1st International Multidisciplinary Acorn as Food Workshop

ACORN 2024
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From Trees to Flour: Unlocking the Hidden Wonders of Acorns

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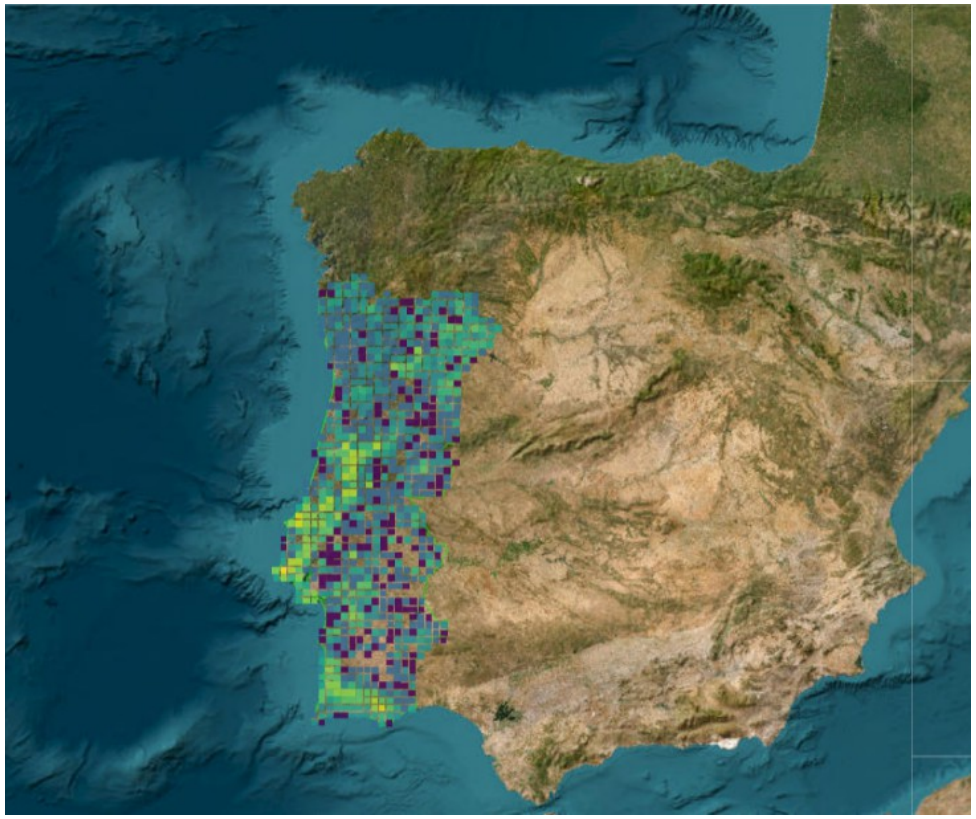
medacornet

- Establishment of an acorn value chain and mapping of producers
- Transformation of acorns, rich in tannins, into edible flour/granules
- Incorporation of acorn ingredients into food products
- Characterization of final food products
- Adopting acorns as a sustainable and healthy Mediterranean food ingredient



Distribution by species of different *Quercus* trees in the Portuguese mainland.
Purple – 1 species, **Blue – 4 species**, **Green – 7 species**, **Yellow – 10 species**.

METHODS

Acorn Kernel

Acorn Shell

Milling

Acorn Flour

Aqueous extraction & freeze-drying

Nutritional Composition

AOAC Methods

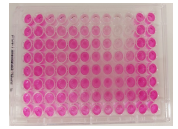
Phenolic Composition

HPLC-DAD-ESI/MS

Antioxidant Activity

TBARS & CAA Methods

Antiproliferative Activity



Colorimetric Sulforhodamine B

Antibacterial Activity

Clinical & Food Bacteria Strains

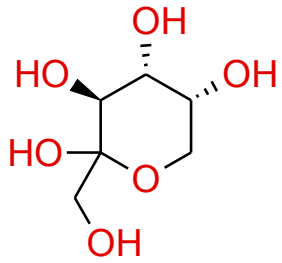
NUTRITIONAL COMPOSITION

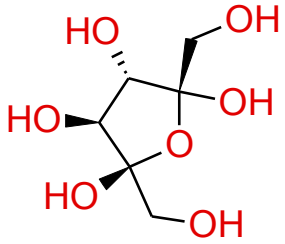
	Fat (g/100g)	Protein (g/100g)	Ash (g/100g)	Fiber (g/100g)	Carbohydrates (g/100g)	Energetic value (kcal/100g)
Q. rotundifolia	8.8 ± 0.4	3.07 ± 0.05	1.9 ± 0.1	16 ± 2	63 ± 2	376 ± 4
Q. suber	4.85270 ± 0.00005	6.1 ± 0.2	2.28 ± 0.08	11.1 ± 0.6	67.9 ± 0.9	362 ± 1
Q.	0.09	3.62 ± 0.02	1.51 ± 0.03	25.7 ± 0.9	57.9	0.7

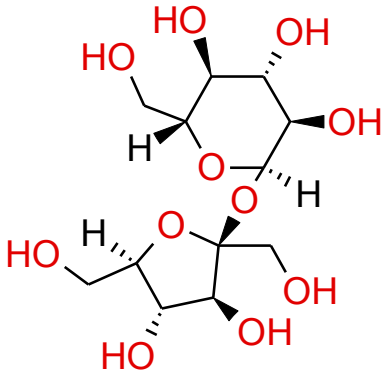
Fatty Acids

- **Oleic Acid C18:1n9c** → **Majority Compound** → **55 – 66 %**
- **Palmitic Acid C16:0**
- **Linoleic Acid C18:2n6c**

Total Soluble Sugars





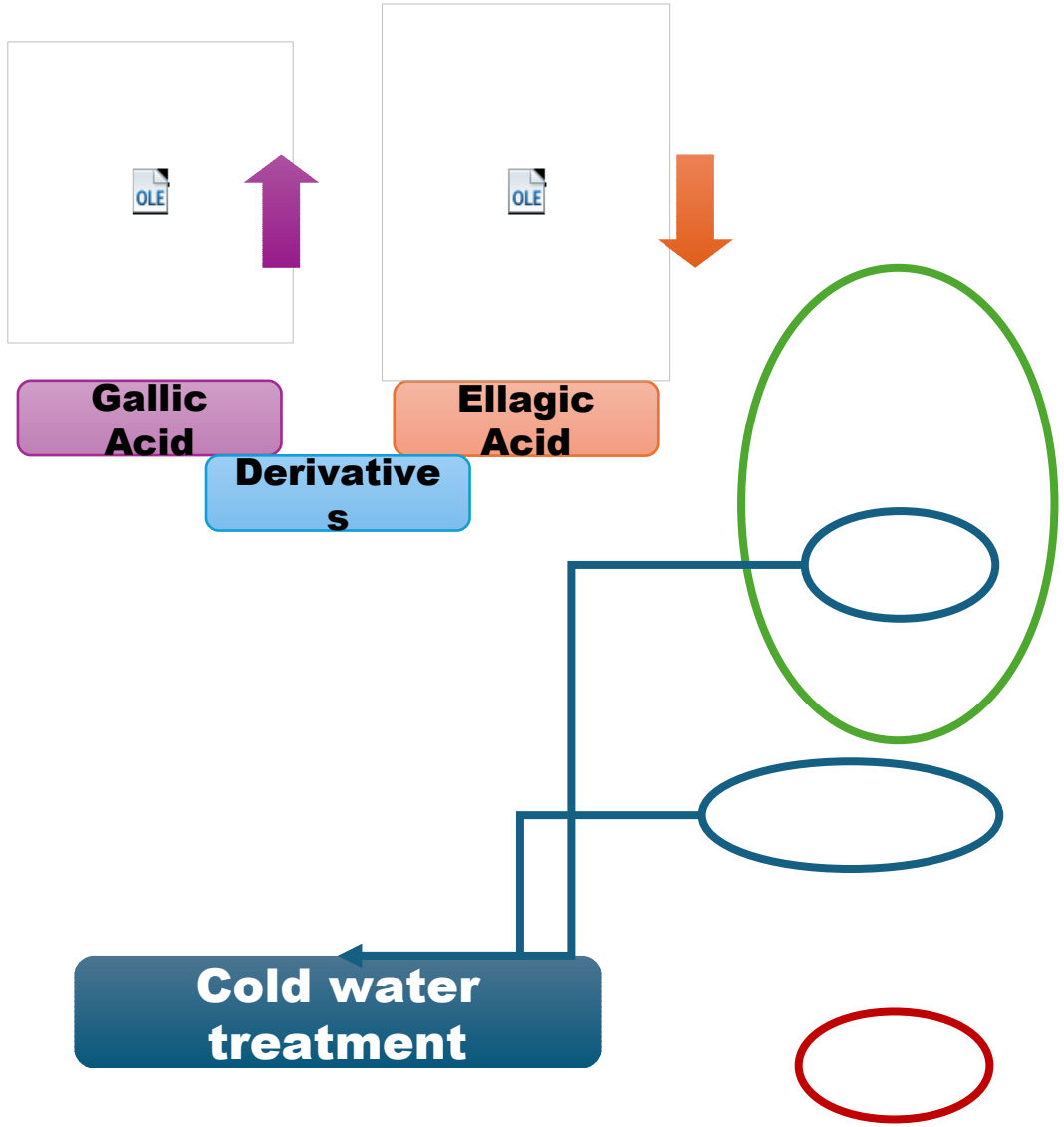


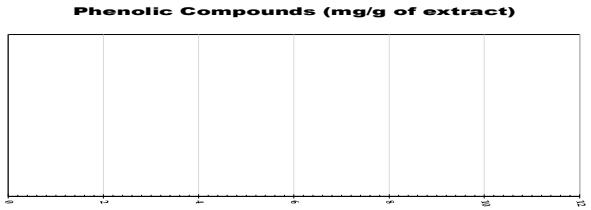
12 – 20 g/100g

PHENOLIC COMPOSITION: FLOUR

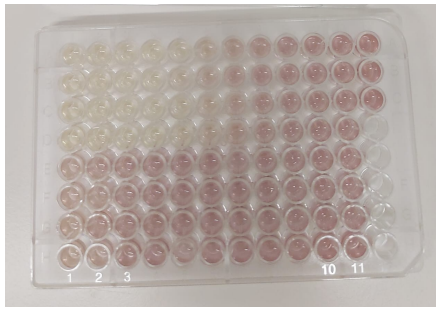
Phenolic Compounds (mg/g of extract)	*Q. robur_1*	*Q. robur_2*	*Q. robur_3*	*Q. robur_4*	*Q. rotundifolia_1*	*Q. rotundifolia_2*	*Q. suber_1*
Digalloyl hexoside	**n.d.**	**n.d.**	**n.d.**	**n.d.**	**n.d.**	4.20 ± 0.02	1.81 ± 0.08
Gallic acid	6.16 ± 0.02	10.8 ± 0.4	16.0 ± 0.3	11.8 ± 0.7	15.8 ± 0.5	1.44 ± 0.03	0.149 ± 0.006
Punicalin	0.408 ± 0.003	0.055 ± 0.004	0.117 ± 0.002	0.0037 ± 0.0001	0.110 ± 0.002	**Tr.**	**Tr.**
Ellagic acid hexoside isomer I	1.2116 ± 0.0001	**n.d.**	**n.d.**	**n.d.**	**n.d.**	**n.d.**	**n.d.**
Ellagic acid hexoside isomer II	1.317 ± 0.002	1.327 ± 0.002	**n.d.**	1.311 ± 0.003	**n.d.**	1.192 ± 0.001	1.207 ± 0.007
Ellagic acid pentoside isomer I	1.2737 ± 0.0004	1.238 ± 0.002	**n.d.**	1.253 ± 0.002	**n.d.**	1.204 ± 0.001	1.203 ± 0.009
Ellagic acid pentoside isomer II	1.1992 ± 0.0001	**n.d.**	**n.d.**	n.d.	**n.d.**	**n.d.**	**n.d.**
Ellagic acid	1.3352 ± 0.0002	1.399 ± 0.002	**n.d.**	1.296 ± 0.001	**n.d.**	1.316 ± 0.001	1.55 ± 0.01
Methyl ellagic acid hexoside	1.2023 ± 0.0001	**n.d.**	**n.d.**	n.d.	**n.d.**	**n.d.**	**n.d.**
Methyl ellagic acid pentoside	1.2033 ± 0.0001	1.2066 ± 0.0001	**n.d.**	1.200 ± 0.001	**n.d.**	1.22 ± 0.03	**n.d.**
Dehydrated tergallic-C-glucoside isomer I	**n.d.**	0.067 ± 0.002	0.256 ± 0.004	0.445 ± 0.005	0.104 ± 0.004	**n.d.**	**n.d.**
Vescalagin	**n.d.**	0.0060 ± 0.0002	0.026 ± 0.001	**Tr.**	0.079 ± 0.004	**n.d.**	**n.d.**
Galloyl-HHDP-glucose isomer I	0.127 ± 0.003	0.034 ± 0.002	0.165 ± 0.002	**Tr.**	0.118 ± 0.002	**n.d.**	**n.d.**
Dehydrated tergallic-C-glucoside isomer II	**Tr.**	0.201 ± 0.003	**Tr.**	0.096 ± 0.003	**Tr.**	**n.d.**	**n.d.**
Digalloyl-HHDP-hexose	**Tr.**	0.99 ± 0.03	0.0060 ± 0.0001	**n.d.**	**Tr.**	**n.d.**	**n.d.**
		0.2278 ±		**Tr.**			

PHENOLIC COMPOSITION: FLOUR





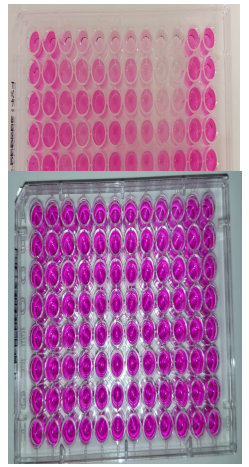
BIOACTIVITIES: FLOUR

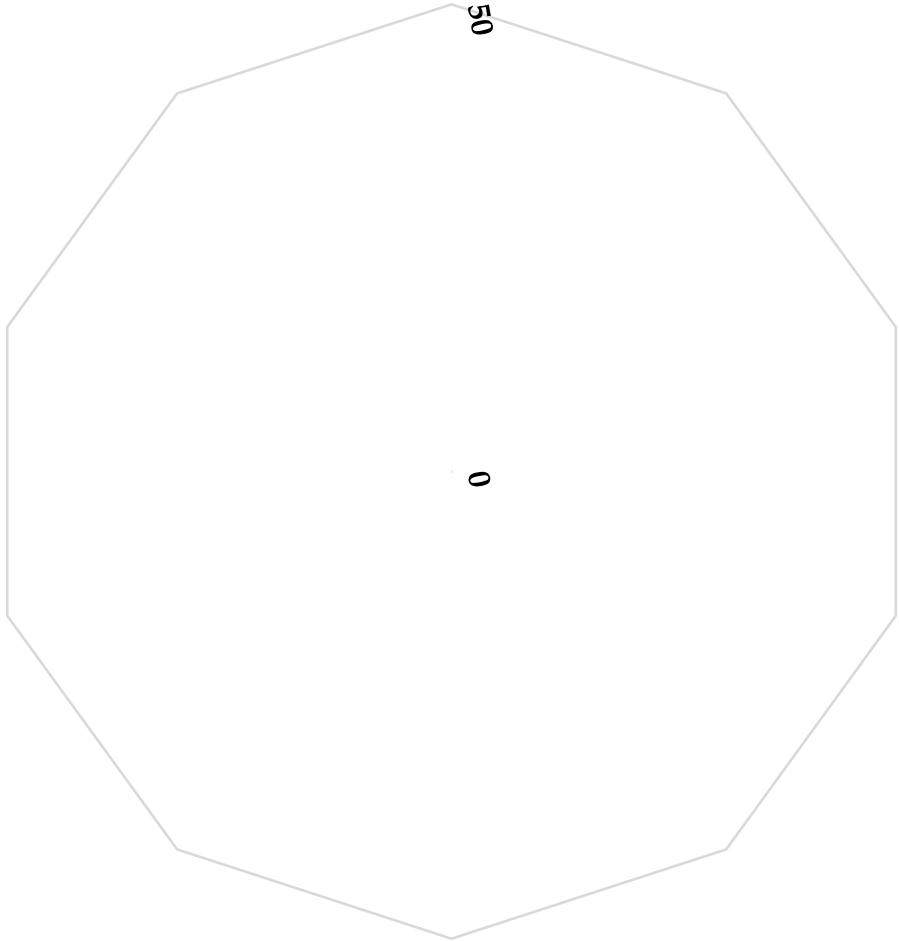


CAA

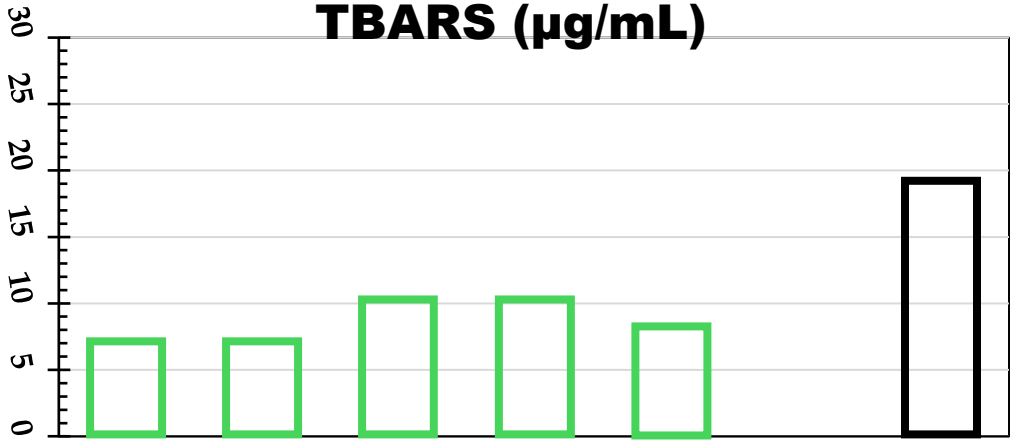
0% inhibition for Maximum Concentration Tested

Antiproliferative Activity (µg/ml)





TBARS (µg/mL)



BIOACTIVITIES: FLOUR

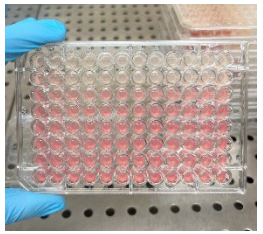
Antibacterial activity - Clinical bacteria (MIC/MBC, mg/mL)

		Acorn shell samples							Positive Controls		
		Q. rob-1	*Q. rob-2*	*Q. rob-3*	*Q. rob-4*	*Q. rot-1*	*Q. rot-2*	*Q. sub-1*	Ampicillin	Imipenem	Vancomycin
Gram-negativ	*E. coli*	1.25/>10	10/>10	5/>10	10/>10	5/>10	10/10	10/10	<0.15/<0.15	8	n.t/n.t
	K. pneumoniae	0.3/>10	1.25/>10	5/>10	5/>10	5/>10	>10/>10	10/10	10/>10	<0.0078/<0.0078	n.t/n.t
	M. morganii	0.3/>10	0.3/>10	2.5/>10	2.5/>10	2.5/>10	2.5/2.5	0.6/5	>10/>10	<0.0078/<0.0078	n.t/n.t
	P. mirabilis	0.6/>10	1.25/>10	0.6/>10	0.6/>10	2.5/>10	2.5/10	0.6/10	<0.15/<0.15	<0.0078/<0.0078	n.t/n.t
	P. aeruginosa	5/>10	2.5/>10	5/>10	5/>10	5/>10	10/10	10/10	>10/>10	0.5/1	n.t/n.t

Antibacterial activity - Food bacteria (MIC/MBC, mg/mL)

		Acorn shell samples							Positive Controls		
		Q. rob-1	*Q. rob-2*	*Q. rob-3*	*Q. rob-4*	*Q. rot-1*	*Q. rot-2*	*Q. sub-1*	Ampicillin	Streptomycin	Methicillin
Gram-negat	*E. cloacae*	2.5/>10	5/>10	5/>10	2.5/>10	5/>10	5/5	2.5/5	0.15/0.15	0.007/0.007	n.t/n.t
	E. coli	2.5/>10	10/>10	10/>10	10/>10	10/>10	10/10	5/5	0.15/0.15	0.01/0.01	n.t/n.t
	P. aeruginosa	10/>10	10/>10	5/>10	5/>10	5/>10	10/10	5/5	0.63/0.63	0.06/0.06	n.t/n.t
	S. enterica	2.5/>10	2.5/>10	2.5/>10	2.5/>10	5/>10	10/10	2.5/5	0.15/0.15	0.007/0.007	n.t/n.t
	Y. enterocolitica	0.07/>10	5/>10	2.5/>10	0.07/>10	5/>10	10/10	10/10	0.15/0.15	0.007/0.007	n.t/n.t

9 Clinical Bacteria strains tested



8 Food Bacteria strains tested

PHENOLIC COMPOSITION: SHELL

Phenolic Compounds (mg/g of extract)	*Q. rotundifolia_1*	*Q. rotundifolia_2*	*Q. suber_1*	*Q. suber_2*	*Q. robur_1*
Digalloyl hexoside	3.9 ± 0.1	8.3 ± 0.1	3.38 ± 0.04	2.93 ± 0.03	3.16 ± 0.04
Gallic acid	0.90 ± 0.03	0.493 ± 0.004	0.81 ± 0.04	0.60 ± 0.03	1.34 ± 0.01
Galloyl-HHDP-glucose	**Tr.**	0.42 ± 0.01	**Tr.**	**Tr.**	**Tr.**
Punicalin	**Tr.**	**n.d.**	**n.d.**	**Tr.**	**Tr.**
Digalloyl-HHDP-hexose	**Tr.**	**n.d.**	**Tr.**	**n.d.**	**n.d.**
Ellagic acid hexoside	1.1927 ± 0.0003	**n.d.**	1.202 ± 0.001	1.195 ± 0.001	1.191 ± 0.001
Ellagic acid pentoside	**n.d.**	**n.d.**	**n.d.**	**n.d.**	1.193 ± 0.001
Ellagic acid	1.259 ± 0.001	1.210 ± 0.002	1.399 ± 0.002	1.425 ± 0.004	1.270 ± 0.003
Methyl ellagic acid pentoside	1.2013 ± 0.0004	1.212 ± 0.001	1.217 ± 0.001	**n.d.**	1.197 ± 0.001
Total phenolic compounds	**8.5 ± 0.1**	**10.5 ± 0.1**	**8.0 ± 0.1**	**6.15 ± 0.08**	**10.6 ± 0.1**

PHENOLIC COMPOSITION: SHELL

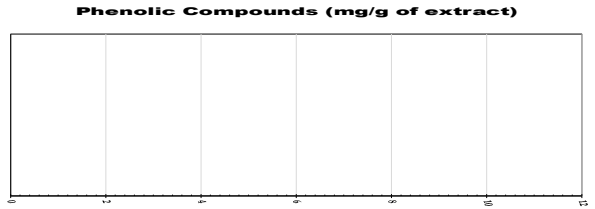
Gallic Acid

Ellagic Acid

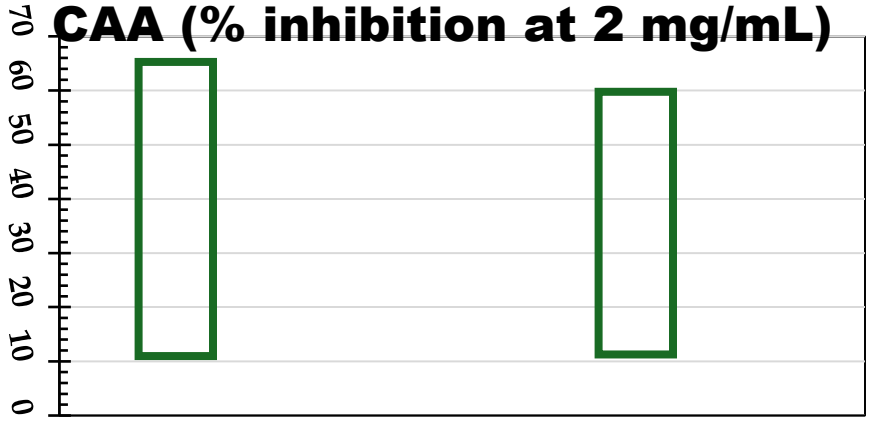
Derivatives

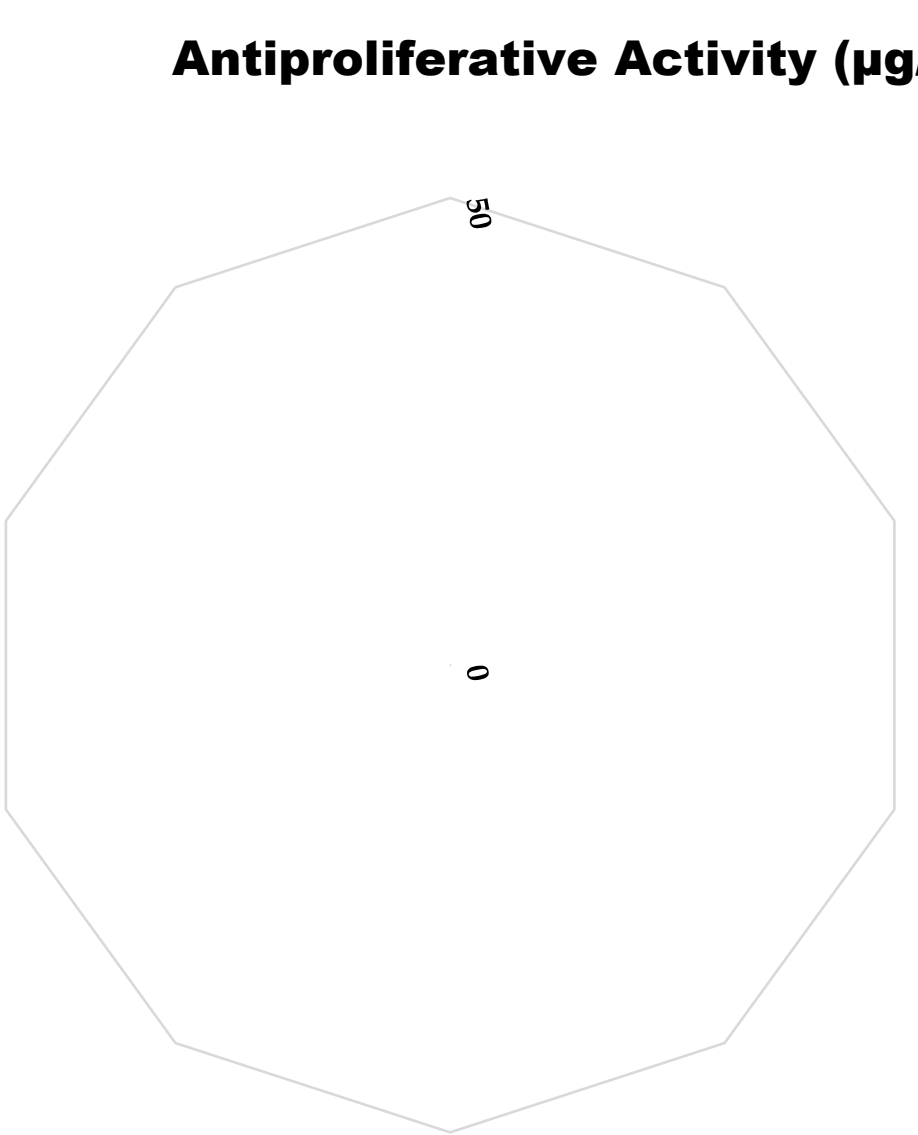
Higher concentration of Digalloyl Hexoside

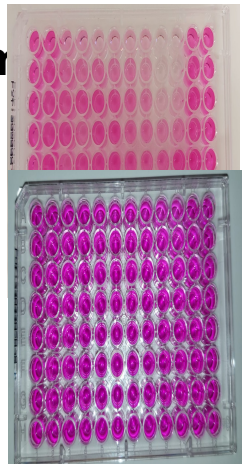
Reddish/brown color

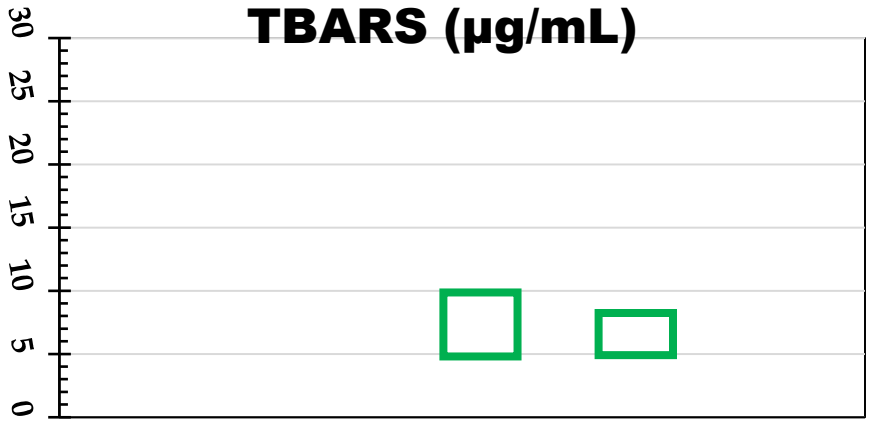


BIOACTIVITIES: SHELL









IOACTIVITIES: SHELL

Antibacterial activity - Clinical bacteria (MIC/MBC, mg/mL)									
		Acorn shell samples					Positive Controls		
		Q. rot-1	*Q. rot-2*	*Q. sub-1*	*Q. sub-2*	*Q. rob-1*	Ampicillin	Imipenem	Vancomycin
Gram-negative	*E. coli*	10/10	>10/>10	2.5/10	>10/>10	>10/>10	<0.15/<0.15	<0.0078/<0.0078	n.t/n.t
	K. pneumoniae	10/>10	>10/>10	5/>10	>10/>10	>10/>10	10/>10	<0.0078/<0.0078	n.t/n.t
	M. morganii	2.5/2.5	>10/>10	0.3/1.25	>10/>10	>10/>10	>10/>10	<0.0078/<0.0078	n.t/n.t
	P. mirabilis	2.5/10	>10/>10	2.5/10	>10/>10	>10/>10	<0.15/<0.15	<0.0078/<0.0078	n.t/n.t
	P. aeruginosa	10/>10	>10/>10	1.25/>10	>10/>10	>10/>10	>10/>10	0.5/1	n.t/n.t

Antibacterial activity - Food bacteria (MIC/MBC, mg/mL)										
		Acorn shell samples					Positive Controls			
		Q. rot-1	*Q. rot-2*	*Q. sub-1*	*Q. sub-2*	*Q. rob-1*	Ampicillin	Streptomycin	Methicillin	
Gram-negati	*E. cloacae*	5/>10	>10/>10	2.5/2.5	>10/>10	>10/>10	0.15/0.15	0.007/0.007	n.t/n.t	t
	E. coli	10/10	>10/>10	5/10	>10/>10	>10/>10	0.15/0.15	0.01/0.01	n.t/n.t	
	P. aeruginosa	10/>10	>10/>10	10/>10	>10/>10	>10/>10	0.63/0.63	0.06/0.06	n.t/n.t	
	S. enterica	5/10	>10/>10	2.5/5	>10/>10	>10/>10	0.15/0.15	0.007/0.007	n.t/n.t	
	Y. enterocolitica	10/10	>10/>10	5/5	>10/>10	>10/>10	0.15/0.15	0.007/0.007	n.t/n.t	

9 Clinical Bacteria strains tested

No antifungal activity against A. *brasiliensis* A. *fumigatus*

8 Food Bacteria strains tested

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CONCLUSIONS & FUTURE PERSPECTIVES

1. Acorn flour is a nutrient-rich ingredient, mainly fiber and unsaturated fatty acids.
2. Acorn flour samples from the species *Q. robur* and *Q. rotundifolia* proved to be rich in phenolic compounds and demonstrated an excellent antioxidant, antiproliferative capacity, and antibacterial potential.
3. Acorn shell extracts have proven to be rich in phenolic compounds with high antioxidant power and antibacterial potential.
4. Future and promising studies to incorporate acorn flour into food products and acorn shell extract in products of various industries will be carried out to establish an added value chain for acorns.

From Trees to Flour: Unlocking the Hidden Wonders of Acorns

THANK YOU FOR YOUR ATTENTION!

Funding

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