Valorizing Oregano Distillation Wastewater in new pasta formulations

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CONTEXT

Trends: Environmental and health awareness → Green / Healthy products.
Industry Problem: Agro-food industry produces a lot of **waste.**
Sustainability Goal: Valorization of waste products.
Resource: Essential Oils (EO) (e.g., oregano) → Rich in bioactive compounds (e.g., carvacrol, thymol).
Essential Oils Waste: EO extraction produces residual wastewater (waste).

OPPORTUNITY & CHALLENGE

OBJECTIVE

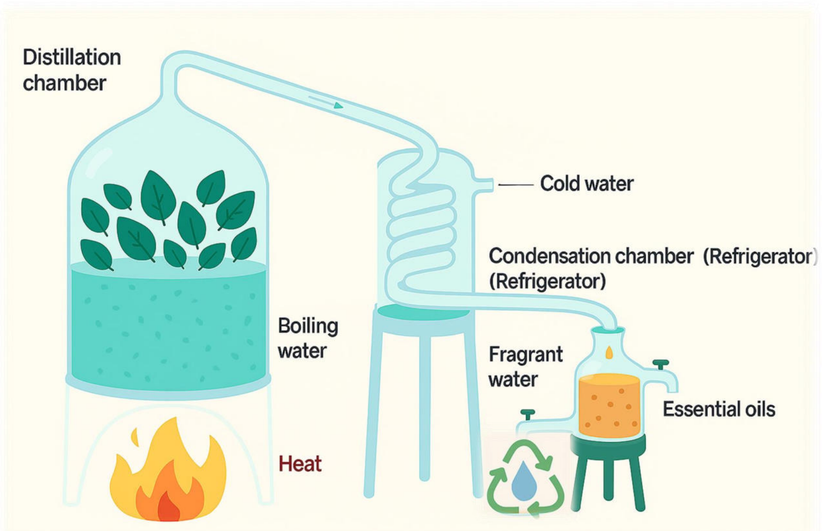
Valorisation of Oregano Distillation Wastewater (OW)

Application: Incorporation into fortified pasta

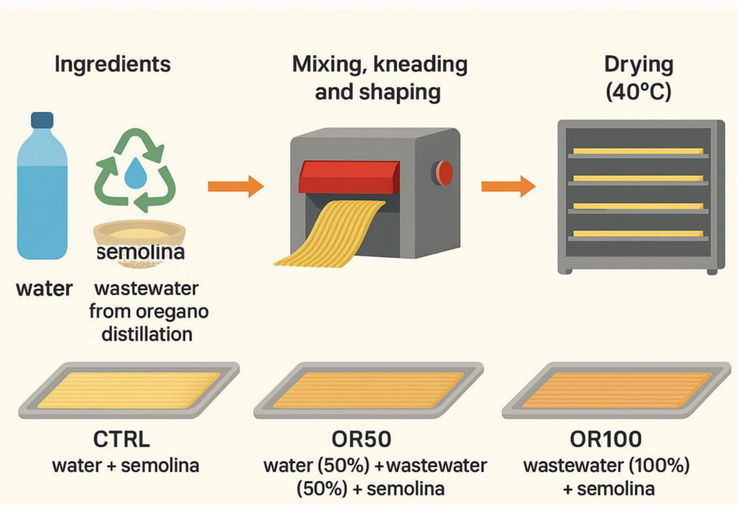
Impact assessment: cooking quality, sensory analysis, content of bioactive compounds, antioxidant activity.

MATERIALS AND METHODS

DISTILLATION PROCESS



PASTA PRODUCTION PROCESS



ANALYSIS

Sensory Analysis

Colour Determination using a Colorimeter

Cooking Quality
Optimal Cooking Time (OCT)
Water Absorption (WAI)
Swelling Index (SI)
Cooking Losses (CL)

Total polyphenol content by Folin Ciacolteau method and HPLC quantification of main components

RESULTS

TOTAL POLYPHENOL CONTENT

The analysis confirms that wastewater from oregano distillation is a significant and rich source of phenolic compounds, particularly **rosmarinic acid**.

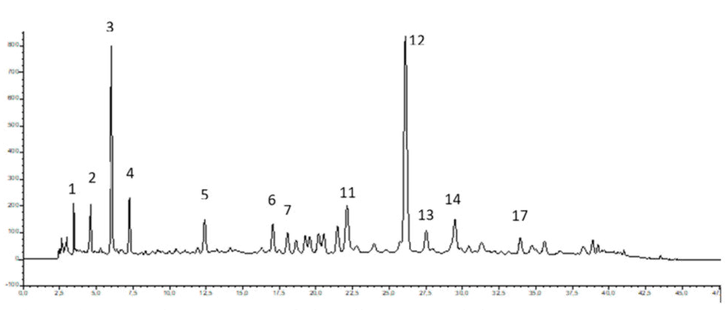


Figure 1. HPLC chromatogram of phenolic compounds in oregano wastewater. Peak identification corresponds to the compounds listed in Table 1

	Retention time	COMPOUND	mg/gr. OF LYOPHILIZED
1	3,5	Gallic acid derivative 1	0,99
2	4,6	Gallic acid derivative 2	2,04
3	6,0	Syringic acidc	9,81
4	11,9	Unknown	N.A.
5	12,4	Dihydrophenilacetic acid	1,38
6	17,1	Luteolin 3′,7-di-O-glucuronide	0,01
7	18,1	Unknown	N.A.
11	22,1	Luteolin-7-O-glucuronide	0,02
12	**26,1**	**Rosmarinic acid**	**46,02**
13	27,5	Luteolin derivative 1	0,01
14	29,5	Apigenin derivative 2	7,82
17	32,0	Luteolin-7-O-rutinoside	0,00

Table 1. Quantitative Analysis of Compounds Identified in wastewater from oregano distinnalion by HPLC-MS.

Wastewater (OW) has a high total phenolic content (TPC), confirming its status as a powerful source of bioactive compounds for fortification.

Fortifying pasta with OW significantly **increases the TPC of the final product** (OR50 and OR100), it also leads to a greater loss of these bioactive compounds in the cooking water

TPC (mg GAE/100 g)			
	Cooked pasta	Cooking water	OW
CTRL	14.15	0.64	
OR50	49.86	3.82	978.837
OR100	79.29	7.19	

Table 2. Total Polyphenol Content (TPC) in Samples, expressed as mg of Gallic Acid Equivalents (GAE) per 100g.

TPC analysis was performed using the Folin-Ciocalteu method.

SENSORY PROFILE

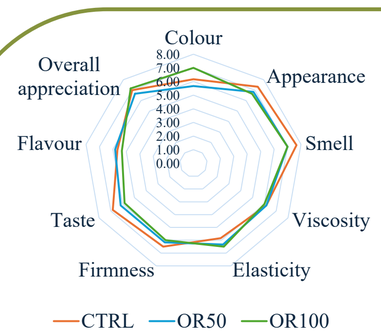


Figure 2. Sensory Profile of Cooked Pasta

Using oregano wastewater instead of water in recipes does not negatively affect sensory characteristcs of pasta compared to the control sample.

Despite receiving the lowest taste score, the **OR100** sample achieved the highest overall appreciation, suggesting that positive sensory characteristics such as darker colour and texture compensated for the less intense flavour.

COOKING QUALITY

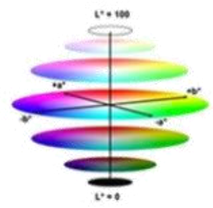
OCT: the results were consistent, suggesting that there was no significant change in the pasta's structure that affected the time required for complete starch gelatinisation.
CL: the fortified samples showed an average value that was higher than that of the control. This increase is attributed to gluten proteins being diluted by oregano wastewater, which weakens the starch-protein matrix and consequently leads to greater solids loss in the water.
WAI and SI:
OR50: The decrease suggests that the wastewater may have stabilised the pasta matrix, resulting in a more compact structure and limited water absorption during cooking.
OR100, however, weakened the protein-starch matrix, allowing greater and easier water penetration (an increase in WAI) and resulting in a slight loss of structural strength.

Pasta samples	OCT (min)	WAI (%)	CL (%)	SI (g water per g dry pasta)
CTRL	7	181.7	5.78	241.15
OR50	7	174.5	5.95	232.85
OR100	7	182.95	6.44	239.28

Table 3. Cooking quality of pasta samples

COLOUR

L∗ decreases: the pasta gradually becomes **darker** (from 53.20 to 45.46) as the oregano extract increases
a∗ increases: the pasta shifts towards **red** (from 0.60 to 3.39), indicating a change in hue caused by the oregano
b∗ decreases: the pasta is slightly less **yellow** (from 17.10 to 15.44)



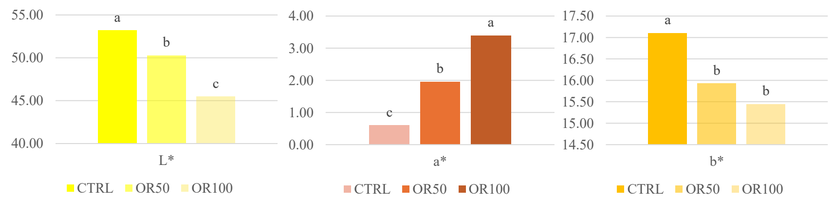


Figure 3. Color parameters (L*, a*, b*) of cooked pasta samples.

CONCLUSION

Fortifying pasta significantly increased its total phenolic content while maintaining good cooking properties (acceptable OCT and CL) and also increase the presence of rosmarinic acid. Using this by-product as an ingredient in pasta production is a sustainable way to enhance a staple food.