SEPARATION OF VALUABLE ENDOGENOUS COMPONENTS FROM CARROT PEEL BY MICROWAVE EXTRACTION

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Abstract
With the rapid development of food technology, the amount of by-products generated is proportionally increasing as well. If not reused, by-products can pose a serious problem to our environment. In addition to managing and reusing such by-products, they may be valorised by extraction of valuable endogenous components using a less sophisticated, plain but modern technology such as microwave-assisted extraction. This new technique has been gaining popularity in recent years because compared to conventional methods, microwave-assisted extraction is characterised by shorter extraction times and lower solvent requirements.
This preliminary experiment aimed to demonstrate that with the right operating parameters and solvent ratio, this method can be used for the efficient extraction of valuable endogenous components from carrot peels. To quantify the endogenous components, polyphenol content (TPC), antioxidant capacity (FRAP) and carotenoid content were investigated. The findings of this study showed that the optimal valuable substance extraction was obtained at 1:10 peel-solvent ratio at 100 W microwave power for fresh carrot peels, and 1:20 peel-solvent ratio at 800 W microwave power for dried carrot peels.

Introduction
According to the ever-increasing demands of the population, food production is rising worldwide. As the amount of the produced food increases, so does the amount of "waste" or by-products generated by the technological processes. As such, carrot processing creates a significant amount (20-25%) of peel waste, which causes environmental and recyclability problems for the food industry. [1-2].

Carrot peel waste contains/may contain large amounts of bioactive substances, which are yet given little commercial value. However, these phytochemicals could be profitably exploited as natural additives either in pharmaceutical or food industry, in agriculture, or in other areas. [3].

Carotenoids and polyphenols are possibly the most valuable components of carrot roots. Both have antioxidant activity, protect the body against cardiovascular disease and cancer, and have anti-inflammatory and immune-boosting effects [4]. Extraction is a suitable method of obtaining these valuable components. In addition to conventional extraction methods, new extraction techniques emerge nowadays, such as Disposable Pipette Extraction (DPX) [5], Ultrasound-assisted Solid-liquid Extraction, Micro Extraction by Packed Sorbent (MEPS) [6], and Microwave-assisted Extraction used in the presented experiment. [7].

Experimental

Materials and solvents

The raw material used was the peels of Nanti carrots (Daucus carota L. ssp. sativus), commercially available in Hungary. Distilled water and 20% ethanol were used as extractants. All chemicals were purchased from Sigma Aldrich.

Sample preparation

After cleaning and weighing the carrots, they were peeled. Then, the about 1 mm thick peels' weight was measured. The carrot peels prepared for drying were dried to constant weight in the drier at 60°C temperature. Afterwards, the fresh and the dried carrot peels were shredded using a laboratory shredder.

For the extraction, 10 ml of solvent were added to 1 g of fresh carrot peel and 20 ml of solvent to 1 g of dried carrot peel.

The extraction

To extract the endogenous components (polyphenols and carotenoids), a plain but also modern technology was chosen: microwave-assisted extraction. To prepare the analytical testing, three different solvents and three different microwave power levels (100 W, 450 W and 800 W) were used for the extraction. The extraction time was 30 seconds in each case. A solvent ratio of 1:10 for fresh samples and a ratio of 1:20 for dried samples were used, taking into consideration the moisture content of the samples. After the microwave treatment, the mixtures were filtered and centrifuged at 13000 rpm at 14 °C temperature for 20 min using a Hettich Zentrifugen MICRO 22R centrifuge.

Analytical methods

Determination of total phenolic contents (TPC) by Folin-Ciocalteu method: The Folin-Ciocalteu spectrophotometric method by Singleton and Rossi [8], at 760 nm is an electron transfer based assay and shows the reducing capacity, which is expressed as phenolic content. Gallic acid (GA) was used to prepare the standard curve. The results were expressed as μM GA/g of dry matter (DM), and fresh matter.

Determination of antioxidant capacities by FRAP (Ferric Reducing Antioxidant Power) method: Measurement of ferric reducing antioxidant power of the peel extracts was carried out based on the procedure of Benzie and Strain [9], at 593 nm. Ascorbic acid (AA) was used as a standard to prepare the calibration solutions. Results were expressed as μMAA/g DM, and fresh matter.

Determination of carotenoid content:

The carotenoid content of all extracts was determined spectrophotometrically (Yang et al., 1998) [10] (in addition to chlorophylls), expressed in μg/g for both fresh and dried samples.

Results and discussion

Figure 1 shows that the extraction with 20 % alcohol resulted in the leaching of more polyphenolic components due to the variable solubility of polyphenols (Figure 1). Compared to the control, the amount of leached polyphenols was the highest at 100 W microwave power. In conclusion, this leaching method was found sufficient for the exploration.

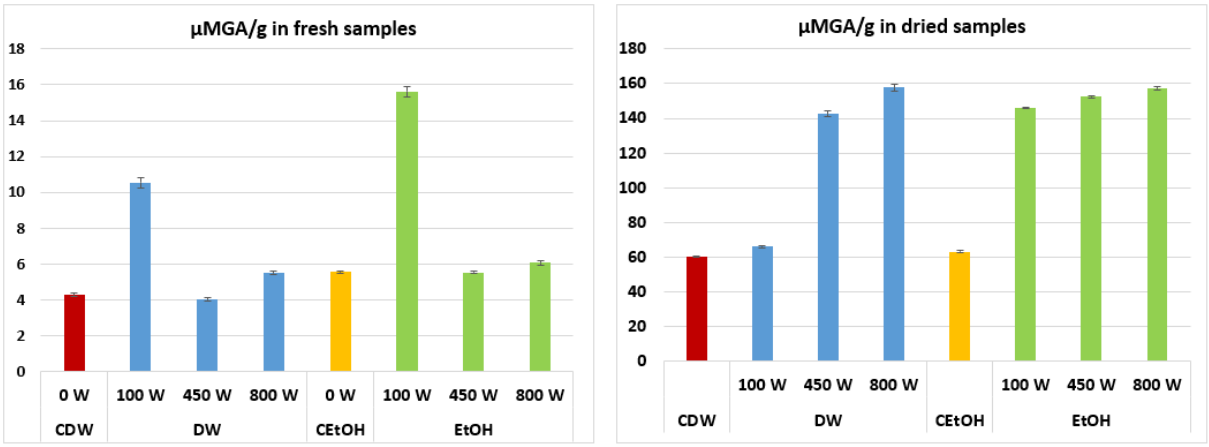

Figure 1. Polyphenol content of fresh and dried carrot peel samples using distilled aqueous and alcoholic solvents and different power levels

Control distilled water | Distilled water | Control alcohol | Alcoholic extract

The results showed that the optimal valuable substance extraction was obtained at 1:10 peel-solvent ratio at 100 W microwave power for fresh carrot peels, and 1:20 peel-solvent ratio at 800 W microwave power for dried carrot peels.

The same conclusion was drawn for antioxidant capacity (FRAP) (Figure 2).

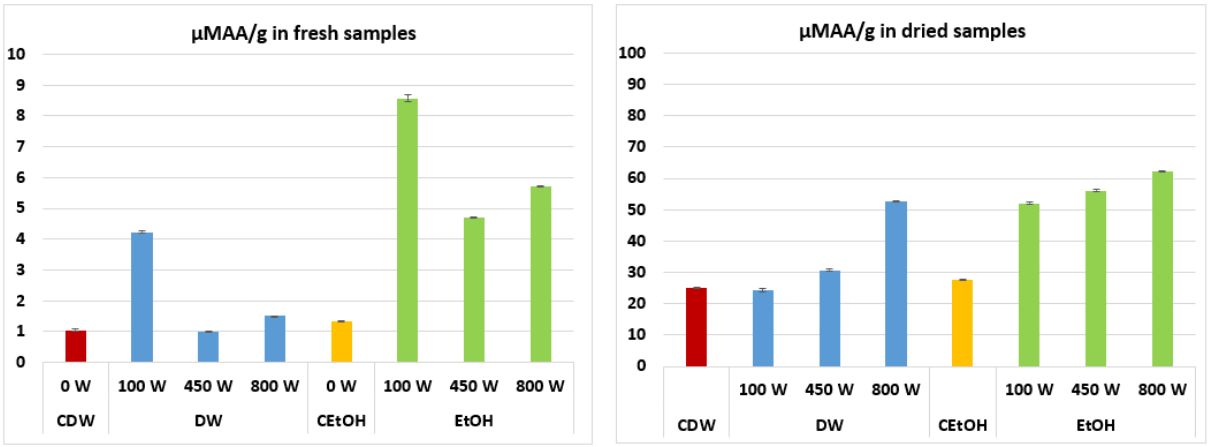

Figure 2. Antioxidant capacity (FRAP) of fresh and dried carrot peel samples using distilled aqueous and alcoholic solvents and different power levels

Control distilled water | Distilled water | Control alcohol | Alcoholic extract

The two adjacent graphs (Figure 3) show the carotenoid content of alcoholic extract of fresh respectively dried carrot peel samples at different power levels. The conclusion was that the carotenoid content of both samples increased with performance enhancement. Furthermore, the carotenoid content of the dried samples was over twice as many as the carotenoid content of the fresh samples.

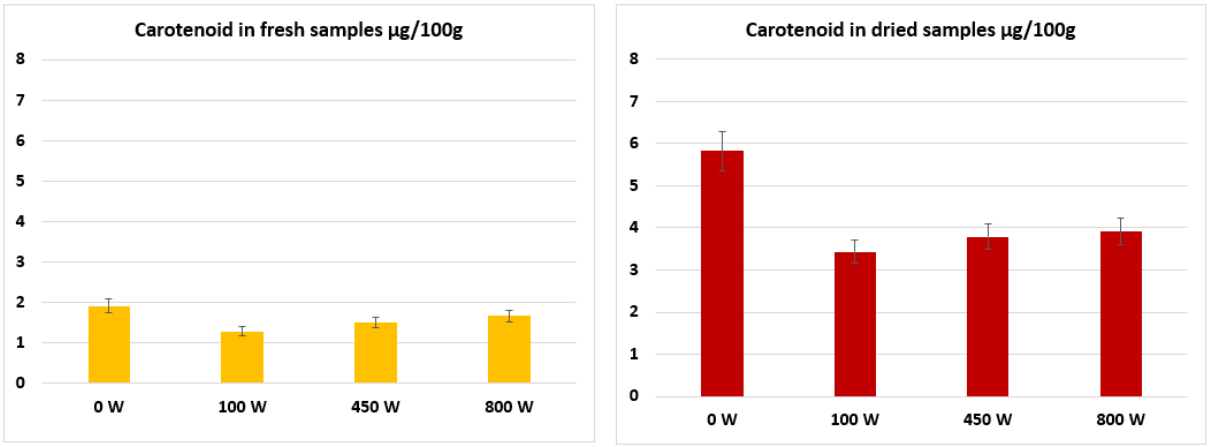

Figure 3. Carotenoid content of fresh and dried carrot peel samples in alcohol extraction using a solvent ratio of 1:10 for fresh samples and 1:20 for dried samples

Conclusion

Based on the results obtained, it is safe to assume that the extraction procedure with 20 % ethyl alcohol proved to be the most efficient for the extraction of the tested components in the case of both fresh and dried carrot peel samples. Considering the whole experiment, the extraction at 100 W proved to be the most efficient for fresh carrot peels

Based on the presented preliminary experiments, it can be concluded that microwave-assisted extraction is suitable for the leaching of valuable endogenous components from carrot peel available in large amounts as food industry waste, and it is worthwhile to address the further utilization of this by-product.

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