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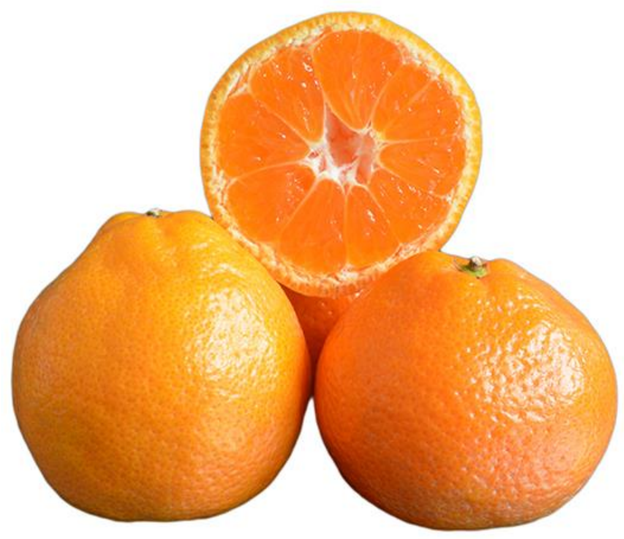
OPTIMIZATION OF HIGH VOLTAGE ELECTRIC DISCHARGE EXTRACTION OF PHENOLICS FROM MANDARIN PEEL



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INTRODUCTION

Citrus fruits are one of the most important crops with worldwide production, while citrus by-products represent a problem regarding their disposal due to the environmental risk. Traditionally, the waste was either burned, causing an increase in carbon dioxide and other greenhouse gasses, or used for cattle feed, but today more environmentally friendly approach was developed for obtaining the new high-value products. The peels make the largest amount of total produced citrus by-products, and they can be utilized for different purposes due to their bioactive compounds content. Since different processes can be applied for the extraction of bioactive compounds from citrus fruit, it is very important to find the most efficient extraction method to obtain the highest yield of selected bioactive compounds. The aim of this study was to investigate the possibility of applying high-voltage electric discharge technique for the extraction of phenolic compounds from mandarin peel (*Okitsu* variety), formed as by-products during the growth and fresh fruit processing.

METHODS

Mandarin peel was subjected to a high voltage electric discharge (HVED) assisted extraction procedure under different experimental conditions: solvent:solid ratio (200, 300, 400 mL/g), frequency (40, 70, 100 Hz) and treatment time (5, 10, 15 min) according to Box–Behnken design (BBD) in order to study the influence of these conditions on the extraction yield and content of phenolic compounds. Extraction was performed using custom-built equipment constructed by Ingeniare CPTS1 at the Faculty of Food Technology Osijek. Separation, identification and quantification of phenolic compounds in extracts from citrus peel were performed using an HPLC instrument equipped with a variable wavelength detector. The antiradical activity and the total phenolic content of the extracts were determined using spectrophotometric assays. Based on the obtained experimental data, the extraction process was optimized using the Design Expert® software.

RESULTS

Table 1 Extraction yield, total phenol content, antiradical activity and phenolic compounds detected in citrus peel extracts obtained with HVED

RUN	Total phenol content (mg GAE/g)	DPPH (%)	Extraction yield (mg/g)	Hesperidin (mg/g)	Narirutin (mg/g)	Rutin (mg/g)	Cryptochlorogenic acid (mg/g)	Kaemferol-3-*O*-rutinoside (mg/g)	Neochlorogenic acid (mg/g)
1	134.44	92.22	416.80	58.51	12.77	2.49	1.05	0.59	0.68
2	166.23	91.97	430.00	59.96	13.55	2.25	0.98	0.59	0.68
3	176.49	94.93	389.00	64.74	13.72	4.35	0.75	0.56	0.53
4	173.15	92.68	453.00	59.46	13.95	4.33	0.93	0.66	0.72
5	179.31	92.30	432.00	67.07	14.20	4.62	0.79	0.61	0.64
6	170.59	92.09	427.20	70.62	14.53	2.55	0.81	0.57	0.64
7	275.46	92.85	391.50	69.76	14.74	2.66	0.84	0.36	0.60
8	274.18	91.80	426.10	55.88	7.47	1.37	0.43	0.23	0.33
9	176.23	92.50	432.31	59.16	12.87	4.19	0.39	0.60	0.54
10	161.36	90.99	424.80	67.08	14.67	4.78	0.85	0.63	0.68
11	96.23	93.91	441.20	59.22	17.39	5.10	1.10	0.90	1.10
12	270.85	91.75	359.50	72.91	12.19	5.25	0.86	0.44	0.66
13	138.28	92.30	418.40	50.52	13.51	4.00	0.85	0.72	0.62
14	115.21	87.06	456.00	62.90	14.40	5.05	0.76	0.51	0.72
15	193.92	91.97	463.20	58.71	13.76	4.56	0.69	0.49	0.71
16	204.95	92.18	422.40	64.50	14.54	4.92	0.65	0.89	0.68
17	232.13	92.90	424.01	68.32	14.58	5.13	0.67	0.61	0.61

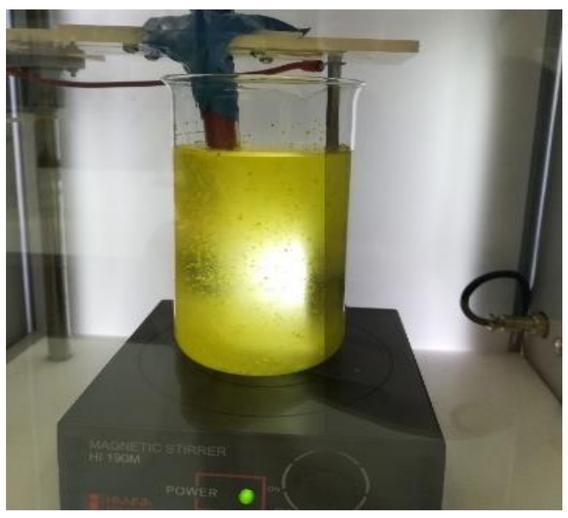

Figure 2. Formation of an electrical discharge between two electrodes in citrus peel extract during HVED treatment

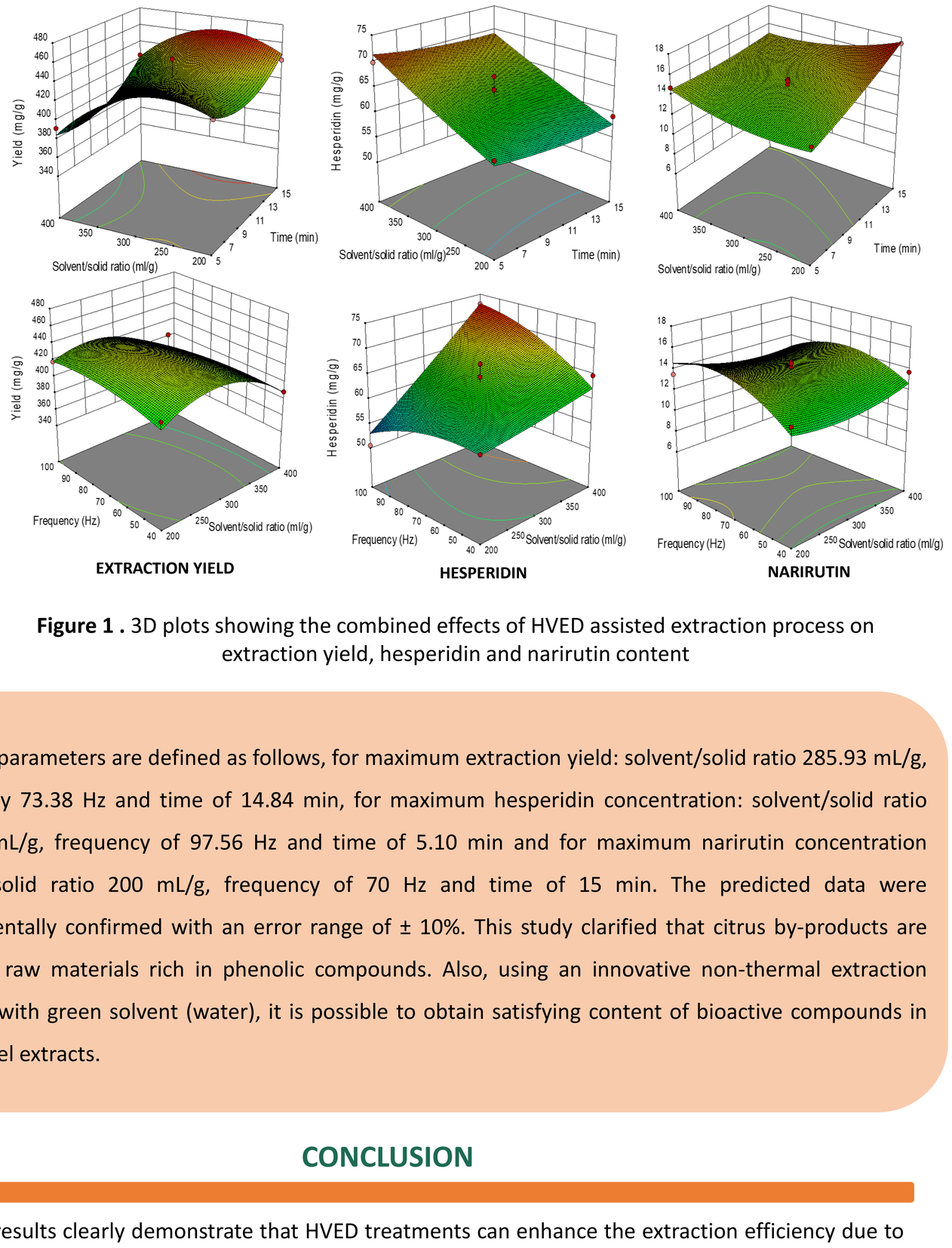

Figure 1 . 3D plots showing the combined effects of HVED assisted extraction process on extraction yield, hesperidin and narirutin content

Optimal parameters are defined as follows, for maximum extraction yield: solvent/solid ratio 285.93 mL/g, frequency 73.38 Hz and time of 14.84 min, for maximum hesperidin concentration: solvent/solid ratio 366.19 mL/g, frequency of 97.56 Hz and time of 5.10 min and for maximum narirutin concentration solvent/solid ratio 200 mL/g, frequency of 70 Hz and time of 15 min. The predicted data were experimentally confirmed with an error range of ± 10%. This study clarified that citrus by-products are valuable raw materials rich in phenolic compounds. Also, using an innovative non-thermal extraction method with green solvent (water), it is possible to obtain satisfying content of bioactive compounds in citrus peel extracts.

CONCLUSION

These results clearly demonstrate that HVED treatments can enhance the extraction efficiency due to electrohydraulic discharge phenomena, including the emission of high-intensity UV light, the generation of shock waves, and the generation of free radicals produced by the photodissociation of water which can decrease particle size and influence fragmentation of cell membranes and intensify mass transfer and increase the release of intracellular compounds into the solvent.

Acknowledgments:

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