar (Methanol and Ethanol), semi-polar (Dichlormethane and Ethyl Acetate) and non-polar extract hexane and petroleum ether (HX and PE). The most powerful extracts are ethyl acetate and ethanol extracts. Several Gram-positive and gram-negative bacteria, yeast and fungi are inhibited by the GP-leave extracts. (Table 3). Limited reports give evidence on the antiviral and anti-parasite of the GP-extract.

With the MIC and disc inhibition methods, antimicrobial activities of the aqueous extract of the GP leaveare not detected. There is no inhibition zone in distilled water extract against *Bacillus subtilis, Escherichia coli* and *Pseudomonas aeruginosa* [18].

Antimicrobial activities of the polar extract (Methanol and Ethanol) of the GP-leave show antimicrobial activities. Methanol extract of GP-leave has antimicrobial activity several Gram-positive, Gram-negative as well as *Candida albicans* [19]. Among Gram-positive bacteria that are inhibited are *Bacillus subtilis, Staphylococcus aureus* and *Streptococcus mutans*. Among Gram-negative bacteria are *Pseudomonas aeruginosa* and *Klebsiella pneumonia* [18]. Their MIC and disc inhibition zone are listed in Table 3. It is reported that there is no inhibition or weak activity against methicillin-resistant *S. aureus* (MRSA) [5]. Ethanolextract of GP-leave show inhibition zone against *Bacillus subtilis, Candida albicans* [18]. *Pseudomonas aeruginosa, Escherichia coli, Streptococcus mutant* [20].

GP ethanol extracts also show evidence of antivirus and malaria parasite that needs to be validated. GP-leave is traditionally used to treat virus infections such as herpes simplex virus. The antivirus activity of ethanolic extract of aerial plant parts has been established to show virucidal and anti-replicative activity against herpes simplex virus HSV-1 and HSV-2. It is confirmed through a clinical trial on patients with persistent herpes labialis where treatment with GP-gels [21]. Beside evidence in antiviral activity, GP extract has reported the ability to exhibit chemo-suppression effects toward malarial parasite strains of *Plasmodium falciparum*and *Plasmodium berghei* [22-23].

Antimicrobial activities of the non-polar extract (Dichlormethane and Ethyl Acetate) of the GP leave also show antibacterial activity. Dichlormethane and Ethyl Acetate extracts of GP-leaves can inhibit *Bacillus cereusand Candida albicans.*Hexane extract and petroleum ether extracts are proved for no inhibition against *Bacillus subtilis* and *Candida albicans* [9, 18].

Their flavonoids and stigmasterol probably determine the antimicrobial activities of GP extract [24-25]. Most of the study of antimicrobial activity of GP are carried out by using MIC and inhibition zone.

There is a synergistic effect of antioxidant and antimicrobial potential. In the case of the wound healing process, antioxidants play a significant role. Antioxidants expressively improve wound healing by protecting tissues from oxidative

damage. With its antioxidant activity, GP leaves extract that rich in flavonoid decrease the lipid peroxidation and promote the strength of collagen fibre. Lipid peroxidation is a common result of oxidative stress, the antioxidative effect of GP inhibits lipid peroxidation. In addition, the administration of Methanol extract before oxidative stress induction is able to reverse the elevation of plasma lipid peroxidation. GP-leave is also known as an excellent anti-inflammatory activity. The antimicrobial activity should be combined with the antioxidant activity. And in this case, GP-extract containing topical cream is potential in accelerating the rate of wound healing.

6. GP-herbal administration

Leave of GP is the most frequent part that used as herbal material. Fresh leave or dry leave powder can be extracted with water and consumed as herbal drink or tea. Usually, the GP-leave need to be washed with water and then dried in dry air until rough powdered.

GP-leave can be extracted with 95% ethanol. Other solvents can also be used to extract GP-leave, such as petroleum ether, methanol, the crude extracts are then fractionated with chloroform, ethyl acetate, n-butanol, and aqueous fraction, in order to get a good quality of preparation.

In order to improve the quality of GP-herbal medicine, fungal chitosan (FCS) encapsulated GP powder mediated silver nanoparticles (GP-AgNPs) can be synthesized. FCS-GP-AgNPs can enhance its antioxidant and antibacterial activity. FCS-GP-AgNPs shows inhibitory activity against *Bacillus cereus*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Escherichia coli*, and *Salmonella enterica*. FCS-GP-AgNPsis biocompatible in terms of less cytotoxicity and promising in antibacterial treatment [26].

7. Conclusions and recommendations

7.1 Conclusions

- Concentrated extracts of GP-leave that have high TPC and TFC can be produced by the use of polar and semi-polar solvents. The aqueous extract is also valuable even it is a diluted extract.
- Antioxidant activities are also found the best in ethyl acetate extract. The aqueous extract is the weakest in antioxidant activity. GP-leave is a potent source of natural antioxidants.
- Antimicrobial activities are detected mainly polar and semi-polar extracts. They show their ability to inhibit the various type of microbiota, including Gram-positive and negative bacteria, and yeast and fungi.
- GP herbal drug administration can be given as herbal drink like tea, and as a capsule or other preparation using concentrated extracts.

7.2 Recommendations

- Phytochemical components of aqueous extract need to be investigated. Not much information was available for the bioactive compounds in aqueous extract (infusate and cognition).
- TPC, TFC and the level of antioxidant activity can be used as a quality standard of the preparation.
- Antimicrobial activities of the non-polar extract, especially ethyl acetate, can becomethe basis of new antimicrobial agents. Modern technicscan enhance the antimicrobial potential, such by applying glycosylation, nanotechnology and encapsulated preparation.
- Clinical trials are necessary for the GP-herbal drink as well as the concentrated extracts and the modern preparation of glycosylation, nanotechnology and encapsulation.

Table 1: TPC, TFC and Antioxidant activity of *Gynura procumbens* leave

Extract	TPC		TFC	IC50 DPPH		Reference
	Original	mg GAE/g de	Original	Original	µg/mL	
Aqueous	4.4 ± 0.79 % GAE (w/w)	44.00 ± 7.90		Weak	Weak	[11]
	39.28±0.18 ug/mL		2.53 ± 0.00 QE ug/mL			[27]
	40.00 ± 0.59 mg GAE/g dw	40.00 ± 0.59	64.59 ± 0.68 mg QE/g dw	0.21 ± 0.02 mg/ML	210.00 ± 2.00	[16]
	1.44 ± 0.03 mg GAE/100 g dw	14.40 ± 0.30		124.37 ± 6.28 µg/mL	124.37 ± 6.28	[1]
Methanol	9.4 ± 0.08 % GAE (w/w)	94.00 ± 0.80		Graphic	270	[11]
				>25 - < 50 µg/mL	25 - 50	[5]
	54.10 mg GAE/g dw	54.10 ± 0.00	13.46 ± 0.00 mg QE/g dw			[28]
	>70.94 - < 183.764			37%: 25 ug/ml 58% 50 ug/ml	40.42 ± 0.00	[5]
	75.70 ± 2.69 mg GAE/g dw	75.70 ± 2.69	164.31 ± 0.67 mg QE/g dw	0.15 ± 0.02 mg/mL	150.00 ± 2.00	[16]
Ethanol	16.08 ± 0.38 mg GAE/g dw	16.88 ± 0.38	10.33 ± 0.88 mg CE/g dw	0.47 ± 0.02 mg/mL	470.00 ± 2.00	[7]
	0.62 mg GAE/100 mg de	62.00 ± 0.00		63.73 ± 2.90 µg/mL	63.73 ± 2.90	[1]
	70.70 ± 2.58 mg GAE/g dw	70.70 ± 2.58	219.35 ± 1.17 mg QE/g dw	0.19 ± 0.05 mg/mL	190.00 ± 5.00	[16]
	16.08 ± 0.38 mg GAE/g dw	16.08 ± 0.38	10.33 ± 0.00 mg CE/g dw	473.70 ± 0.01 µg/mL	473.70 ± 0.01	[29]
95% Ethanol (soxlet)	35.11± 0.77 ug/mL	35.11 ± 0.77	23.44 ± 0.00 QE µg/mL			[27]
95% Ethanol maceration	50.58±0.32 µg/mL	50.58 ± 0.32	24.52 ± 0.00 QE µg/mL			[27]

95% Ethanol ultrasonication	49.52±0.31 µg/mL	49.52 ± 031	23.22 ± 0.00 QE µg/mL			[27]
Ethanol 80%	2.15 ± 0.15 GAE mg/g dw	2.15 ± 0.15	1.25 ± 0.13 Rutin mg/g dw			[30]
Ethanol 75%	54.58 µg/mL	54.58 ± 0.00	26.26 ± 0.00 QE µg/mL			[27]
Ethanol 70%	3.15 ± 0.19 mg GAE/100 mg de	31.50 ± 1.90		131.92 ± 8.99 µg/mL	131.92 ± 8.99	[1]
Ethanol 50%	3.81 ± 0.04 mg GAE/100 mg dw	38.10 ± 0.40		66.28 ± 3.95 µg/mL	66.28 ± 3.95	[1]
	76.14±0.61 µg/mL	76.14 ± 0.61	16.79 ± 0.00 QE µg/mL			[27]
Ethanol 20%	1.58 ± 0.32 mg GAE/ 100 mg dw	15.80 ± 3.20		317.41 ± 8.32 µg/mL	317.41 ± 8.32	[1]
Butanol	>70.94 - < 183.764 mg GAE/100 mg dw			45% 200 ug/mL 58% 400 ug/mL	276.96 ± 0.00	[5]
	5.92 ± 1.61 mg GAE/g dw	5.92 ± 1.61	4.92 ± 0.29 mg CE/g dw	0.71 ± 0.03	710.00 ± 3.00	[7]
	8.3 ± 0.87 % GAE (w/w)	8.30 ± 8.70		Graphic	110.00	[11]
Chloroform	0.77 ± 0.20 mg GAE/g dw	0.77 ± 0.20	0.08 ± 0.00 mg CE/g dw	3.33 ± 0.06 mg/mL	3330.00 ± 6.00	[7]
	70.94 mg GAE/g dw	70.94 ± 0.00				[5]
	70.94 mg GAE/g dw	70.94 ± 0.00		40% 50 ug/mL 58% 100 ug/mL	77.76 ± 0.00	[5]
	6.25 ± 0.5 % GAE (w/w)	62.50 ± 5.00		Weak	Weak	[11]
Etyl Acetate	24.36 ± 1.11 mg GAE/g dw	24.36 ± 1.11	17.33 ±1.39 mg CE/g dw	0.22 ± 0.01 mg/mL	220.00 ± 1.00	[7]
	183.764 mg GAe/g dw	183.76 ± 0.00				[5]
	23.4±0.26 % GAE (w/w)	234.00 ± 2.60		Graphic	5.9	[11]
	183.764 mg GAE/g dw	183.76 ± 0.00		50%: 50 ug/mL	50.00 ± 0.00	[5]
Ethyl Acetate fraction	24.36 ± 1.11 mg GAE/g dw	24.36 ± 1.10	17.33 ± 1.39 mg CE/g dw	220.58 ± 0.01 µg/mL	220.58 ± 0.01	[29]

Table 2: Composition of phenolic acids in different extract od GP-leave

Compound	MeOH µg/gDW	EtOH* µg/gDW	BuOH** µg/gDW	CHL** µg/gDW	EtAc* µg/gDW
Hydrobenzoic acids					
Gallic acid	nd	88.00±2.27	53.45 ±0.98	39.20 ±1.35	501.91 ± 1.28
Protocatechuic acid	nd	83.71±3.78	45.79 ±2.15	nd	209.24± 3.81
p-Hydroxybenzoic acid	nd	292.47±2.51	20.11 ±3.10	nd	132.40±1.10
Vanillic acid	nd	76.77 ± 4.23	nd	nd	77.15 ± 0.70
Syringic acid	nd	120.55 ± 1.68	86.82± 2.64	39.20 ±1.35	169.20 ± 1.40
Hydroxycinnamic acids					
Chlorogenic acid	nd	nd	nd	nd	nd
Caffeic acid	nd	111.72 ± 0.68	109.72 ±0.46	123.02±0.55	136.34 ±0.02
p-Coumaric acid	nd	826.15 ± 4.22	844.13 ±4.09	nd	2701.75 ± 8.64
Ferrulic acid	nd	99.08± 0.36	106.79 ±0.57	113.16 ±0.72	280.95 ± 0.50
Sinapic acid	nd	387.99 ± 3.65	228.38 ±3.32	113.31±1.00	188.85 ± 2.56
Flavonoids**					
Rutin	nd	42.56 ±0.36	53.26 ±3.65	36.88 ±0.69	84.38±0.24
Myricetin	nd	251.10 ±3.67	nd	nd	261.18 ±1.65
Quercetin	nd	135.87 ±0.40	129.78 ±1.31	122.79 ±0.59	193.22 ±1.47
Apigenin	nd	49.92 ±0.73	nd	nd	85.92 ±1.45
Kaempferol	nd	464.53 ±1.81	232.34 ±1.80	240.27 ±0.61	192.60 ±0.67
Kaempferol-3-O- rutinoside***	0.74 ±0.03%			4.52 ±0.13%	70.76 ±0.20%
Astragalin***	2.92 ± 0.05%			0.33 ±0.03%	12.75 ±2.04%

* [29]

** [7]

*** [11]

Table 3: Antimicrobial activity of the leave of *Gynura procumbens*

Extract	microbiota	MIC (mg/mL)	Inhibition zone (mm)	Reference
Gram positive bacteria				
Water	*Steptococcus aureus*		ni	[18]
	Bacillus subtilis		ni	[18]
Methanol	*Vibrio alginolyticus*	0.7 (700 ppm)		[31]
	Streptococcus aureus	100	8.0 ± 0.03	[5]

	S. aureus MRSA	nd	nd	[5]
	Streptococcus aureus			[8]
Methanol→Hexane	*Bacillus subtilis*	25		[32]
Methanol→Hexane	*Streptococcus aureus*	125 (12.5 %)		[32]
Ethanol	*Streptococcus aureus*		14	[18]
	Bacillus subtilis		15	[18]
	Streptococcus mutans		2.5 %: 7,80 10%: 8,45 ± 0,15	[20]
Dichlormethane	*Bacillus subtilis*		7±0.12	[9]
	Bascillus cereus		7 ± 0.10	[9]
Ethyl Acetate	*Streptococcus aureus*		20	[18]
	Bacillus subtilis		20	[18]
	Bacillus subtilis		7 ± 0.19	[9]
	Bacillus cereus		7 ± 0.09	[9]
Petroleum Ether	*Streptococcus aureus*		-	[18]
	Bacillus subtilis		-	[18]
Acidic hydrolysis	*Streptococcus aureus*	37.5	19 (Con.150 mg/mL)	[8]
Gram negative bacteria				
Water	*E.coli*		-	[18]
	P.aeroginosa		-	[18]
Ethanol	*Escherichia coli*		14	[18]
	P. aeruginosa		13	[18]
Methanol→Hexane	*P. aeruginosa*	50		[32]
	Klebsiella pneumonia	50		[32]
Dichlormethane	*P. aeruginosa*		6 ± 0.16	[9]
	Salmonella typhi		7 ± 0.10	[9]
Ethyl Acetate	*P. aeruginosa*		7 ± 0.17	[9]
	P. aeruginosa		20	[18]
	E.coli		20	[18]
	Salmonella typhi		7 ± 0.17	[9]
Petroleum Ether	*E.coli*		-	[18]
	P. aeroginosa		-	[18]
Yeast and fungi				
Water	*Candida albicans*		-	[18]
Methanol	*Aspergillus niger*		-	[9]
	Sacharomycescerevacae		-	[9]
	Candida albicans	-	-	[8]
Methanol-SPE	*Candida albicans*		6.0	[19]
Methanol-SPE	*Trichophyton rubrum*		9.0	[19]
Ethanol	*Candida albicans*		12	
Dichlormethane	*Aspergillus niger*		7 ± 0.18	[9]
	Candida albicans		6 ± 0.1	[9]
	Sacharomycescerevacae		6± 0.15	[9]
Ethyl Acetate	*Aspergillus niger*		7 ± 0.19	[9]
	Candida albicans		7 ± 0.16	[9]
	Sacharomycescerevacae		6 ± 0.18	[9]
	Candida albicans		20	[18]
n- hexane	*Aspergillus niger*		-	[9]
	Sacharomycescerevacae		-	[9]
Petroleum Ether	*Candida albicans*		-	[18]
Acidic hydrolysis	*Candida albicans*	75	11 Conc.150 mg/mL	[8]

As for *G. procumbens*, only the methanol extract was effective against the pathogens. It was found Fig. 2 (continued) [5].that 100 mg/mL methanol extract of *G. procumbens* inhibited S. aureus by 42% (Fig. 2Biv), 6-times greater than that against MRSA, the resistant strain (by 7%; Fig. 2 Biv0). Interestingly [5].

Abbreviation

GP : *Gynura procumbens*
DNA : Deoxyribonucleic Acid
TFC : Total FlavonoidsCompounds
TPC : Total Phenolic Compounds
GPP : Polysaccharides from *Gynura procumbens*
DPPH : 2,2-Diphenyl-1-picrylhydrazyl
MRSA : Methicillin-Resistant *Staphylococcus aureus*
MIC : Minimum Inhibitory Concentration
FCS-GP-AgNPs : Fungal chitosan (FCS) encapsulated *Gynura procumbens* (GP) mediated silver nanoparticles (GP-AgNPs)
mg GAE/g de : milligrams of Gallic Acid Equivalents, per gram dry extract
mg CE/g dw : milligrams of Catechin Equivalents, per gram dry weight
mg QE/g dw : milligrams of Quercetin Equivalent, per gram dry weight
ppm : parts per million
SPE : Solid Phase Extraction

9. References

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