Inhibition of fish cooking wastewater oxidation with acorn extract

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Rationale

- Fish and fish oils are excellent sources of omega-3 long-chain polyunsaturated fatty acids (PUFAs), especially eicosapentaenoic (EPA) and docosapentaenoic acids (DHA).
- EPA and DHA have been associated with several health benefits related to the brain, cardiovascular and kidney functions as well as to inflammatory and immunological responses[1].
- PUFAs multiple bonds' chemical nature makes them highly unstable and easily oxidizable. Their oxidation contributes to off-flavors in foods and their products (*e.g.* hydroperoxides and aldehydes) have also been associated with harmful health effects[1,2].
- Value-added strategies to stabilize PUFAs present in fish oils such as the application of antioxidant extracts have gained popularity[2].
- Acorn is a fruit of *Quercus coccifera* L. (kermes oak) species, reported as a potent natural antioxidant with a high total phenolic content[3].

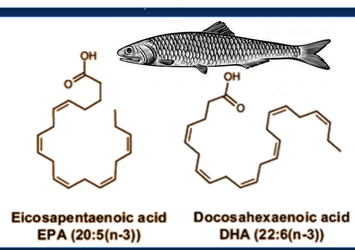
Aim

Evaluate the antioxidant stabilization potential of a natural antioxidant extract on a rich source of omega-3

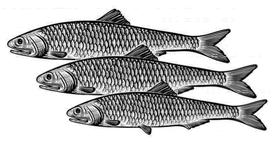
- Phenolic acids (*e.g.* gallic acid)
- Tannins (*e.g.* ellagic acid)
- Flavonoids

Acorn extract

Wastewater resultant from *Sardina pilchardus* cooking (circular economy valorization)



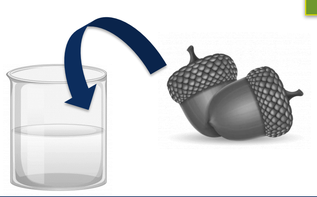
Materials and methods



Sardina pilchardus cooking

Wastewater from sardine cooking

Cooking water (control sample)



Treatment with acorn extract

Centrifugation to separate the fat fraction

- Soxhlet method
- Peroxide index (ISO 3960:2007)
- Total fatty acid derivatization method index (GC-FID)

Results and discussion

	Total fat content (g/100g)	Peroxide index (meq O_2/kg of fat)
Cooking water (control sample) - CW	83.10±0.14	98.75±0.07
Cooking water treated with acorn extract –CW-AE	83.25±0.28	97.50±0.14

- The results indicated a decrease in the oxidation index with acorn extract treatment.
- In order to identify and quantify the impact of antioxidant extract (mainly on omega-3 long-chain PUFAs concentration), the fatty acids profile of sardine cooking water was monitored.

- The results suggested some variations in both [saturated] and [unsaturated] fatty acids.
- However, these variations were more evident in long-chain unsaturated fatty acids: oleic acid (omega-9), LA (omega-6), ALA (omega-3), C18:2 c0t11, c20:1 c9, arachidonic acid (omega-6), EPA, DPA and DHA - which were more incident in acorn extract-treated sample.
- In the antioxidant-treated sample, the EPA had a concentration of 115.7 µg mL^{-1} and DHA of 28.4 µg mL^{-1}, in contrast to 0.25 and 0.0 µg mL^{-1}, respectively, in the control sample.

Fatty acid	CW (µg/mL)	CW-AE (µg/mL)
C12:0 Lauric acid	0.72±0.07	0.65±0.00
C14:0 i Isomyristic acid	0.14±0.01	0.12±0.01
C14:0 Myristic acid	52.13±3.94	47.20±0.36
C15:0 Pentadecenoic acid	3.47±0.23	3.02±0.02
C15:1	0.06±0.02	0.53±0.06
C16 Palmitic acid	157.38±9.25	137.27±0.72
C16:1 t9 TFA	2.38±0.17	2.04±0.01
C16:1 c7	0.16±0.03	0.13±0.02
C16:1 c9 Palmitoleic acid	80.31±6.33	73.01±2.29
C17 i isoheptadecanoic acid	1.13±0.09	1.02±0.00
C17 ai	**2.73±0.25**	0.43±0.01
C16:1 c11	0.27±0.03	**2.88±0.00**
C17:0 Margaric acid	0.31±0.03	**8.98±0.06**
C17:1 c9	**113.56±15.51**	0.96±0.02
C17:1 c10	15.57±22.02	9.46±0.13
C18 i Isooctanoic acid	**0.82±0.05**	0.26±0.00
C18:0 Stearic acid	0.08±0.00	**26.88±0.12**
C17:1 t10	**6.83±0.52**	0.12±0.01
C18:1 t12	0.10±0.04	**0.84±0.01**
C18:1 c9 Oleic acid	0.07±0.00	**87.65±0.38**

Fatty acid	CW	CW-AE
C18:1 c11	4.38±0.35	**23.59±3.97**
C18:1 c12	0.94±1.25	0.65±0.01
C18:1 c13	**1.08±1.41**	0.16±0.02
C18:2 t9t12 Linolelaidic acid	0.53±0.62	**3.42±0.01**
C18:1 c14	**1.95±1.18**	0.15±0.00
C18:2 c9t12	**1.75±2.01**	0.47±0.03
C18:2 c9c12 Linoleic acid (LA)	2.68±3.21	**5.37±0.05**
C18:2 c9c15	2.70±3.75	3.98±0.03
C18:3 t0t12c15	0.11±0.07	0.26±0.01
C18:3 c6c9c13	**32.04±2.77**	1.51±0.01
C18:3 c9c12c15 α-Linolenic acid (ALA)	0.32±0.04	**4.45±0.09**
C20:0 Arachidic acid	5.10±0.37	**13.61±0.12**
C18:2 c0t11	0.88±0.07	**14.04±0.01**
c20:1 c9	0.08±0.02	**4.25±0.18**
C20:4 c5c8c11c14 Arachidonic acid	1.51±0.40	**5.96±0.10**
C22:0 Behenic acid	0.17±0.03	**4.97±6.56**
C20:5 c5c8c11c14c17 (EPA)	0.25±0.02	**115.72±0.7**
C24:0 Lignoceric acid	0.38±0.00	**0.89±0.00**
C22:5 docosapentaenoic acid (DPA)	0±0	**10.93±0.01**
C22:6 c4,c7,c10,c13,c16,c19 (DHA)	0±0	**28.39±0.15**

Conclusions

- The intake of fish oil supplements has been increased due to their rich omega-3 long-chain PUFAs nutritional composition and consequent health claims.
- According to the European Food Safety Authority, the intake of 250 mg per day of EPA and DHA is recommended for the maintenance of general cardiovascular health in healthy children and adults. It is also recommended an intake between 2 and 3 g per day to maintain normal blood pressure and triglyceride levels[4].
- Although their high nutritional value, PUFAs are highly susceptible to oxidation and antioxidants have been applied to try to stabilize the PUFAs profile[1,2].
- Based on a circular economy valorization approach, the potential oxidation inhibition of an acorn extract on wastewater from sardine cooking (a rich source of omega-3 long-chain PUFAs) was investigated. The preliminary results indicated that acorn extract may reduce the peroxide index and prevent PUFAs oxidation.
- As future work, stability tests will be carried out to define the potential applications of this omega-3 long-chain PUFAs rich oil (based on wastewater from sardine cooking) as a food ingredient or in the incorporation and development of a fish oil nutritional supplement.

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Acknowledgments

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