ANTIOXIDANT AND ANTIBACTERIAL ACTIVITIES OF BITTER ORANGE (*Citrus aurantium* L.) AND SWEET ORANGE (*Citrus sinensis* L. Osbeck) PEEL EXTRACTS

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Introduction

Citrus processing generates a substantial amount of peel waste, which is a valuable source of bioactive compounds with potential antimicrobial properties. This study investigated the antioxidant and antibacterial activities of bitter orange (BO) and sweet orange (SO) peels.

Materials and Methods

The fruits were washed and air-dried at room temperature. The flavedo and albedo were removed with a fruit peeler and crushed.

- total phenolics (TP) - Folin-Ciocalteu colorimetric method with gallic acid as standard
- antioxidant activity (AA) – ABTS and DPPH assay - methods with Trolox as standard; measurements were performed in three parallels

Extracts were prepared by extraction in an ultrasound bath (25 °C, 15 min.) using ethanol (1:10), vacuum concentrated, and tested by agar disc-diffusion (5 mm discs) at 25 mg mL^{-1} in DMSO.

Four bacterial strains (*E. coli*, *S. enteritidis*, *L. monocytogenes*, *S. aureus*) were tested using the disc diffusion method. Bacterial suspensions (0.5 McFarland) were swabbed onto Mueller-Hinton agar. Sterile discs (5 mm) were loaded with 10 µL of orange extracts, alongside control antibiotics (tetracycline, penicillin G, cefotaxime, erythromycin, ceftazidime, piperacillin). After 1-hour pre-diffusion at 4°C, plates were incubated at 37°C, and inhibition zones were quantified with a digital caliper. All assays were conducted in duplicate.

Results

Table 1 Total phenolics and antioxidant activity of BO and SO

Sample	TP (g kg^{-1})	AA (µmol 100 mL^{-1})	
		ABTS	DPPH
Flavedo BO	16.388 ± 0.562	95.004 ± 1.151	19.666 ± 1.962
Albedo BO	49.394 ± 0.308	201.937 ± 5.105	27.395 ± 0.259
Flavedo SO	22.579 ± 1.274	122.652 ± 3.271	23.675 ± 0.733
Albedo SO	17.770 ± 1.932	106.996 ± 3.335	5.752 ± 0.543

Table 2 Bitter orange and sweet orange antibacterial activity

Tested bacteria		Bitter orange		Sweet orange	
		flavedo	albedo	flavedo	albedo
G (-)	*E. coli*	7.98^{a*}	6.53^{ab}	7.74^{b}	7.94^{a}
	S. enteritidis	8.61^{b}	7.19^{b}	9.10^{c}	8.13^{a}
G (+)	*L. monocytogenes*	0	0	0	0
	S. aureus	0	0	0	0

* inhibition zones in mm; a, b, c - Rows with different letters are statistically significantly different ANOVA, Bonferroni post-hock test ($p < 0.05$)

Conclusions

- BO contains a significantly higher proportion of TP and greater antioxidant activity than SO.
- In BO`s, the albedo was a richer source of phenolic compounds than the flavedo, while in SO, the flavedo had higher TP content and greater AA than the albedo, regardless of the assay used.

- Antibacterial activity screening revealed species-specific susceptibility among G(-) bacteria.
- *S. enteritidis* showed significantly greater susceptibility to SO extracts (both flavedo and albedo), whereas
- *E. coli* exhibited consistent inhibition patterns across all citrus extract types, with no significant differences between BO and SO varieties or tissue types.

✓Higher concentrations of citrus peel extracts may provide a naturally derived, consumer-acceptable alternative for pathogen control in specific applications.

✓Additionally, valorisation of orange peel waste can significantly reduce agro-industrial waste by transforming it into a source of value-added antibacterial and antioxidant extracts, thereby supporting a circular economy.