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Green synthesis of silver nanoparticles using extract of common wormwood and hop fins, characterization and antimicrobial activity

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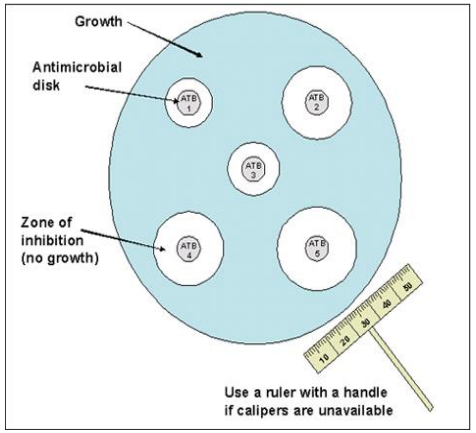
Green synthesis provides advancement over chemical and physical methods, as it is cost effective, environment friendly, and does not require high pressure, temperature and toxic chemicals.

The aim of this study was designed with an objective to synthesize silver nanoparticles (AgNPs) using aqueous extracts of common wormwood and hop fins.

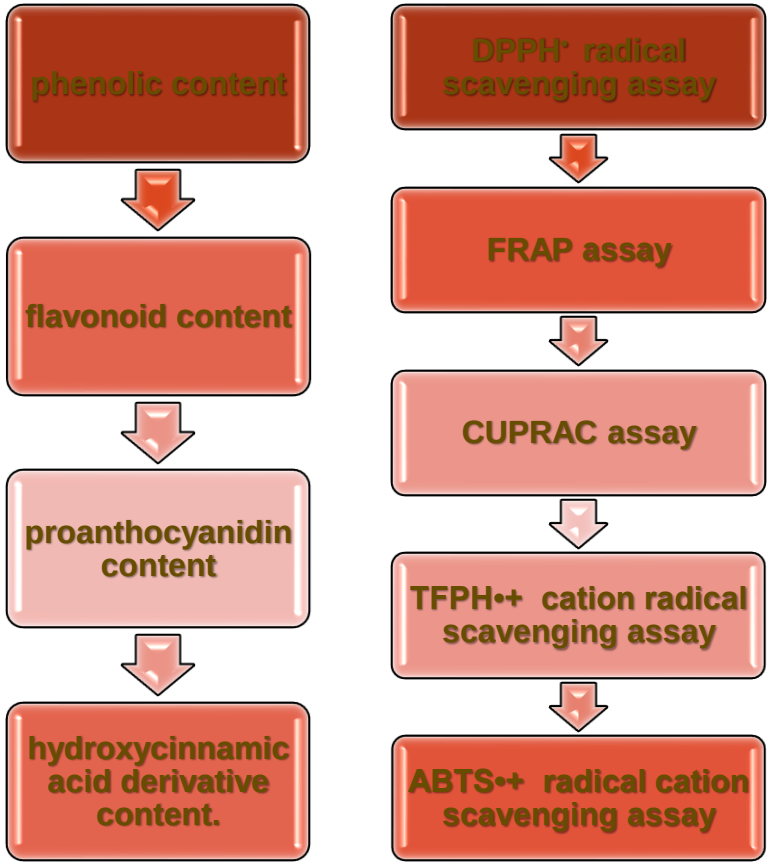
Structural analysis methods: SEM – Quanta 200 FEG

Kirby-Bauer disk diffusion method

Staphylococcus aureus, Staphylococcus haemolyticus, Enterococcus durans, Bacillus pseudomycoides, Salmonella enterica , Aeromonas hydrophila, Acinetobacter baumannii, Acinetobacter johnsonii, Enterobacter cloacea, Cronobacter sakazakii, Klebsiella pneumonia, Escherichia coli, and Pseudomonas aeruginosa.

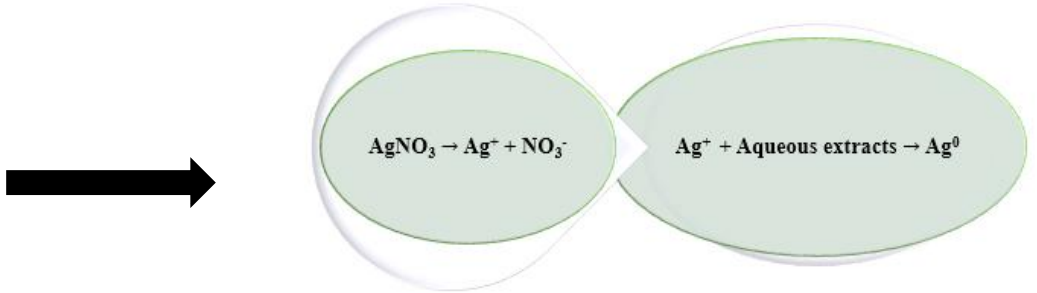


Quantitative composition
antioxidant activity *in virto*



Results

Aqueous extracts of *A. absinthium* and *H. lupulus* have been used for the synthesis of AgNPs. The biomolecules present in the extracts are responsible for the reduction of Ag^+ ions to Ag^0 in a single step:



Compound name	A. absinthium	H. lupulus
The total amount of proanthocyanidins, mg EE/g DW	0.99 ± 0.63	**6.31 ± 0.26**
The total amount of hydroxycinnamic acid derivatives, mg CAE/g DW	2.34 ± 0.01	**3.94 ± 0.13**
The total amount of phenolic compounds, mg GAE/g DW	10.88 ± 0.62	10.79 ± 1.44
The total amount of flavonoids, mg RE/g DW	**4.42 ± 0.28**	2.28 ± 0.09
	A. absinthium/Ag	H. lupulus/Ag
The total amount of proanthocyanidins, mg EE/g DW	0.86 ± 0.28	3.46 ± 0.17
The total amount of hydroxycinnamic acid derivatives, mg CAE/g DW	2.05 ± 0.20	3.64 ± 0.09
The total amount of phenolic compounds, mg GAE/g DW	8.98 ± 0.24	6.76 ± 0.32
The total amount of flavonoids, mg RE/g DW	3.94 ± 0.31	1.52 ± 0.08

Extract name	ABTS, TE, mmol/g DW	DPPH, TE, mmol/g DW	CUPRAC, TE, mmol/g DW	TFPH, TE, mmol/g DW	FRAP, TE, mmol/g DW
A. absinthium	0.49 ± 0.03	0.13 ± 0.00	0.10 ± 0.00	0.015 ± 0.005	0.26 ± 0.01
H. lupulus	0.51 ± 0.05	0.14 ± 0.00	0.18 ± 0.00	0.034 ± 0.001	0.36 ± 0.04
A. absinthium/AgNPs	**0.55 ± 0.05**	**0.14 ± 0.00**	0.10 ± 0.00	0.057 ± 0.005	0.26 ± 0.01
H. lupulus/ AgNPs	**0.86 ± 0.05**	**0.11 ± 0.00**	0.073 ± 0.00 2	0.073 ± 0.002	0.25 ± 0.02

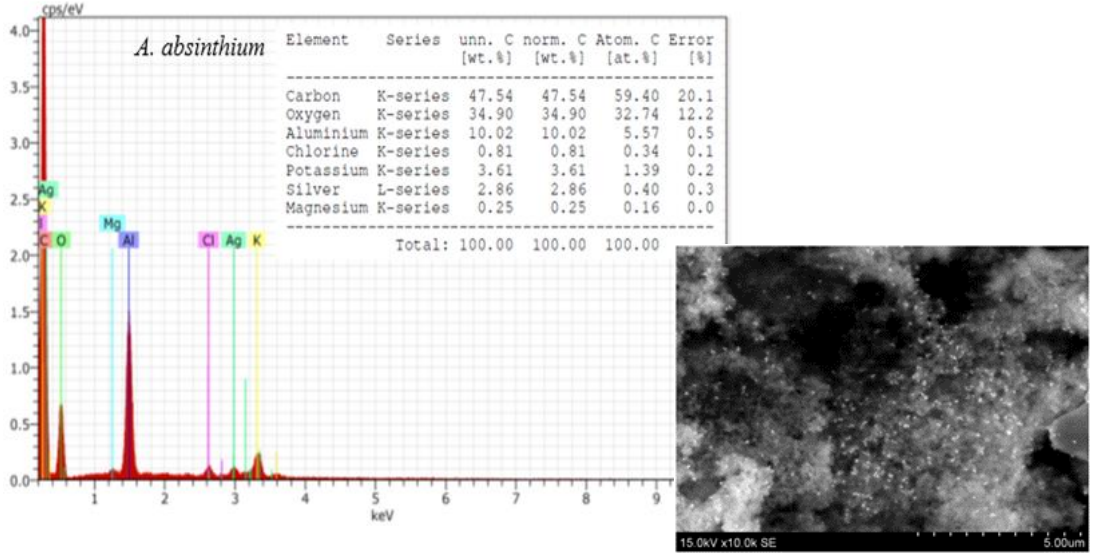
Extracts/AgNPs showed significant antioxidant potential activity in all cases. *A. absinthium*/AgNPs and *H. lupulus*/AgNPs displayed activities against DPPH (0.14 ± 0.00 and 0.11 ± 0.00 mmol/g), ABTS (0.55 ± 0.05 and 0.86 ± 0.05 mmol/g), respectively.

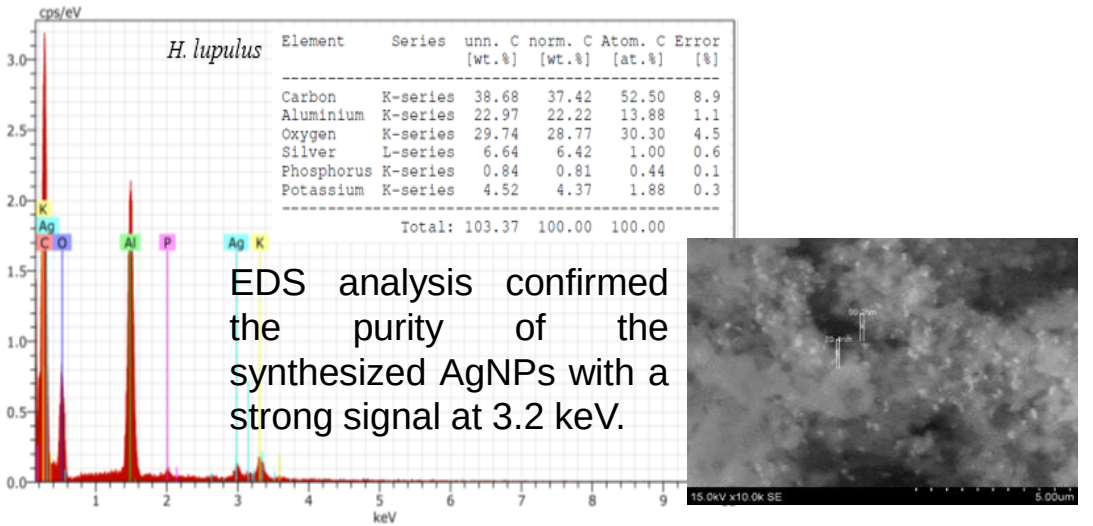
Results

Pathogenic and opportunistic bacteria strains	Samples			
	A. absinthium		H. lupulus	
	Pure	AgNPs	Pure	AgNPs
S.aureus	6.3±0.1	13.3±0.6	20.3±0.6	25.6±0.3
S.haemolyticus	0	13.2±0.4	14.2±0.4	17.2±0.5
P.aeruginosa	0	15.6±0.5	0	15.6±0.4
E.durans	4.3±0.2	13.6±0.5	13.4±0.4	18.1±0.7
S.enterica	0	12.2±0.6	0	14.3±0.4
A.hydrophila	0	11.3±0.8	0	9.1±0.2
A.baumanii	0	11.5±0.8	6±0.8	18.1±0.2
A.johnsonii	8.4±0.7	17.6±0.7	10±0.3	19.2±0.3
E.cloaceae	3.47±0.5	9.0±0.1	8±0.4	17.2±0.1
C.sakazakii	6.7±0.1	19.3±0.7	7±0.4	21.3±0.6
K. pneumonia	0	12.1±0.0	0	17.3±0.5
E. coli	3.0±0.7	13.3±0.4	7±0.8	18.5±0.3

Inhibition zones, mm

A. absinthium/AgNPs and *H. lupulus/AgNPs* exhibited higher antibacterial activity against all tested bacterial strains compared to their respective pure extracts. It is concluded that AgNPs synthesized in extracts have a broad range of biological applications, and it can be used as an eco-friendly material without having negative effects in the environment.





EDS analysis confirmed the purity of the synthesized AgNPs with a strong signal at 3.2 keV.

Conclusions

- The antioxidant activity of the obtained extracts was very similar;
- Common wormwood /AgNPs and hop fins/AgNPs strongly inhibit the viability of gram-positive and gram-negative bacteria strains;
- The inhibition zone diameter increased by 0 to ~17 mm in both cases comparing common wormwood and hop fins and extract with AgNPs.