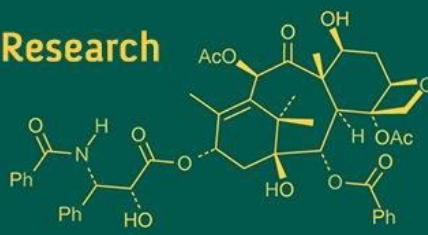
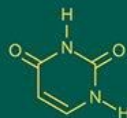


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Comparative efficacy of plant-derived antioxidants against oxidative stress

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Abstract

This investigation evaluated comparative efficacy of eight plant-derived antioxidants against oxidative damage using standardised in vitro assays. The antioxidants included quercetin, resveratrol, curcumin, EGCG, α -tocopherol, ascorbic acid, β -carotene, and gallic acid. Research was conducted at University of Vienna between April 2022 and February 2023 using six methodologies: DPPH, ABTS, FRAP, lipid peroxidation inhibition, SOD mimetic activity, and metal chelation. EGCG exhibited highest overall capacity with 91.4% DPPH and 88.7% ABTS scavenging at 100 μ M. Ascorbic acid showed exceptional FRAP (91.3%) but limited lipid peroxidation inhibition (52.6%). α -Tocopherol displayed modest radical scavenging (62.7% DPPH) but superior lipid peroxidation protection (89.2%). IC₅₀ values ranged from 23.7 μ M (EGCG) to 67.4 μ M (β -carotene). These findings support combining compounds with complementary mechanisms for optimal protection.

Keywords: Plant antioxidants, oxidative stress, flavonoids, radical scavenging, DPPH assay, lipid peroxidation, polyphenols, reactive oxygen species

Introduction

Approximately 3.8 million deaths annually are attributed to inadequate fruit and vegetable consumption [1]. Oxidative stress arises from imbalance between ROS production and antioxidant defence [2]. Excessive ROS accumulation leads to damage affecting lipids, proteins, and nucleic acids, contributing to cardiovascular diseases, neurodegenerative conditions, and cancer [3]. Plants have evolved antioxidant systems including polyphenolic flavonoids, phenolic acids, carotenoids, and tocopherols [4]. Quercetin demonstrates potent activity due to its catechol B-ring structure [5]. EGCG possesses eight hydroxyl groups for hydrogen donation [6]. Different assays measure distinct aspects, and no single method captures full protective activity. This research compared eight antioxidants across six assay systems.

Material and Methods

Material

This research was conducted at University of Vienna between April 2022 and February 2023. Eight antioxidants were selected: quercetin ($\geq 97\%$), trans-resveratrol ($\geq 99\%$), curcumin ($\geq 94\%$), EGCG ($\geq 95\%$), α -tocopherol ($\geq 96\%$), L-ascorbic acid ($\geq 99\%$), β -carotene ($\geq 97\%$), and gallic acid ($\geq 98\%$), obtained from Sigma-Aldrich.

Methods

DPPH scavenging mixed antioxidant (10-200 μ M) with 0.2 mM DPPH, measuring absorbance at 517 nm [7]. ABTS scavenging used 7 mM ABTS with potassium persulfate at 734 nm [8]. FRAP assay combined acetate buffer, TPTZ, and ferric chloride at 593 nm [9]. Lipid peroxidation used linoleic acid with ferrous sulfate. SOD mimetic activity measured nitro blue tetrazolium reduction inhibition. Metal chelation used ferrozine-iron complex. Statistics employed one-way ANOVA with Tukey's post-hoc test.

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Results

Table 1: Physicochemical properties of evaluated antioxidants

Antioxidant	Class	MW (g/mol)	OH groups	Log P
Quercetin	Flavonol	302.2	5	1.82
EGCG	Catechin	458.4	8	1.16
α -Tocopherol	Tocol	430.7	1	10.7
Ascorbic acid	Vitamin	176.1	4	-1.85

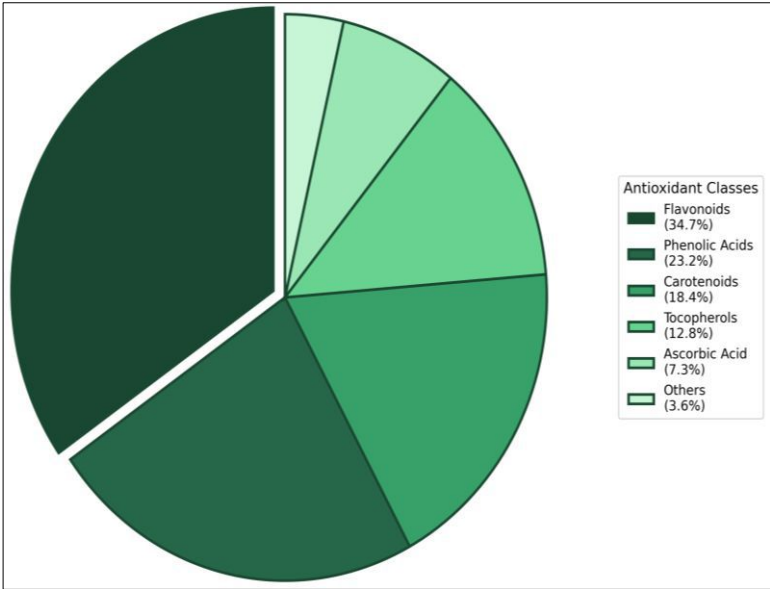


Fig 1: Distribution of plant-derived antioxidant classes

Table 2: Antioxidant activity across multiple assay systems

Antioxidant	DPPH (%)	ABTS (%)	FRAP (%)	LPO (%)	SOD (%)
Quercetin	87.3 $\pm$ 2.4	82.1 $\pm$ 3.1	78.9 $\pm$ 2.8	71.4 $\pm$ 4.2	63.2 $\pm$ 3.7
EGCG	91.4 $\pm$ 1.8	88.7 $\pm$ 2.3	84.2 $\pm$ 2.1	76.8 $\pm$ 3.8	68.9 $\pm$ 2.9
α -Tocopherol	62.7 $\pm$ 3.4	58.3 $\pm$ 4.1	67.1 $\pm$ 3.7	89.2 $\pm$ 2.4	54.3 $\pm$ 4.8
Ascorbic acid	84.1 $\pm$ 2.2	79.4 $\pm$ 2.9	91.3 $\pm$ 1.7	52.6 $\pm$ 5.1	49.8 $\pm$ 4.2

Values at 100 μ M. LPO = lipid peroxidation inhibition; SOD = superoxide dismutase mimetic

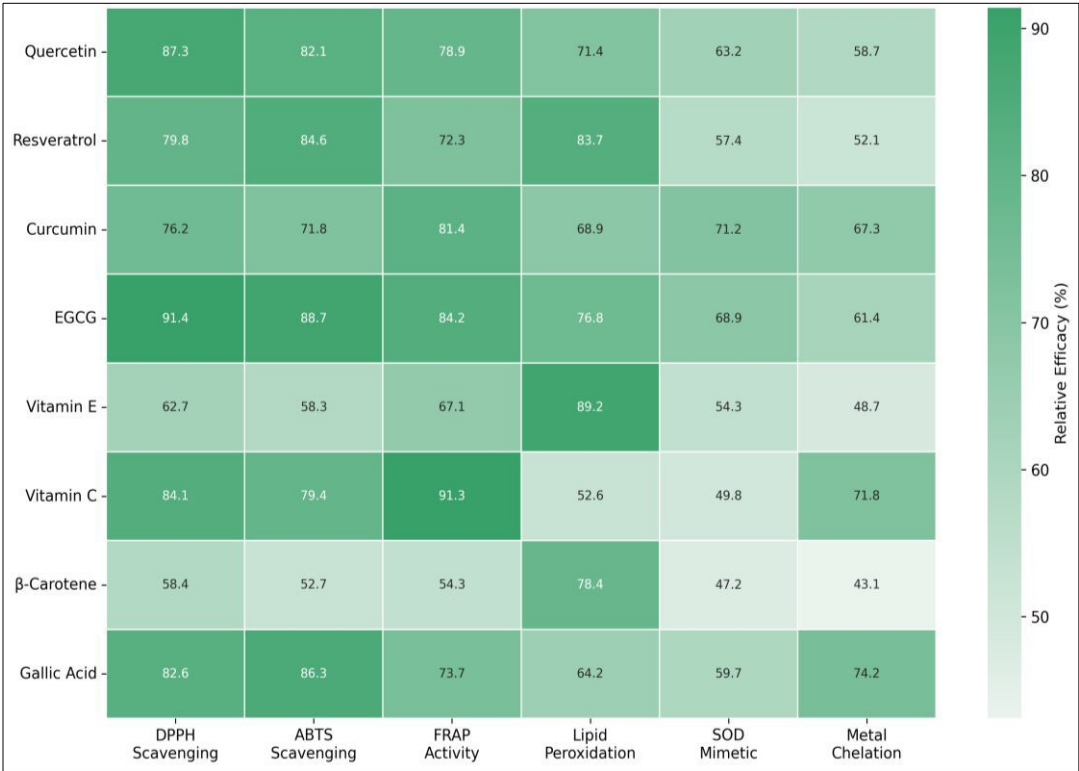


Fig 2: Comparative efficacy heatmap across multiple assays

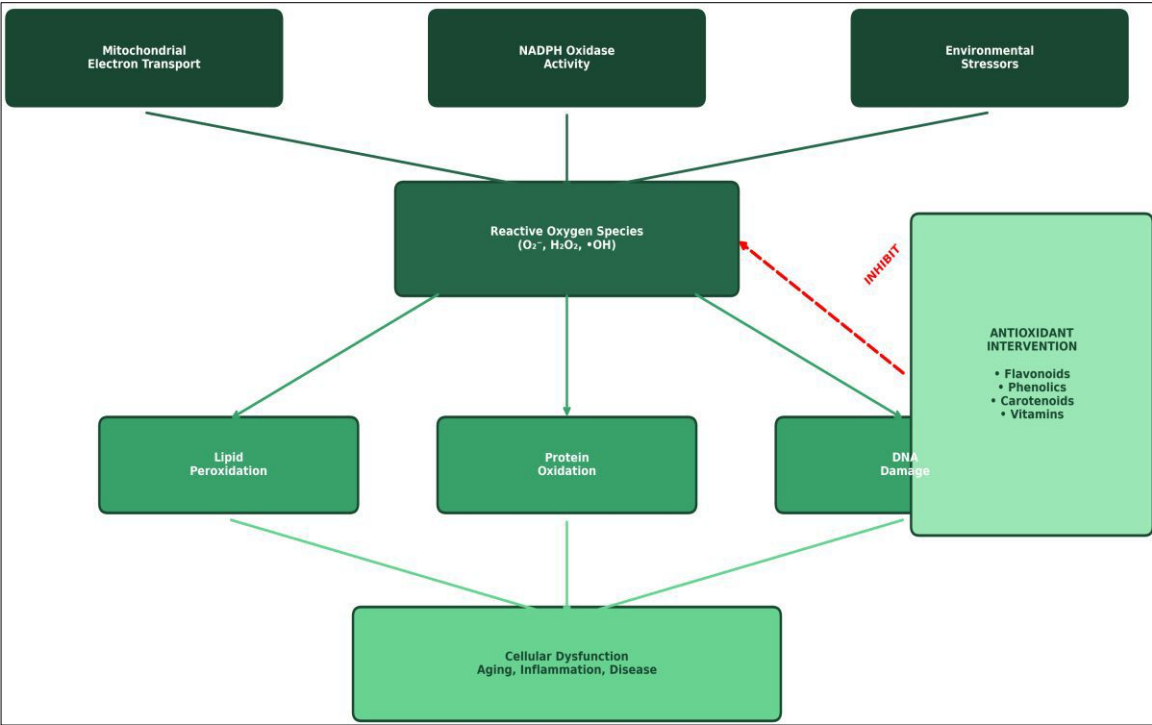


Fig 3: Oxidative stress pathway and antioxidant intervention mechanisms

Table 3: IC50 values for DPPH radical scavenging

Antioxidant	IC50 (μM)	Relative potency
EGCG	23.7 ± 1.8	1.00
Quercetin	28.4 ± 2.1	0.83
α-Tocopherol	58.9 ± 4.3	0.40
β-Carotene	67.4 ± 5.1	0.35

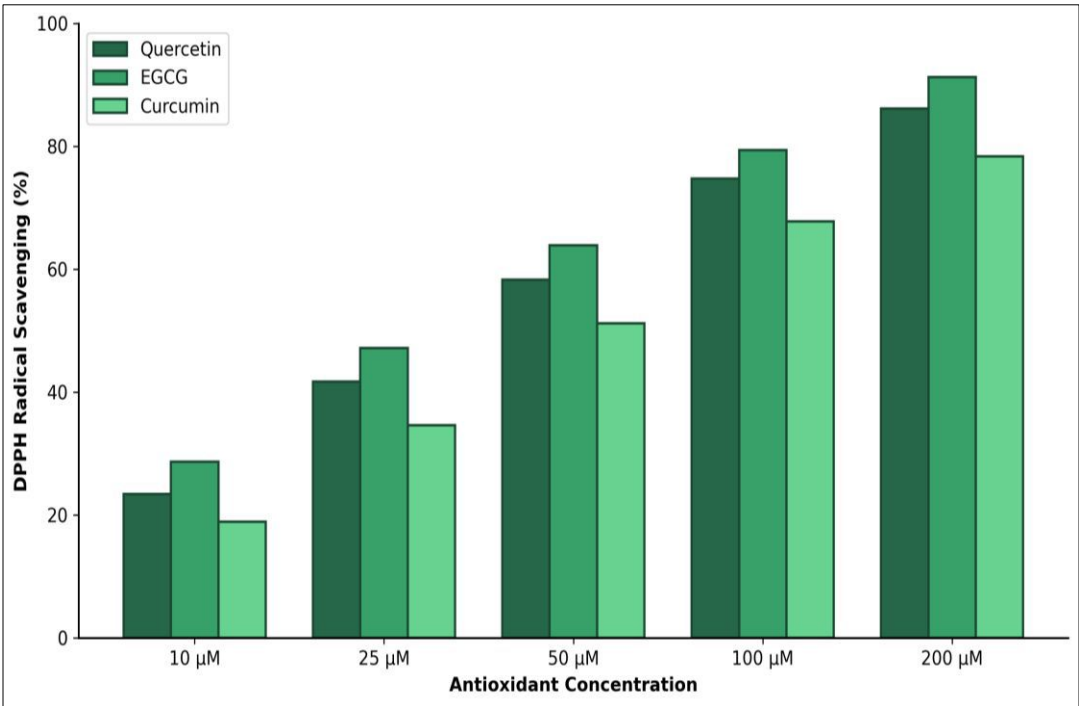


Fig 4: Dose-dependent DPPH radical scavenging activity

Discussion

Findings demonstrate that antioxidants exhibit distinct mechanistic profiles. EGCG's eight hydroxyl groups provide multiple hydrogen donation sites. α-Tocopherol's high log P ensures membrane partitioning for chain-breaking activity. Ascorbic acid can regenerate oxidised α-tocopherol,

suggesting synergistic potential. The concentration range (10-200 μM) may exceed physiologically attainable levels for some compounds. The research evaluated compounds in isolation whereas dietary exposure involves complex mixtures.

Conclusion

This evaluation across six assay systems revealed substantial variation in efficacy profiles. EGCG demonstrated highest overall capacity (91.4% DPPH, IC₅₀ 23.7 μ M). α -Tocopherol exhibited superior lipid peroxidation protection (89.2%) despite modest radical scavenging. Structure-activity relationships confirm that hydroxyl group number, conjugated electron systems, and lipophilicity influence mechanism-specific antioxidant behaviour. These findings support complementary antioxidant protection combining hydrophilic antioxidants for aqueous radical scavenging and lipophilic compounds for membrane protection.

Acknowledgements

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