Phenolic compounds

Polyphenols are ubiquitous secondary metabolites present in plant foods

Antioxidant is a natural or synthetic substance added to products to prevent or delay their oxidative deterioration

In food matrices, antioxidants have a broad action that include, for example, prevention of rancidity of fats, as well as decreasing the adverse effects of reactive species, such as reactive oxygen and nitrogen species (ROS and RNS)


Beneficial effect on human health


Anti-microbial property


Additives in biomedicine practices


Food supplements (sensory and nutritional properties, shelf-life)


Quality and process indicators


Potential tools for functionalization of materials

sensors MDPI

Review

Nanomaterial-Based Sensing and Biosensing of Phenolic Compounds and Related Antioxidant Capacity in Food

Flavio Della Pelle and Dario Compagnone *

sensors MDPI

Review

An Overview of Optical and Electrochemical Sensors and Biosensors for Analysis of Antioxidants in Food during the Last 5 Years

Maryam Nejadmansouri [1], Marjan Majdinasab [1], Gilvanda S. Nunes [2] and Jean Louis Marty [3,*]

Phenolic compounds

- Common food sources

- Selected Food sample for lab-practicals

Chacko *et al. Chinese Medicine* 2010, **5**:13
http://www.cmjournal.org/content/5/1/13

CHINESE MEDICINE

REVIEW **Open Access**

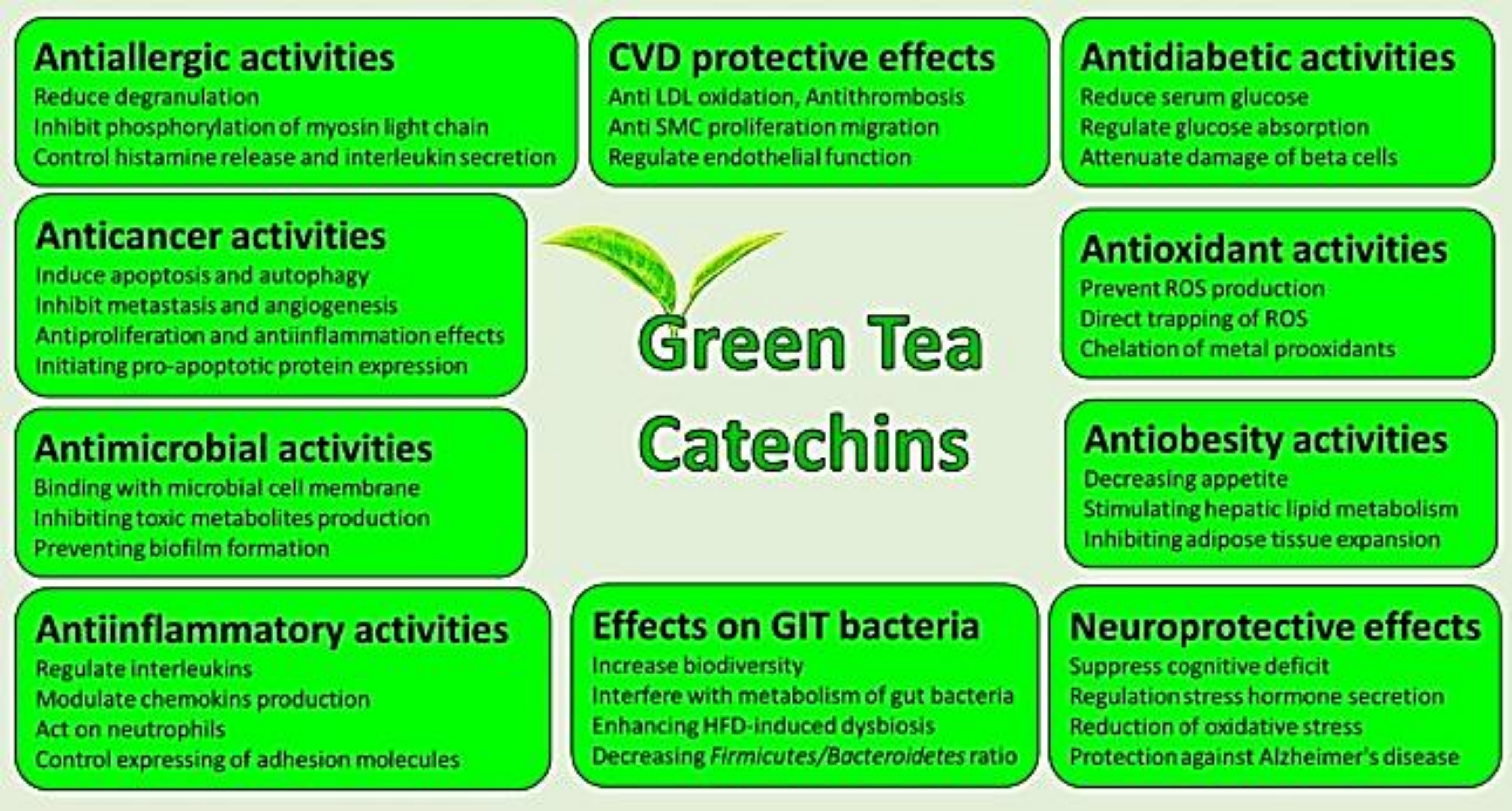
Beneficial effects of green tea: A literature review

Sabu M Chacko[1*], Priya T Thambi[1], Ramadasan Kuttan[2], Ikuo Nishigaki[1]

Green tea contains polyphenols, which include flavanols, flavandiols, flavonoids, and phenolic acids; these compounds may account for up to 30% of the dry weight. Most of the green tea polyphenols (GTPs) are flavonols, commonly known as catechins. Products derived from green tea are mainly extracts of green tea in liquid or powder form that vary in the proportion of polyphenols (45-90%) and caffeine content (0.4-10%). The major flavonoids of green tea are various catechins, which are found in greater amounts in green

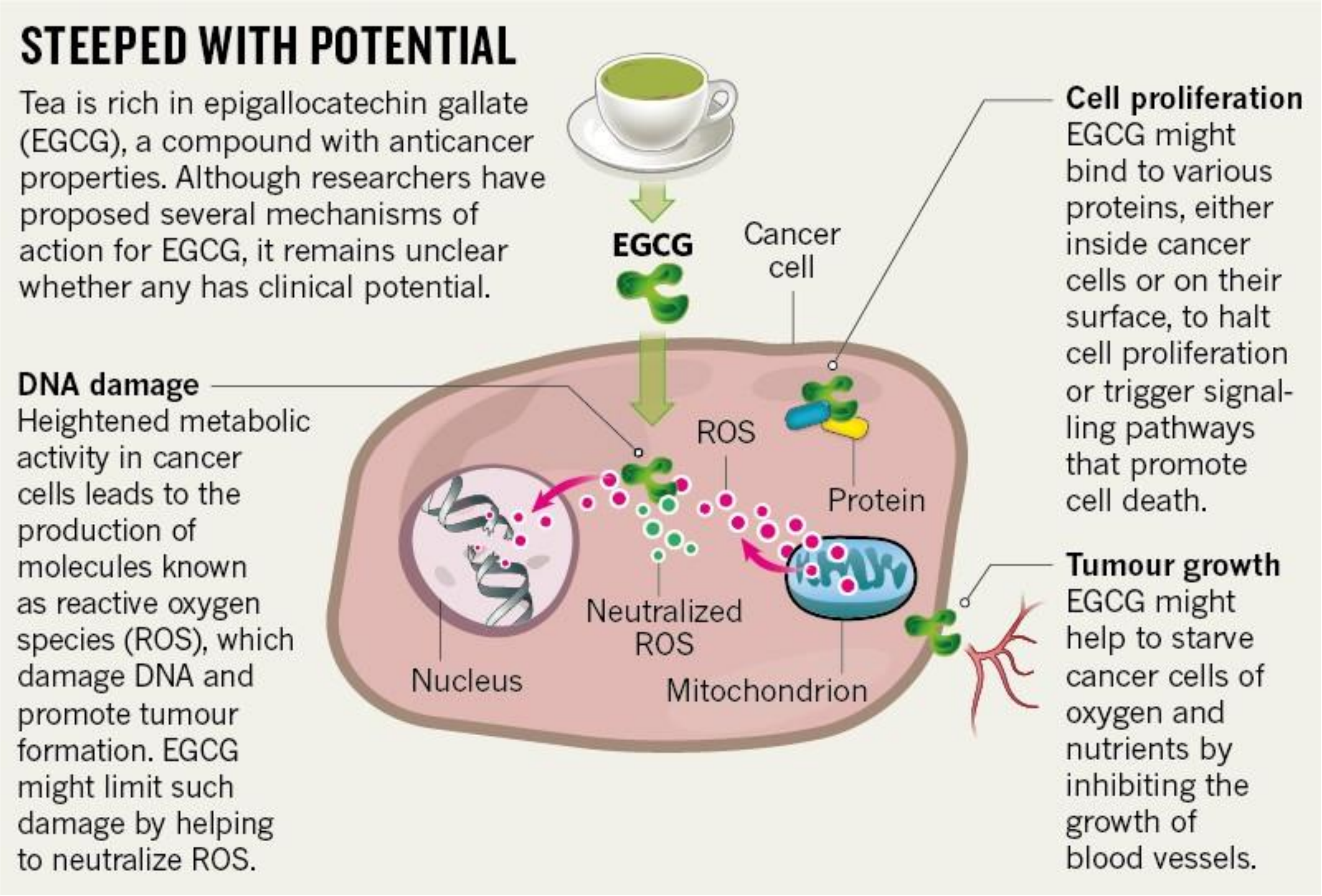
Phenolic compounds and the biotechnologies

- General effects



Phenolic compounds

- In vitro effects



Phenolic compounds

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- In vivo effects

Biotechnology Reports 24 (2019) e00370

Contents lists available at ScienceDirect

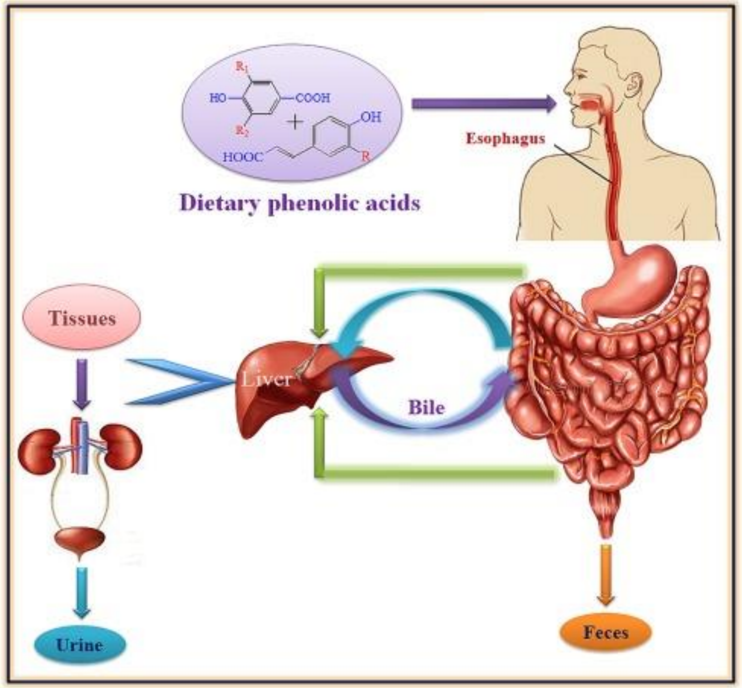
Biotechnology Reports

journal homepage: www.elsevier.com/locate/btre

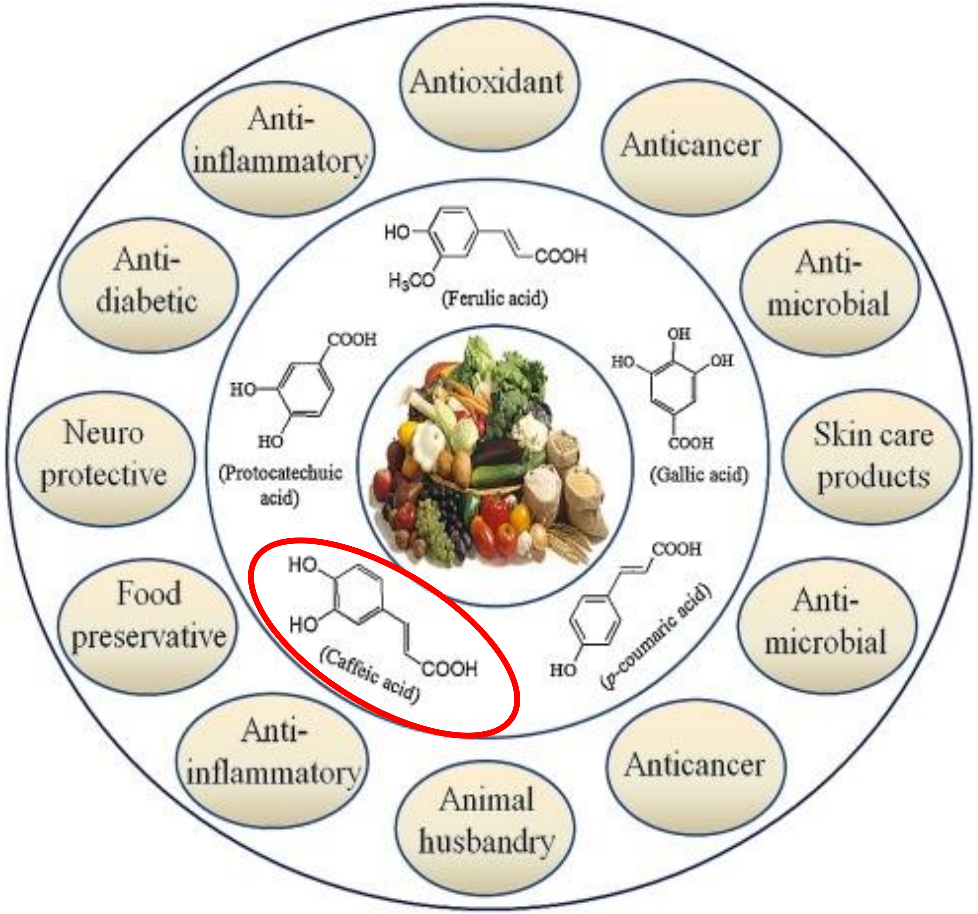
Phenolic acids: Natural versatile molecules with promising therapeutic applications

Naresh Kumar[a], Nidhi Goel[b,*]

[a] Discipline of Biosciences and Biomedical Engineering, Indian Institute of Technology Indore, Simrol Campus, Indore, Madhya Pradesh-453552, India
[b] Department of Chemistry, Institute of Science, Banaras Hindu University, Varanasi, Uttar Pradesh-221005, India



Polyphenolic compounds are bioactive substances widely distributed in the vegetable kingdom. They act as natural antioxidants and their presence contributes to the color, flavor and aroma of food. Therefore, they are considered dietary antioxidants with interesting benefits to health.

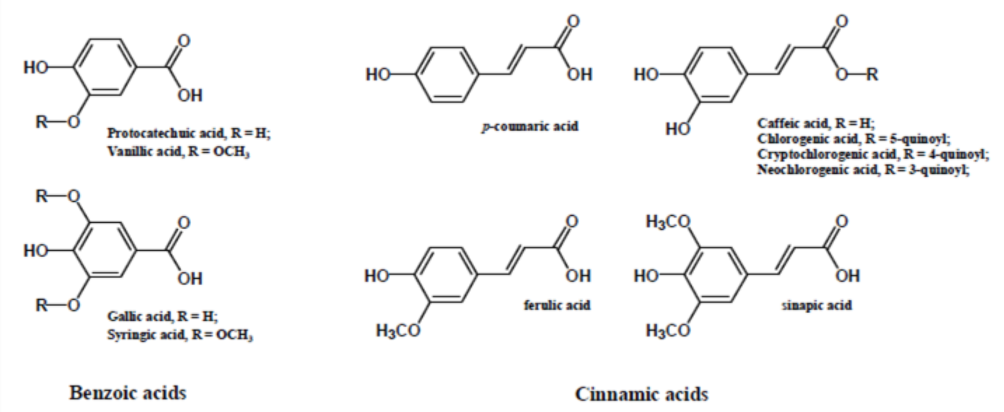


Phenolic compounds, how many structures?

Phenolic compounds in food

Phenolic acids in food

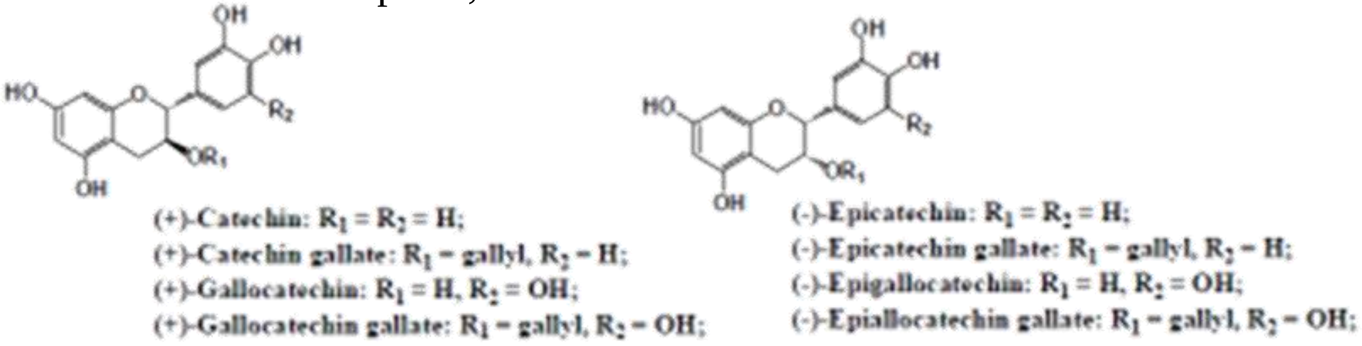
Fruits, vegetables, grains, seeds...



Flavanols

Or flavan-3-ols or catechins.

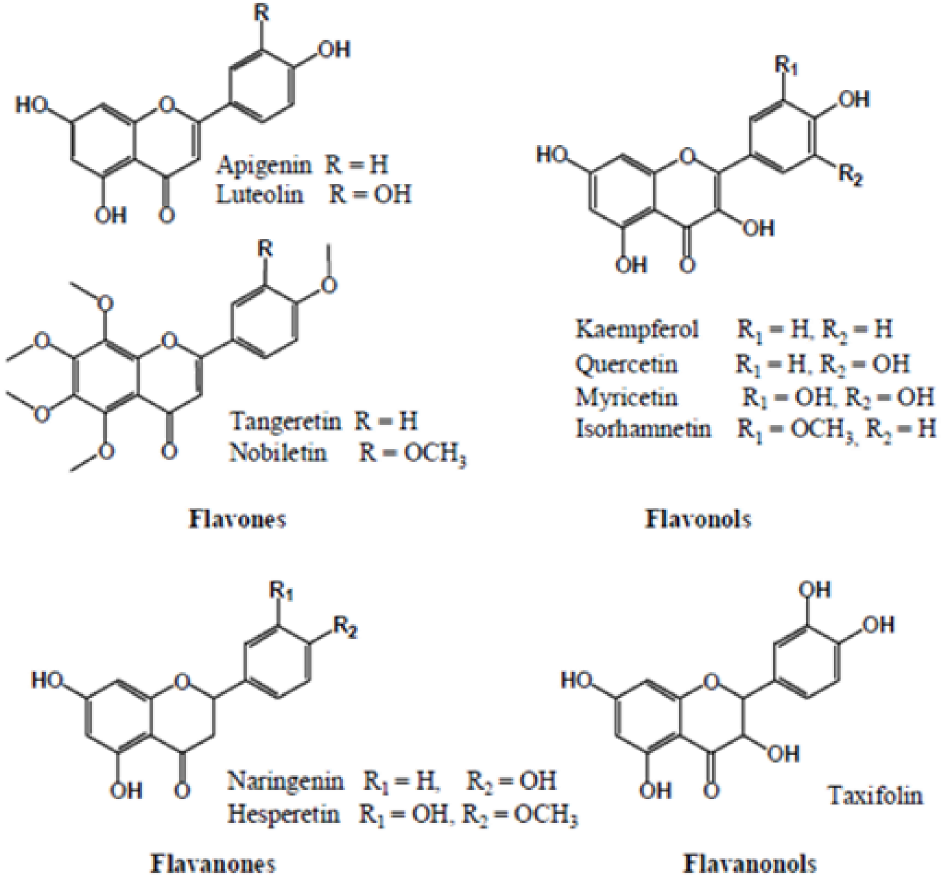
Black and green tea, apples, blueberries, peaches, pears, strawberries



Flavonoids

Flavones, Flavonols, Flavanones and Flavanonols

Brightly coloured fruits and vegetables: blueberries, plums, apples, cherries, oranges, strawberries, spinach...



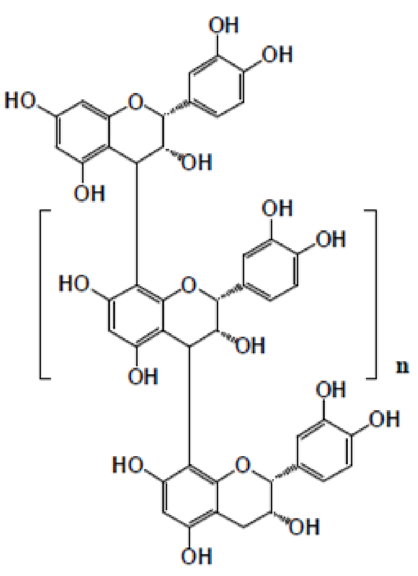
Tsao, R. (2010). *Nutrients*, *2*(12), 1231-1246.

Phenolic compounds, how many structures?

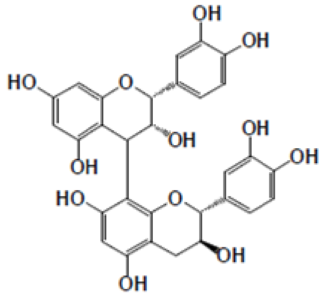
Phenolic compounds in food

Procyanidins

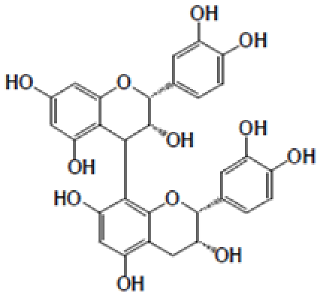
Grapes (seeds and skins), apples, chocolate and cocoa, red wines, blueberries, cranberries, pecans, pistachios



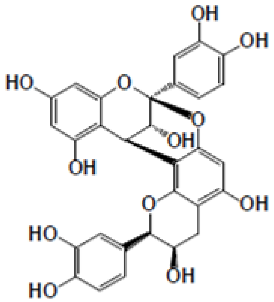
Procyanidins: n > 0;
Oligomeric procyanidins: n = 0-7



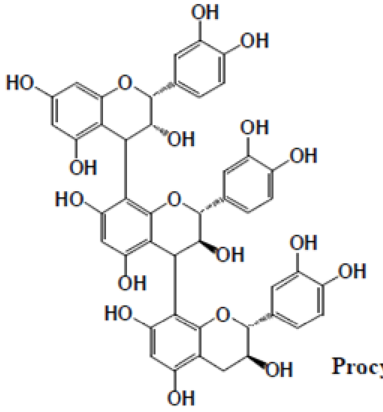
Procyanidin B1



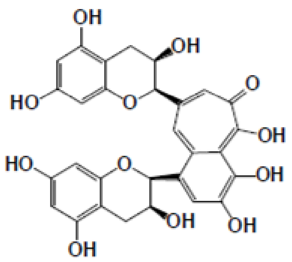
Procyanidin B2



Procyanidin A2



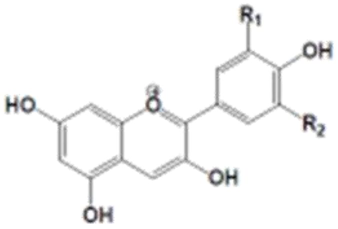
Procyanidin C1



Theaflavin

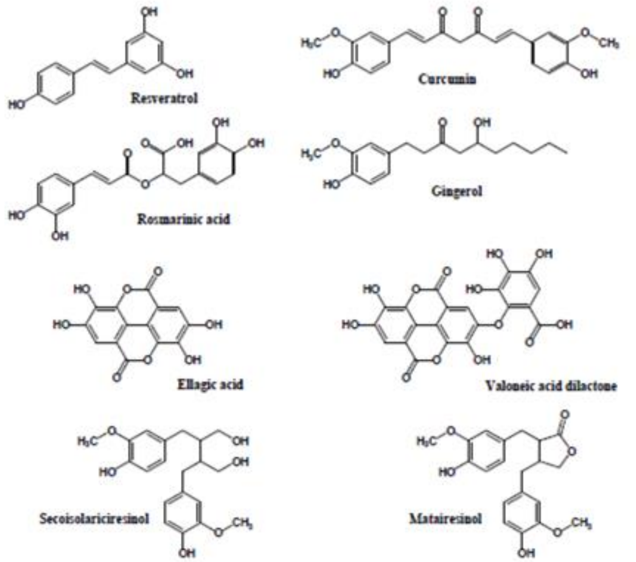
Anthocyanidins

Blue and purple pigments food



Anthocyanidin	R_1	R_2
Cyanidin	-OH	-H
Delphinidin	-OH	-OH
Pelargonidin	-H	-H
Malvidin	$-OCH_3$	$-OCH_3$
Peonidin	$-OCH_3$	-H
Petunidin	-OH	$-OCH_3$

Other important polyphenols…

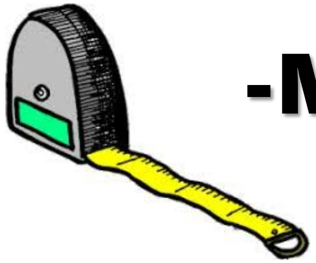


Tsao, R. (2010). *Nutrients*, *2*(12), 1231-1246.
Neveu, V., Perez-Jiménez, J., Vos, F., Crespy, V., Du Chaffaut, L., Mennen, L., ... & Scalbert, A. (2010). *Database*, *2010*.

Optical-based method

Phenols content evaluation

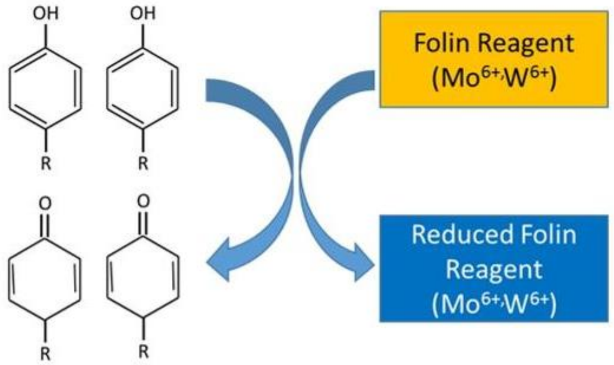
SPECTROPHOTO-

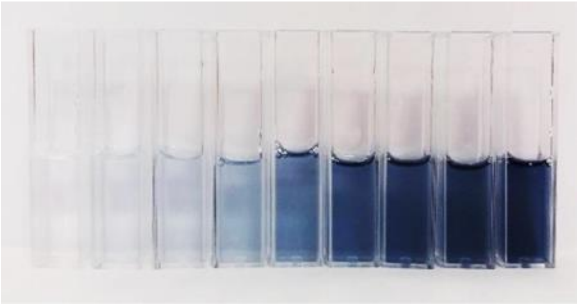


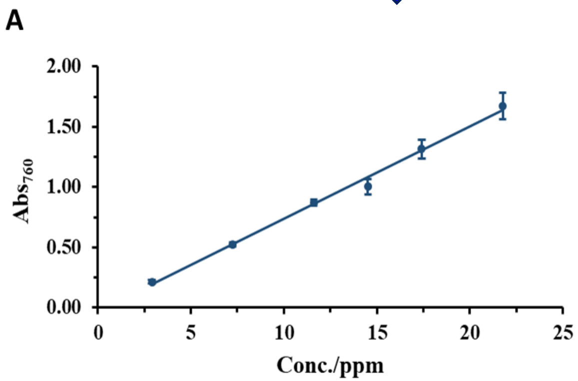
-METRY

FOLIN CIOCALTEU

Total polyphenols content

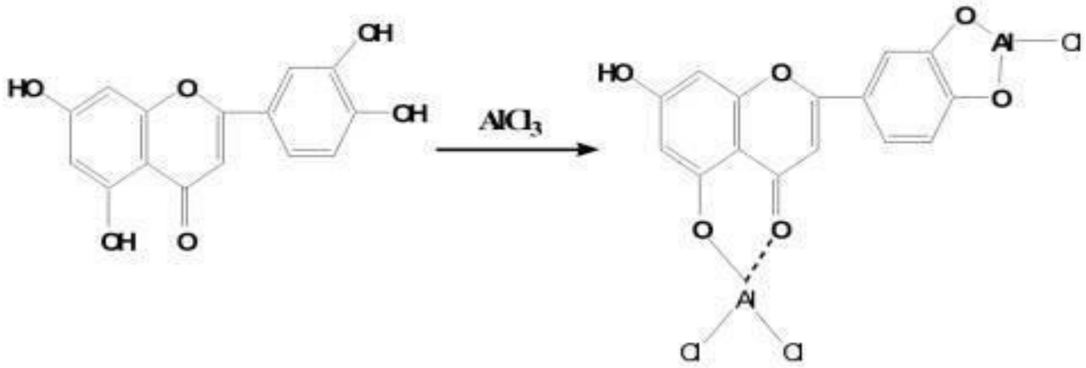






$AlCl_3$

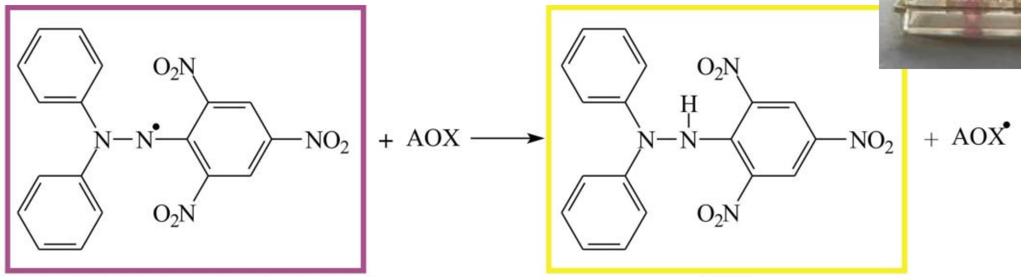
Flavonoid Content evaluation



Optical-based method

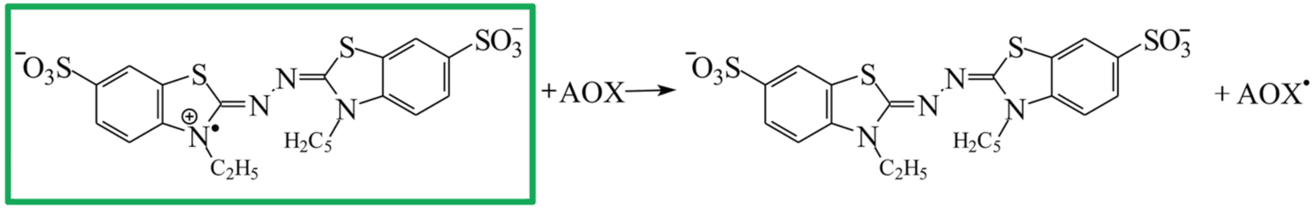
Antioxidant capacity evaluation

Antioxidant capacity assay	Principle of the method	End-product determination
	Spectrometry	
DPPH	Antioxidant reaction with an organic radical	Colorimetry
ABTS	Antioxidant reaction with an organic cation radical	Colorimetry
FRAP	Antioxidant reaction with a Fe(III) complex	Colorimetry
PFRAP	Potassium ferricyanide reduction by antioxidants and subsequent reaction of potassium ferrocyanide with Fe3+	Colorimetry
CUPRAC	Cu (II) reduction to Cu (I) by antioxidants	Colorimetry
ORAC	Antioxidant reaction with peroxyl radicals, induced by AAPH (2,2'-azobis-2-amidino-propane)	Loss of fluorescence of fluorescein
HORAC	Antioxidant capacity to quench OH radicals generated by a Co(II) based Fenton-like system	Loss of fluorescence of fluorescein
TRAP	Antioxidant capacity to scavenge luminol-derived radicals, generated from AAPH decomposition	Chemiluminescence quenching
Fluorimetry	Emission of light by a substance that has absorbed light or other electromagnetic radiation of a different wavelength	Recording of fluorescence excitation/ emission spectra



DPPH radical (2,2-diphenyl-1-picrylhydrazyl)
intense purple color

DPPH

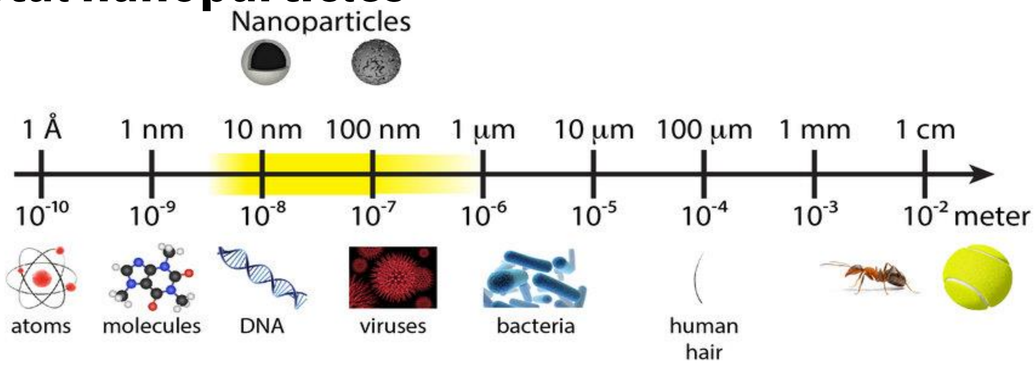


ABTS radical (2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid)
blue green color

ABTS

Nanomaterials

Metal nanoparticles



Materials with one external dimension in the range of 1-100 nm

They exhibit a wide range of properties, including optical, electrical, catalytic, magnetic, and biological activity.


Regulatory Toxicology and Pharmacology 65 (2013) 119–125

Contents lists available at SciVerse ScienceDirect

Regulatory Toxicology and Pharmacology

journal homepage: www.elsevier.com/locate/yrtph

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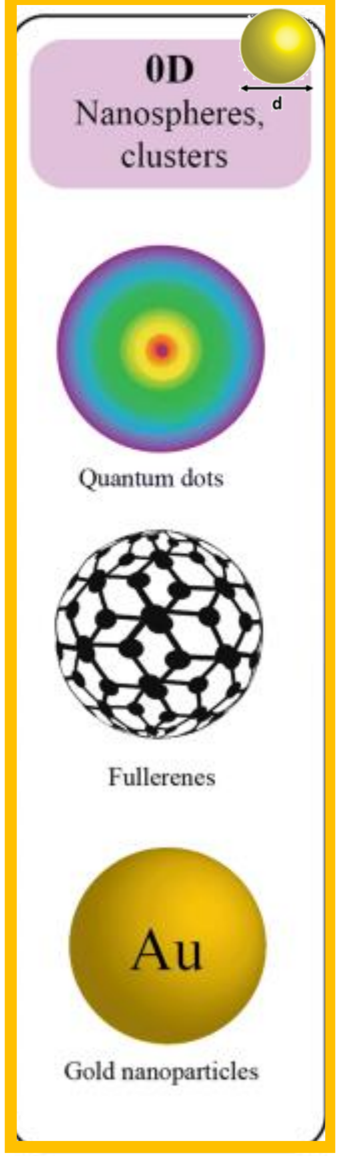
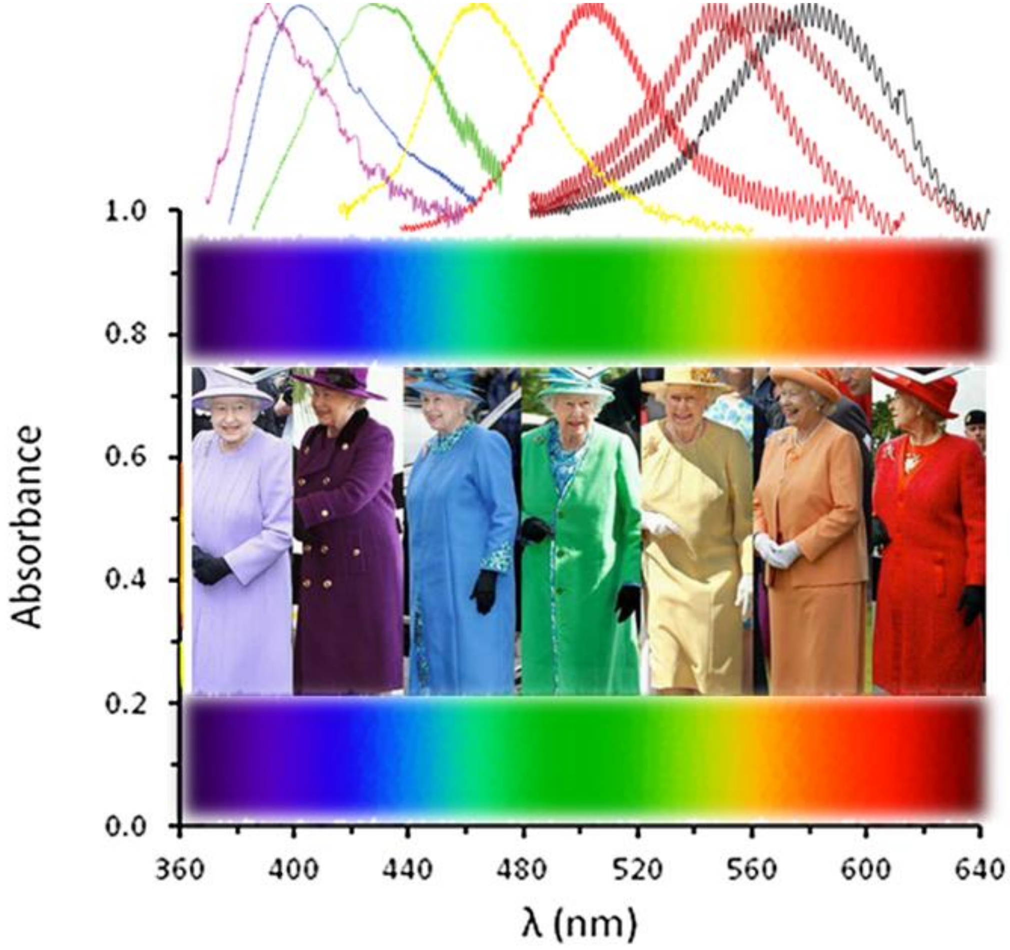
Considerations on the EU definition of a nanomaterial: Science to support policy making

Eric A.J. Bleeker *, Wim H. de Jong, Robert E. Geertsma, Monique Groenewold, Evelyn H.W. Heugens, Marjorie Koers-Jacquemijns, Dik van de Meent, Jan R. Popma, Anton G. Rietveld, Susan W.P. Wijnhoven, Flemming R. Cassee, Agnes G. Oomen

Metal NPs





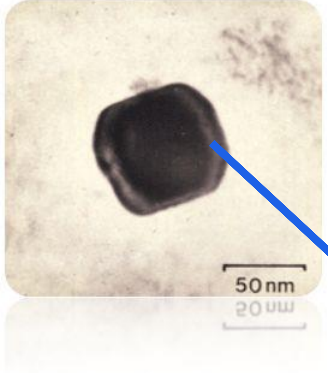
Metal nanoparticles

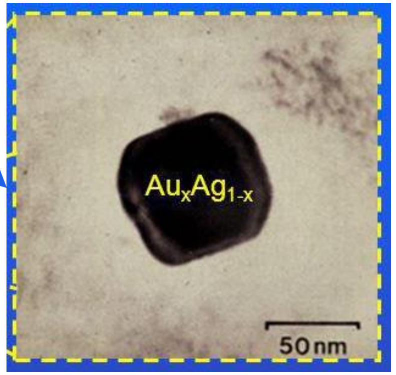
From Romans…

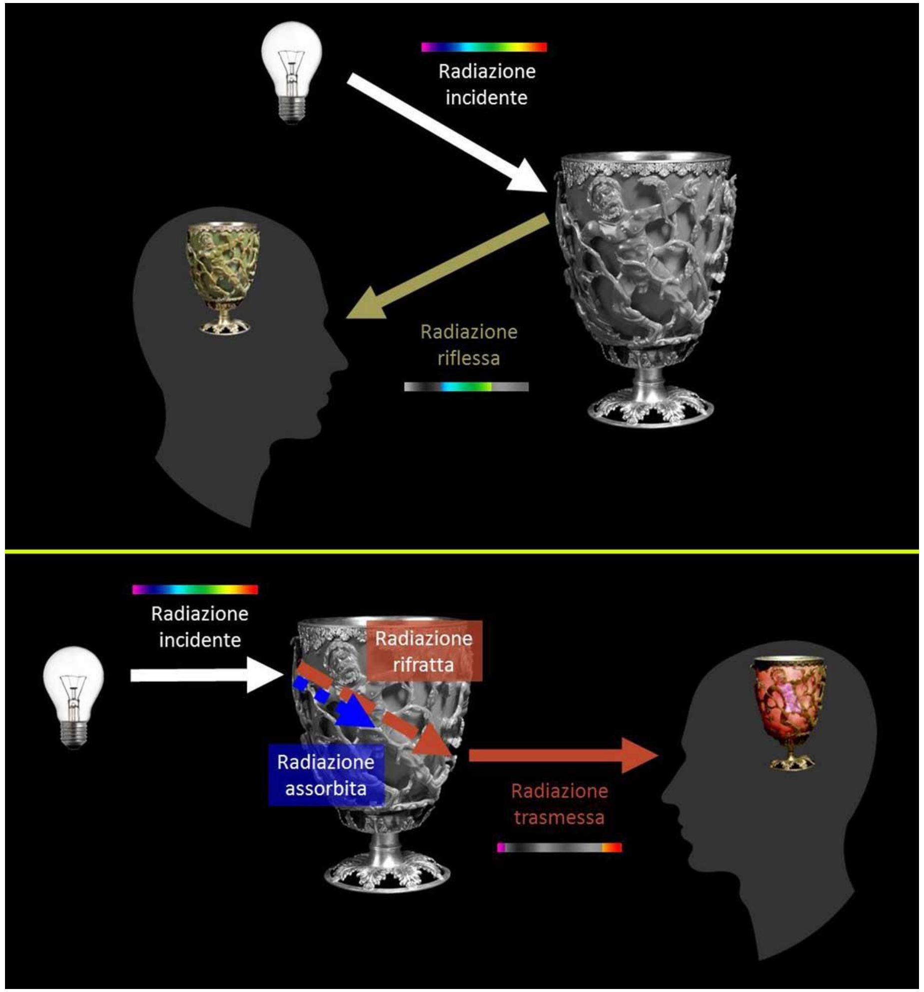
Nanotecnologia romana

I colori cangianti della Coppa di Licurgo, datata IV secolo a.C., sono dovuti a nanoparticelle di oro e argento disperse nella matrice vetrosa.


(Coppa di Licurgo, British Museum)







Novoselov, K. S., **Geim**, A. K., Morozov, S. V., Jiang, D. A., Zhang, Y., Dubonos, S. V., ... & Firsov, A. A. (**2004**). *science*, *306*(5696), 666-669.

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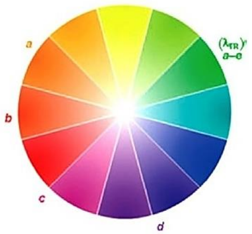
Metal nanoparticles: their camaleontic features

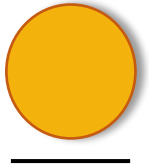


MNPs can interact in different ways with VIS-electromagnetic radiation depending on their shapes, sizes, and composition.

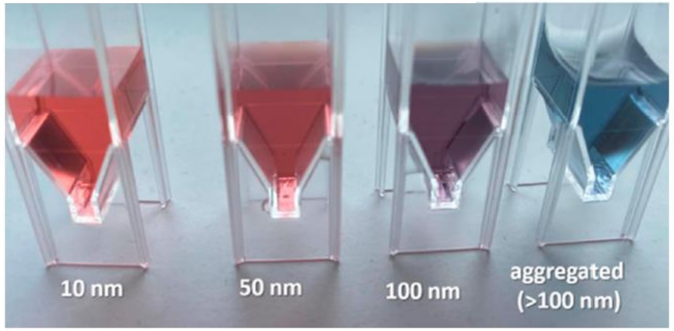
Gold nanoparticles

Diameter

size →



10 nm

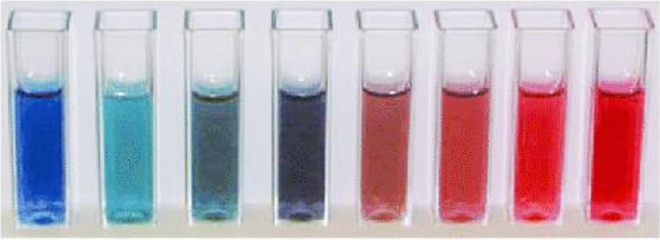


Gold nanorods

Nanorods

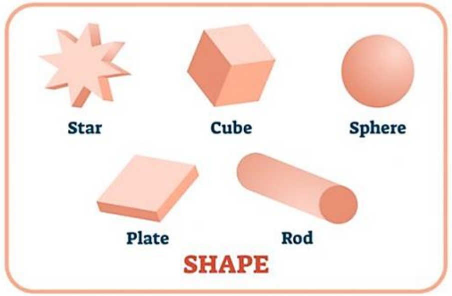
aspect ratio →

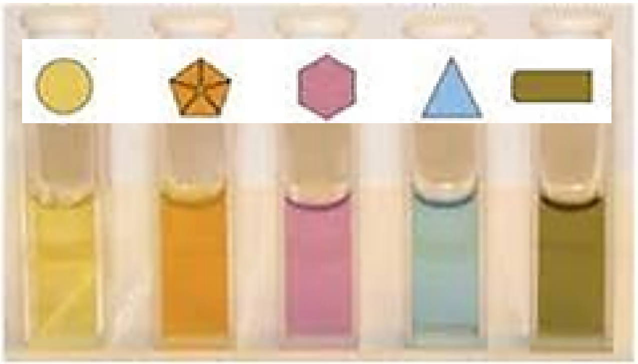
50 nm



Silver nanoparticles

Shape





Silica-gold core-shell nanoparticles

Nanoshells

← shell thickness

140 nm

Gold nanocages

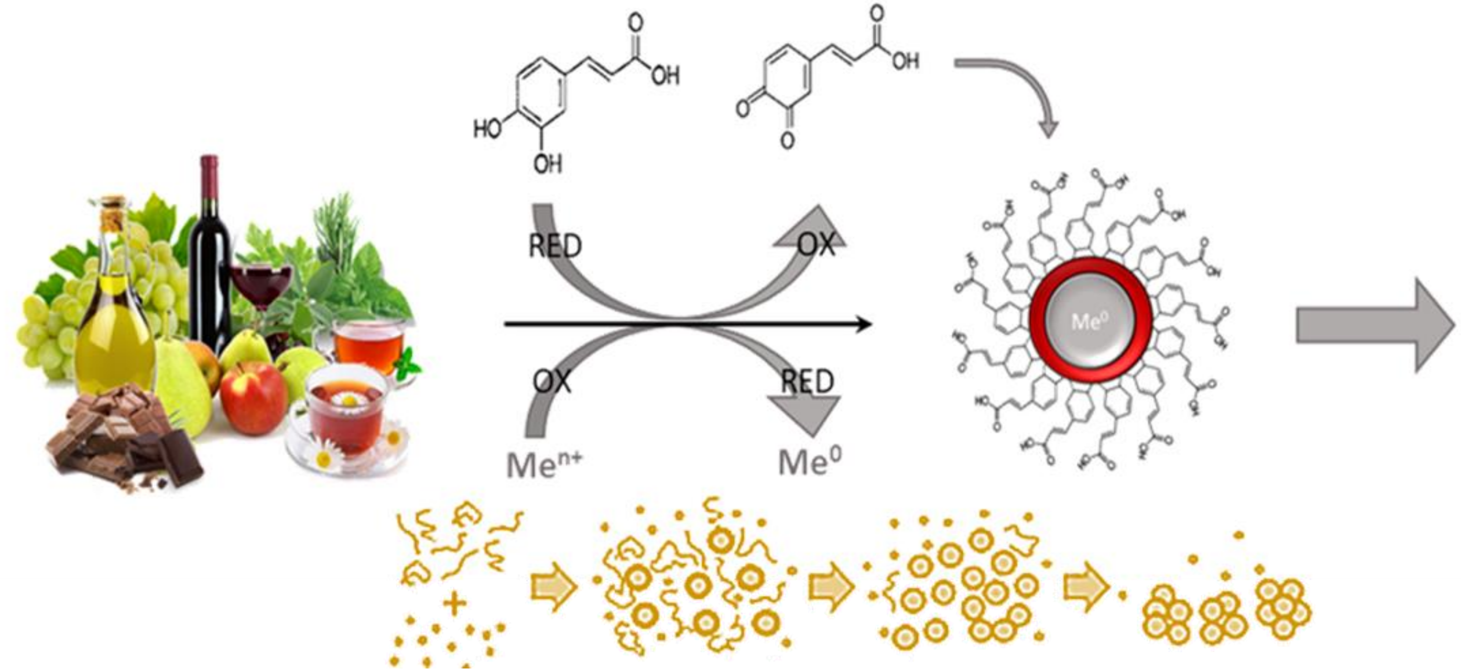
Nanocages

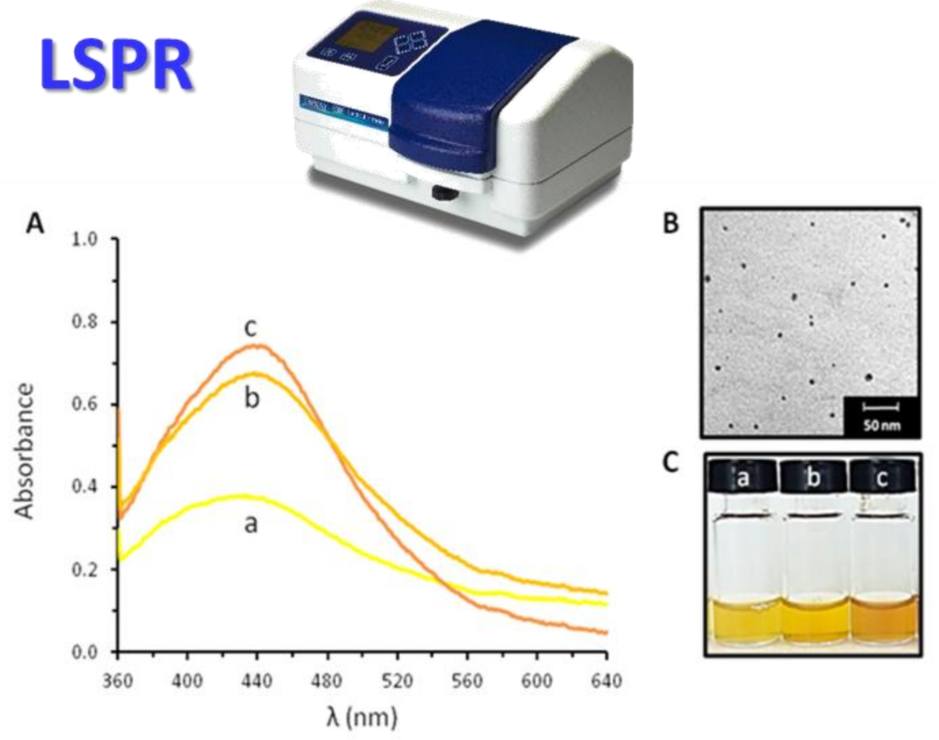
% gold →

50 nm

Optical-based method

Metal nanoparticles-based spectrophotometric method. Main strategy

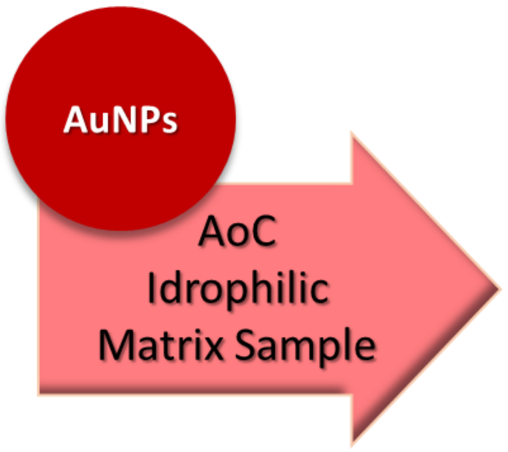


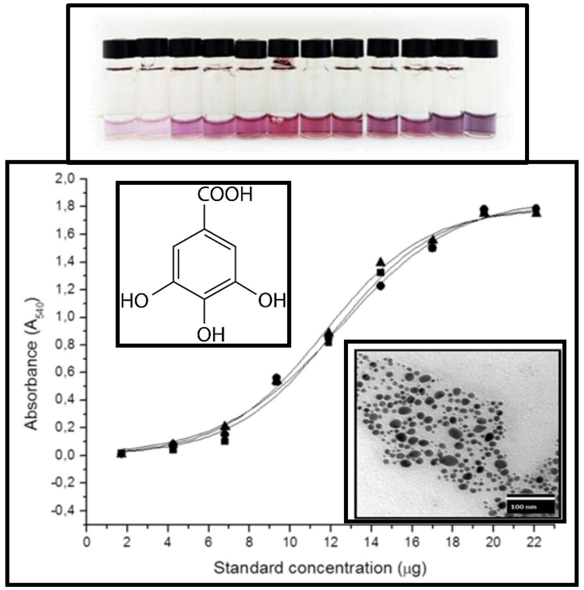


Della Pelle, F., & Compagnone, D. (2018). https://doi.org/10.3390/s18020462
Della Pelle, F., Scroccarello, A., Sergi, M., Mascini, M., Del Carlo, M., & Compagnone, D. (2018). https://doi.org/10.1016/j.foodchem.2018.02.141
Della Pelle, F., Sergi, M., Del Carlo, M., Compagnone, D., & Escarpa, A. (2015). https://doi.org/10.1021/acs.analchem.5b01489
Della Pelle, F., Vilela, D., Gonzàlez, M. C., Lo Sterzo, C., Compagnone, D., Del Carlo, M., & Escarpa, A. (2015). https://doi.org/10.1016/j.foodchem.2015.01.045

Plasmonic-active nanostructured materials for sensing and biosensing

AuNPs from polyphenolic extract to fat matrix





MNPs formation is proportional to polyphenols content

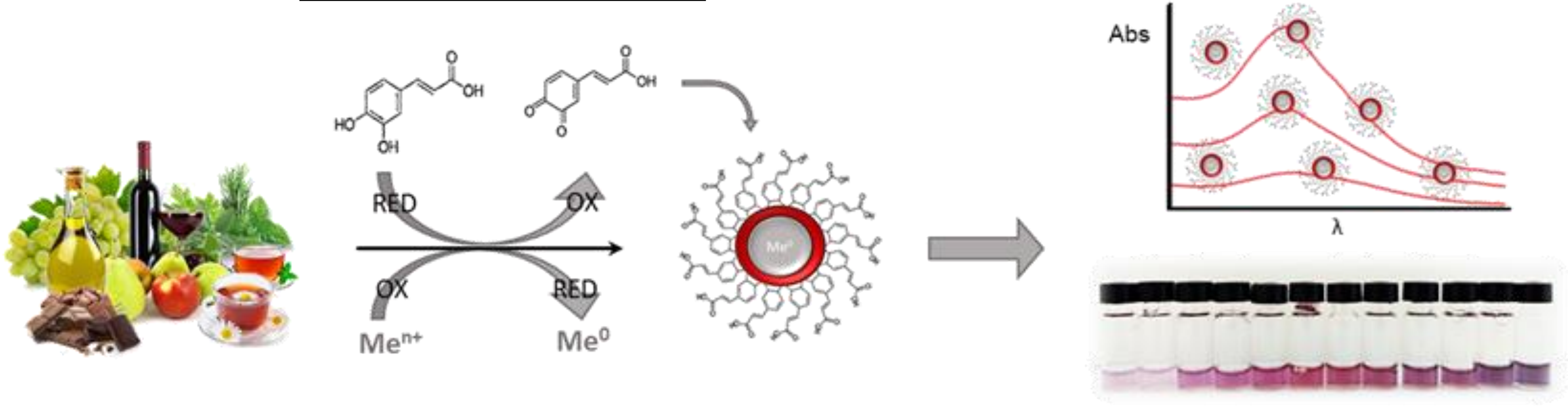
Food Chemistry 178 (2015) 70–75
Contents lists available at ScienceDirect
Food Chemistry
journal homepage: www.elsevier.com/locate/foodchem
ELSEVIER

Analytical Methods

Antioxidant capacity index based on gold nanoparticles formation. Application to extra virgin olive oil samples

Flavio Della Pelle [a,b], Diana Vilela [a], María Cristina González [a], Claudio Lo Sterzo [b], Darío Compagnone [b], Michele Del Carlo [b,*], Alberto Escarpa [a,*]

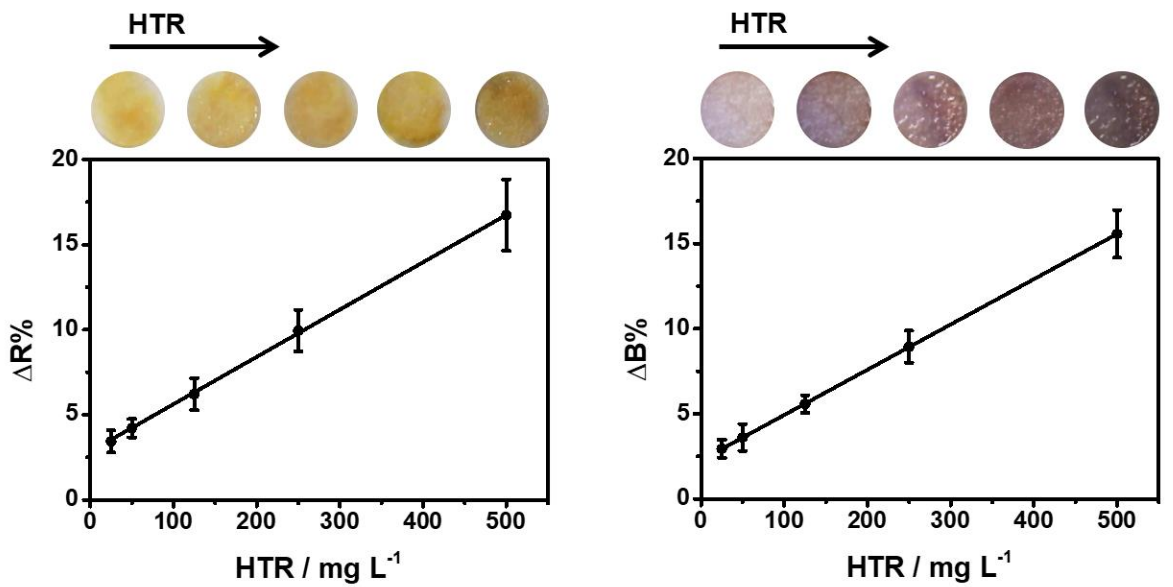
[a] Departamento de Química Analítica, Química-Física e Ingeniería Química, Facultad de Química, Universidad de Alcalá, 28871 Alcalá de Henares, Madrid, Spain
[b] Facoltà di Bioscienze e Tecnologie Agro-Alimentari e Ambientali, Università degli Studi di Teramo, 64023 Mosciano Sant'Angelo, Italy



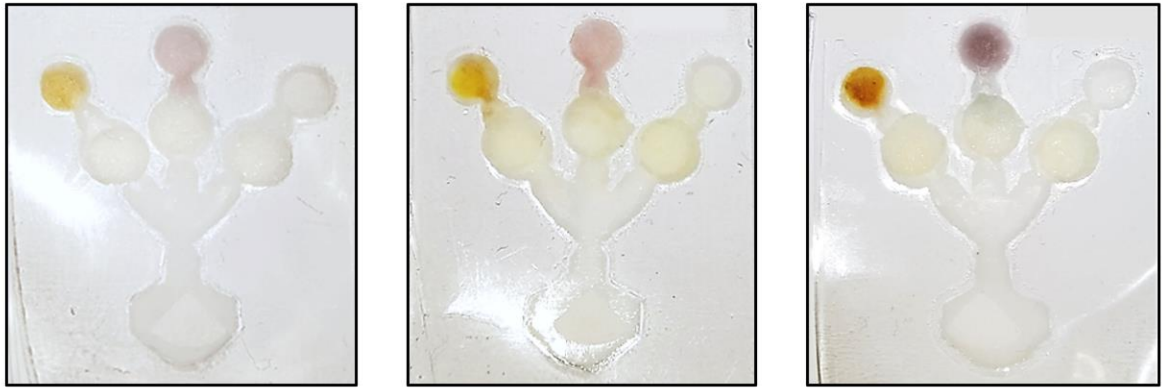
Paper-based colorimetric sensor

Extraction-free olive oil phenolic compounds evaluation trough a seed growth strategy

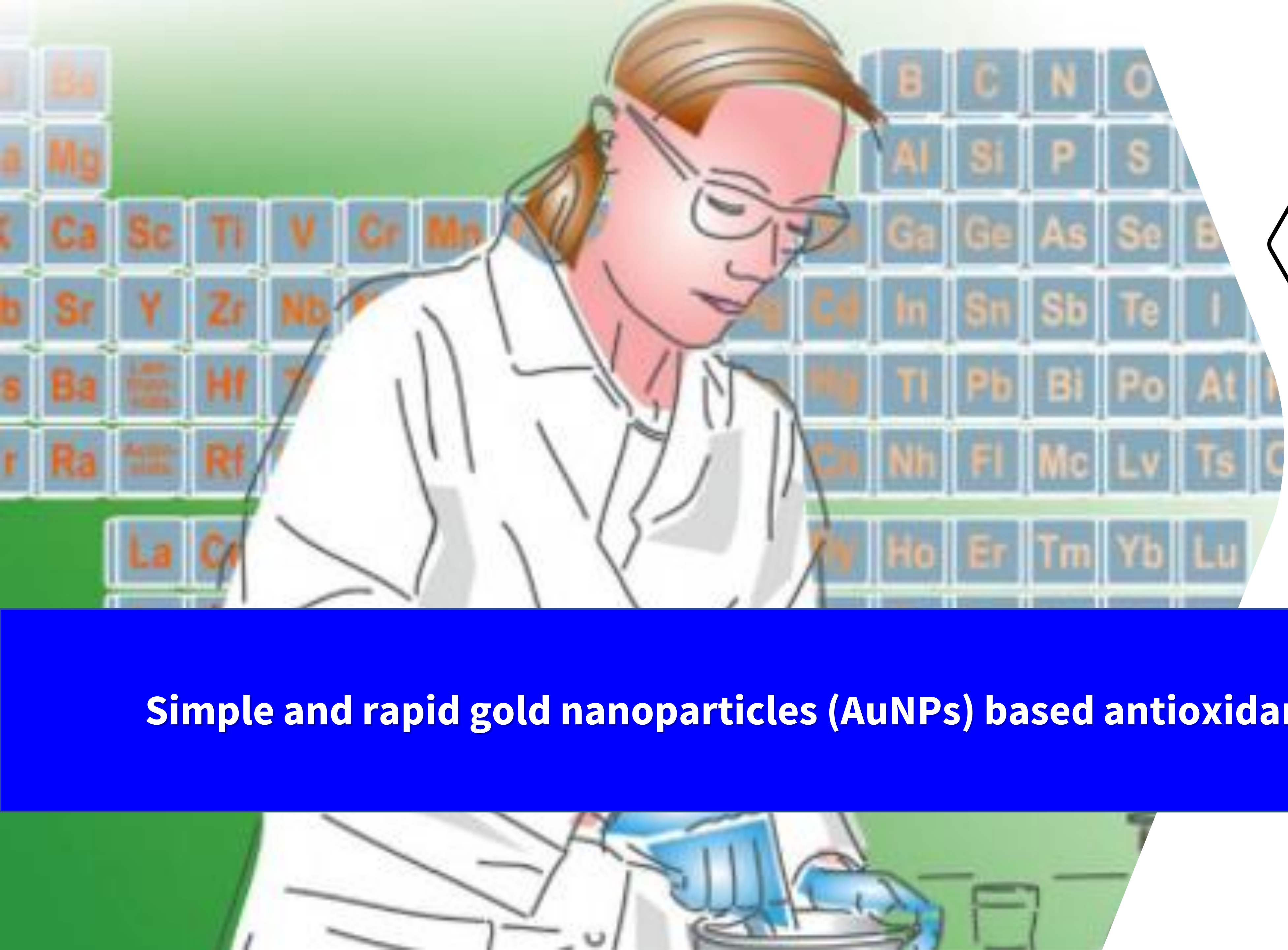
Dose-response curve



EVOO samples' phenolyc compounds content



Low Mean High



LAB-EXPERIENCE INTRODUCTION

Simple and rapid gold nanoparticles (AuNPs) based antioxidant capacity assay

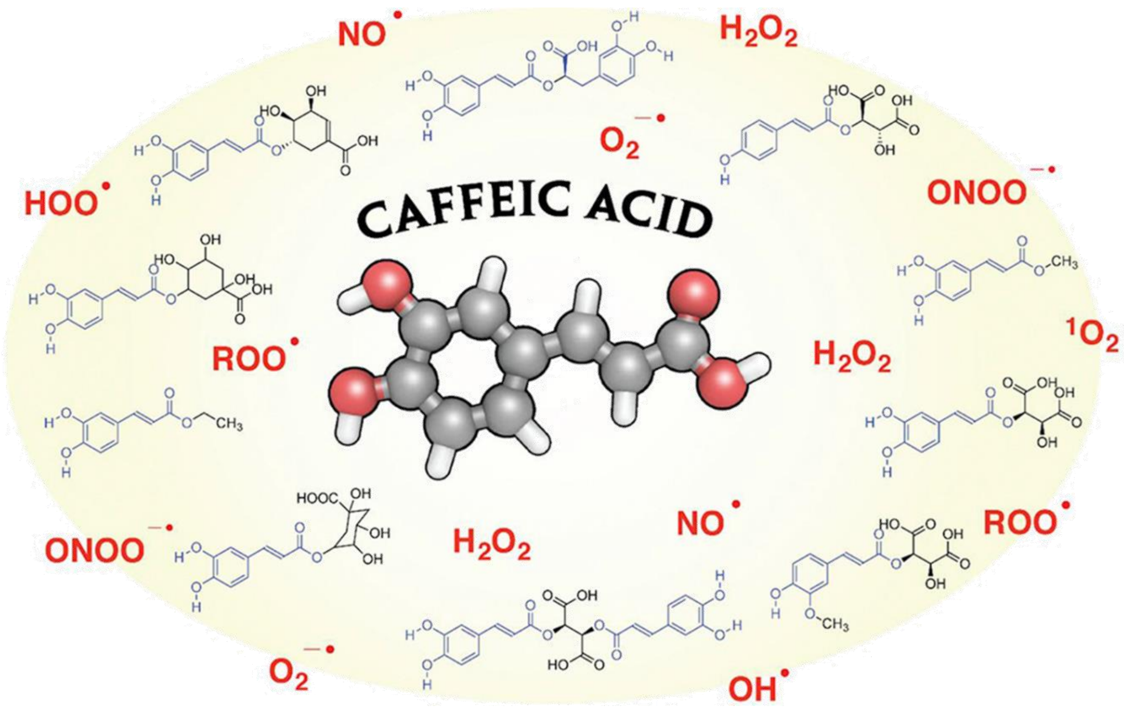
Analyte selection

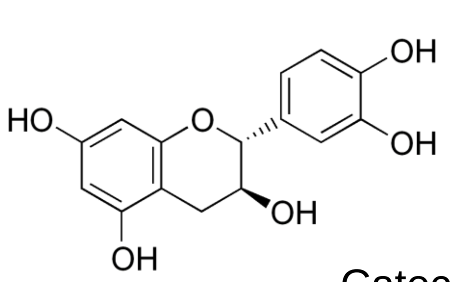

C. R. Chimie 20 (2017) 1072–1082
Contents lists available at ScienceDirect
Comptes Rendus Chimie
www.sciencedirect.com

Full paper/Mémoire

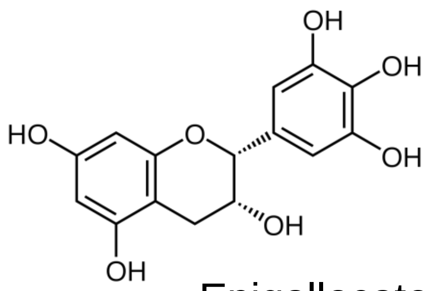
Antioxidant properties of several caffeic acid derivatives: A theoretical study

Alicja Urbaniak [a], Jacek Kujawski [b], Kornelia Czaja [b], Malgorzata Szelag [c, *]

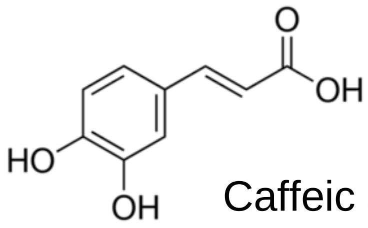




Catechin



Epigallocatechin



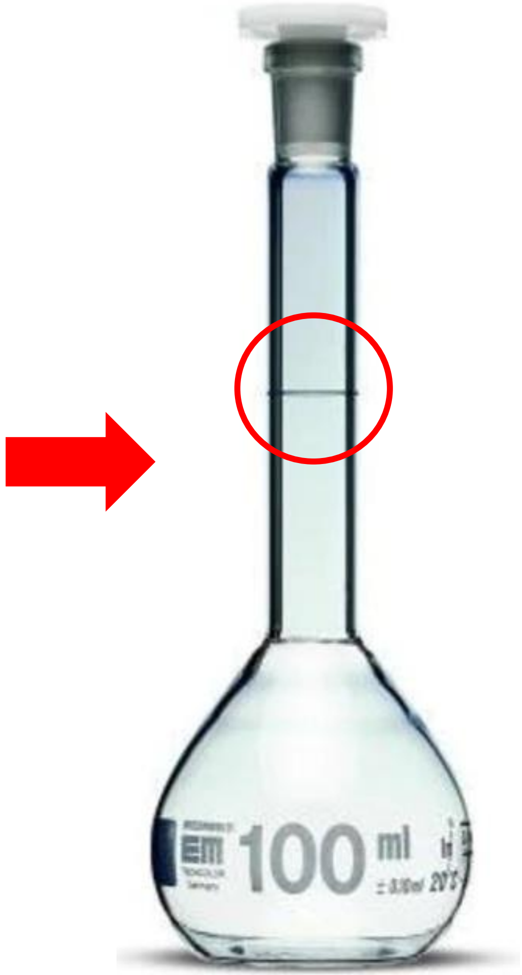
Caffeic acid

Why we use the caffeic acid as standard to perform the calibration curve?

1) Stock solution preparation

CAFFEIC ACID SOLUTION PREPARATION

Perform the calculation



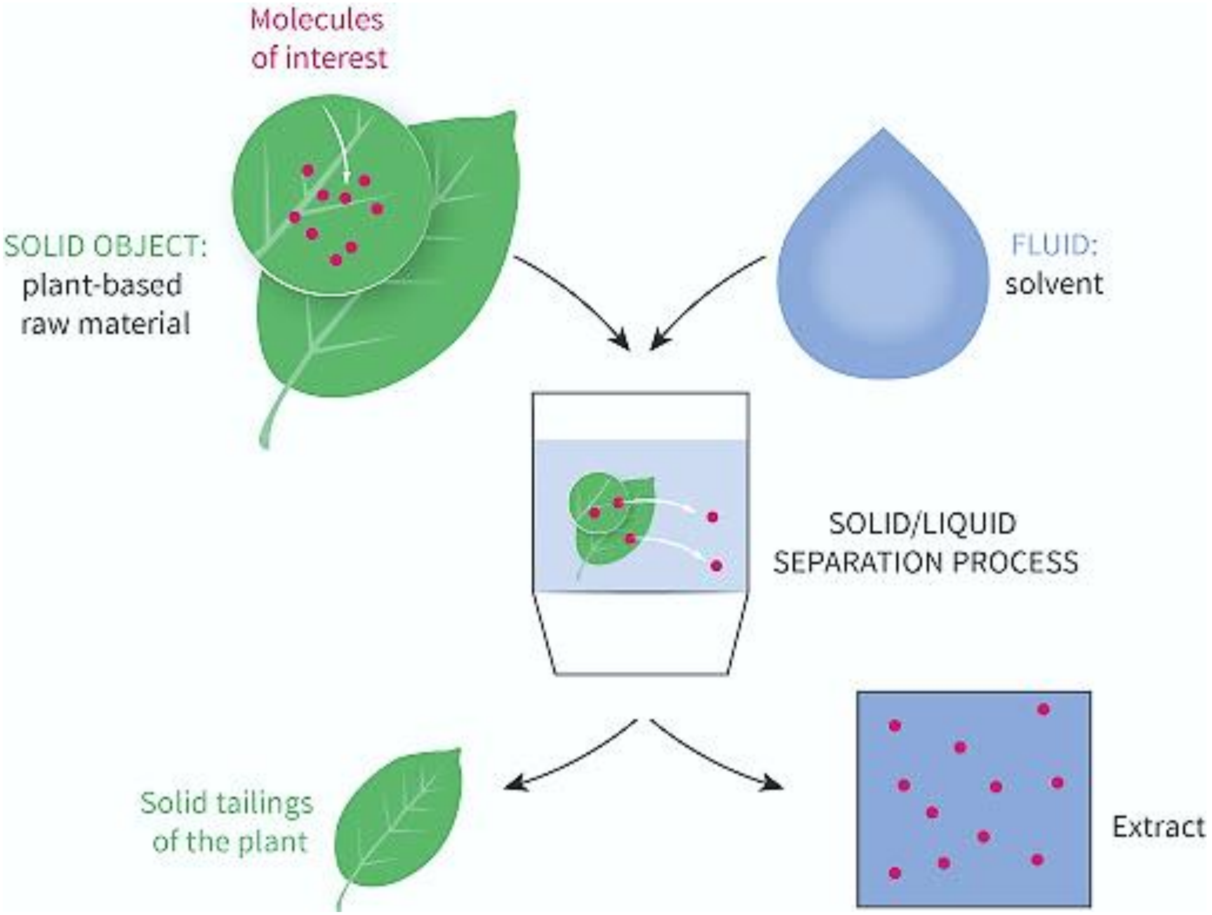
Sample extraction

Lab-experience Step n.2

Solid-liquid extraction. Phenolic compounds extraction form solid sample.

A) **Sample Weight**

B) **Sample Extraction**



Antioxidant capacity assay

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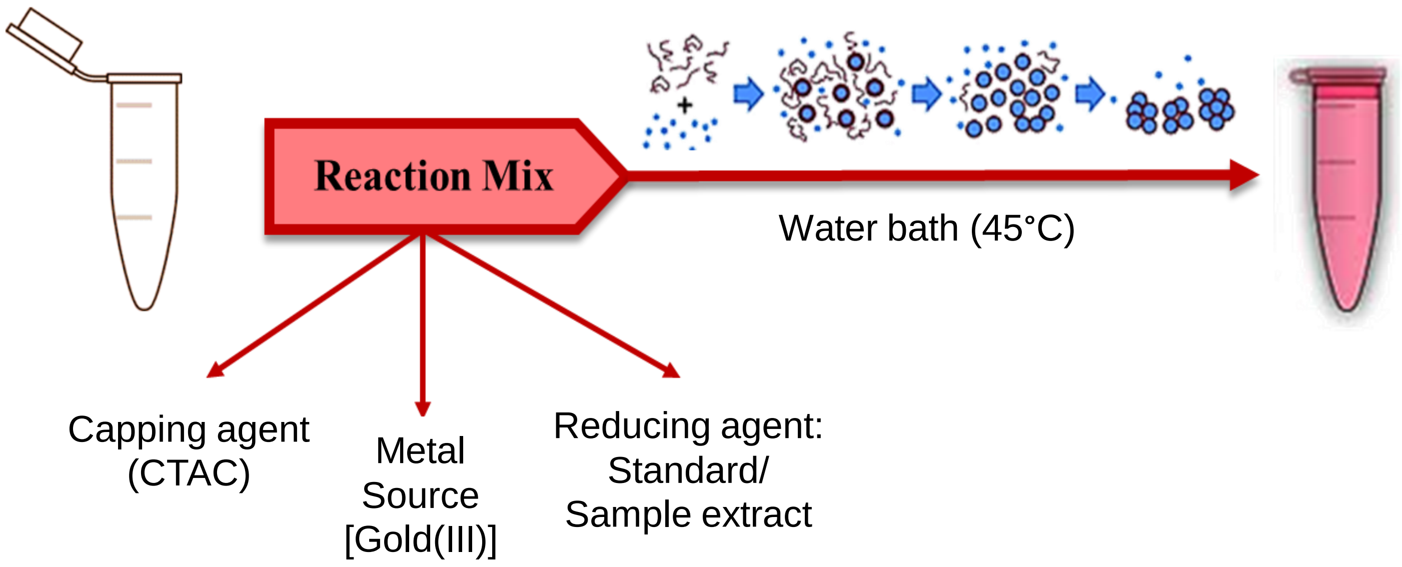
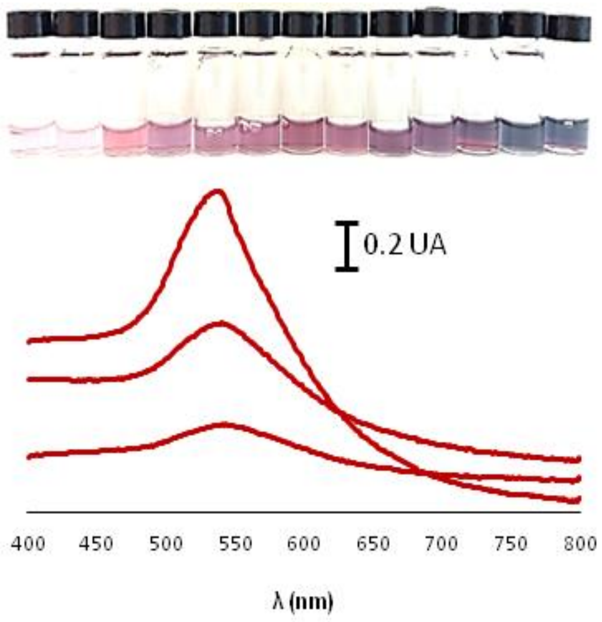
☐ Lab-experience Step n.3

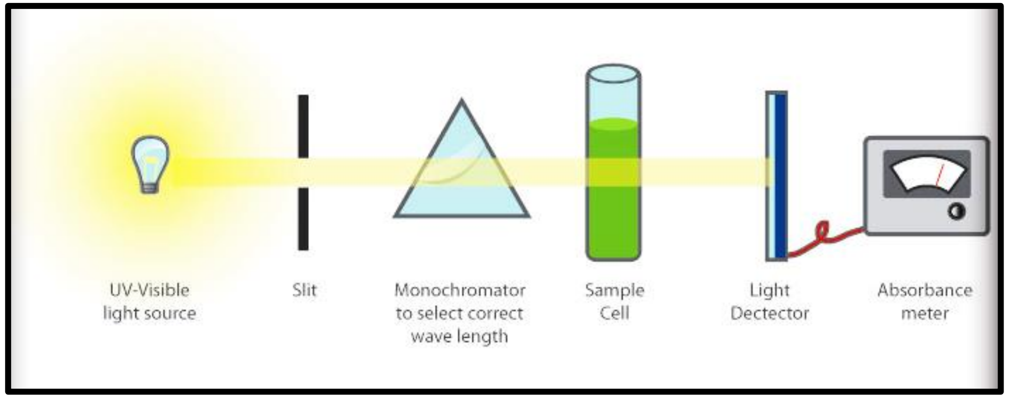
Simple and rapid gold nanoparticles (AuNPs) based antioxidant capacity assay



AuNPs



*** Spectrophotometer**



4.1) Caffeic acid evaluation in food sample

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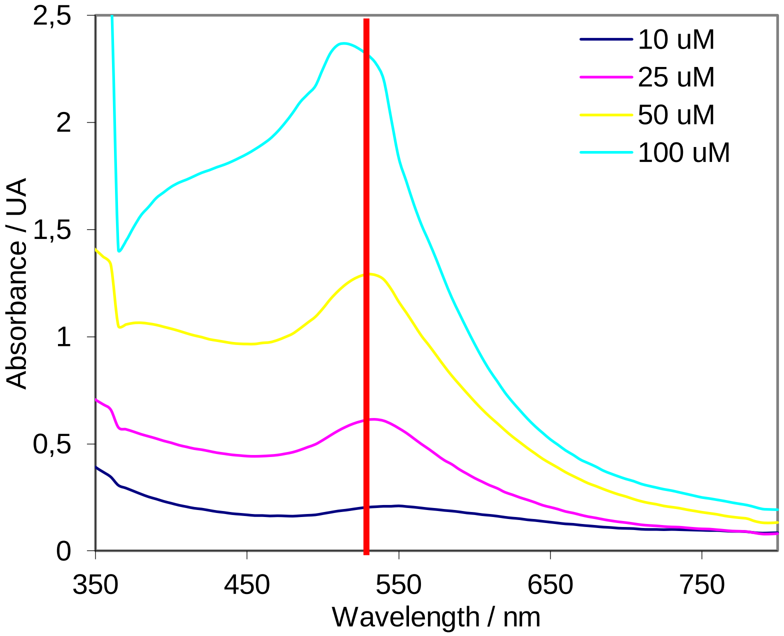
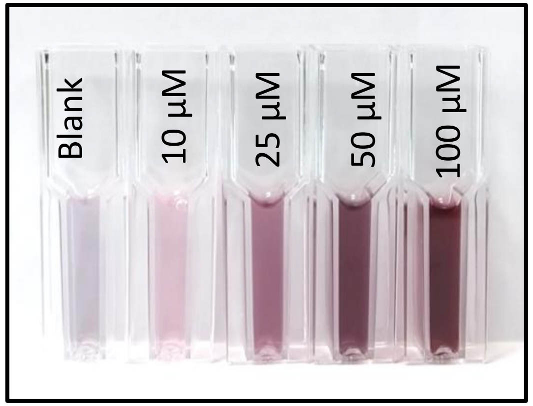
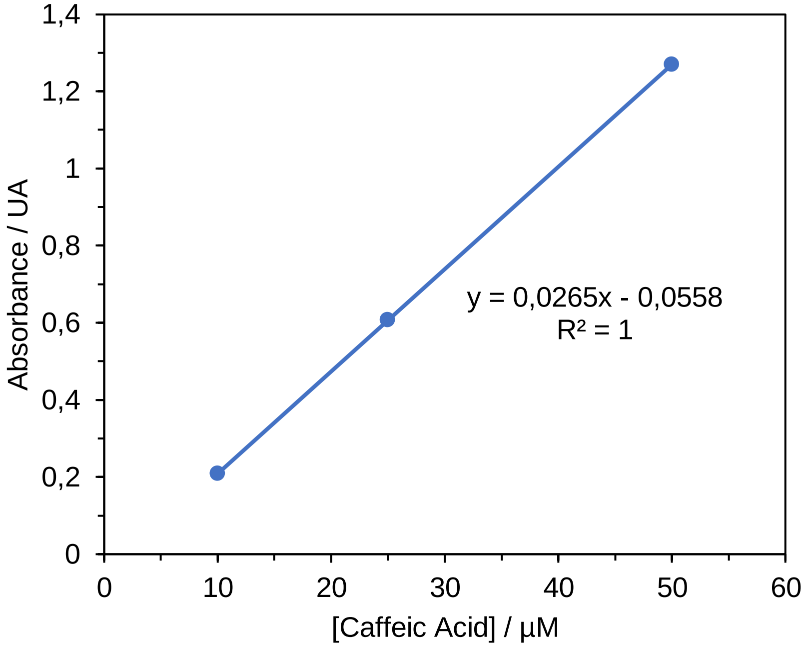
- Experimental dose-response curve construction



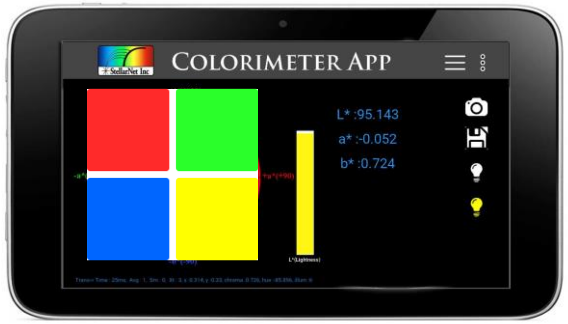




4.6) Caffeic acid evaluation in food sample

☐ Colorimetric approach

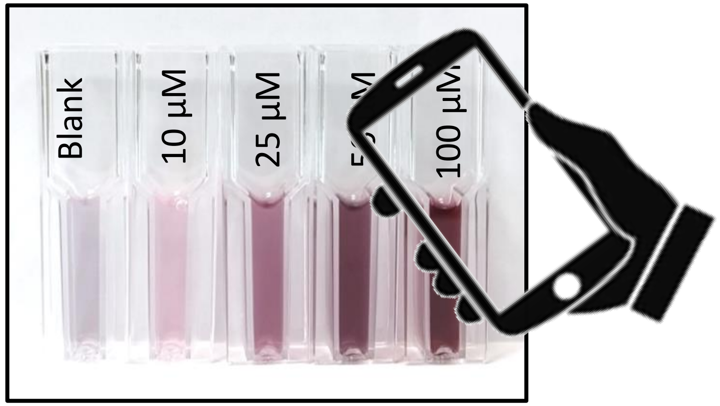
Google Play

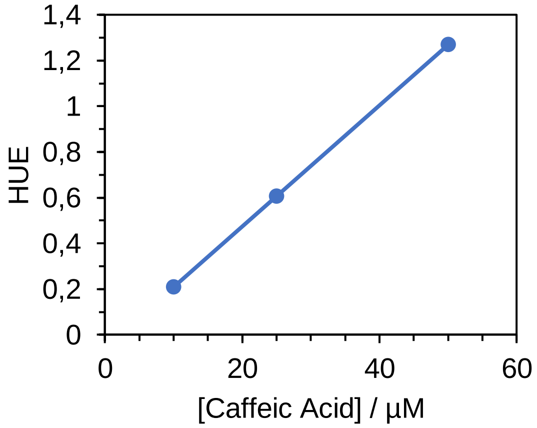


1) Take a picture of the reacted calibration curve using the white sheet as background
2) Take a picture of the reacted sample using the white sheet as background
3) With the downloaded app, take the analytical signal in the RGB colorimetric space
4) Try to build up the calibration curve using the RGB and the single hue (R, G, and B) as signal

Dose-response curve

HUE vs. [Standard]





SAMPLE and sample analysis

$$x = \frac{y \pm q}{m}$$