DEVELOPMENT OF ELECTROCHEMICAL SENSORS FOR DETERMINATION OF VITAMIN C AND EVALUATION OF ANTIOXIDANT ACTIVITY

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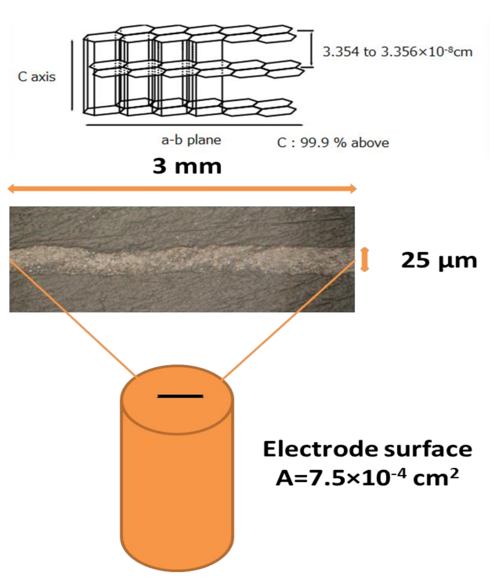
INTRODUCTION

It is known that carbon materials due to low ohmic resistance can significantly improve the electroanalytical properties of the sensing layers. Carbon materials also provide a variety of modification options that often have been used to develop highly sensitive sensors to investigate electrochemical properties and detect organic and inorganic compounds. The first goal of this work was to develop a simple electrochemical method for the determination of Vitamin C (VitC). The cyclic voltammetry was used to characterize microelectrodes and square wave voltammetry to quantify VitC. A procedure for quantifying VitC in the real sample is established. The second goal was to determine the effect of the addition of a different type of "green" biowaste on plant growth, VitC content, and antioxidant activity in arugula (*Eruca sativa L*) by using carbon microelectrode. The obtained results were compared with the standardized methods. After three weeks of cultivation, small differences in growth and large differences in certain nutritional characteristics were observed. The addition of peanut shell contributes to soil aeration and the fastest development of healthy and green *Eruca sativa* has been observed. The addition of black coffee makes the soil slightly alkaline and results in a significant increase in the VitC content and antioxidant activity.

Keywords: carbon microelectrodes, "green" biowaste, vitamin C, antioxidant activity

INSTRUMENTATION:

- ✓ Potentiostat (Autolab PGSTAT 302N), connected to PC and driven by GPES 4.9 Software (Eco Chemie).
- ✓ Cary 5000 UV-Vis-NIR spectrophotometer by Agilent Technologies
- ✓ **Electrode:** pyrolytic graphite sheet (PGS - EYGS121803) electrode; Electrode surface A=7.5×10^{-4} cm^2;



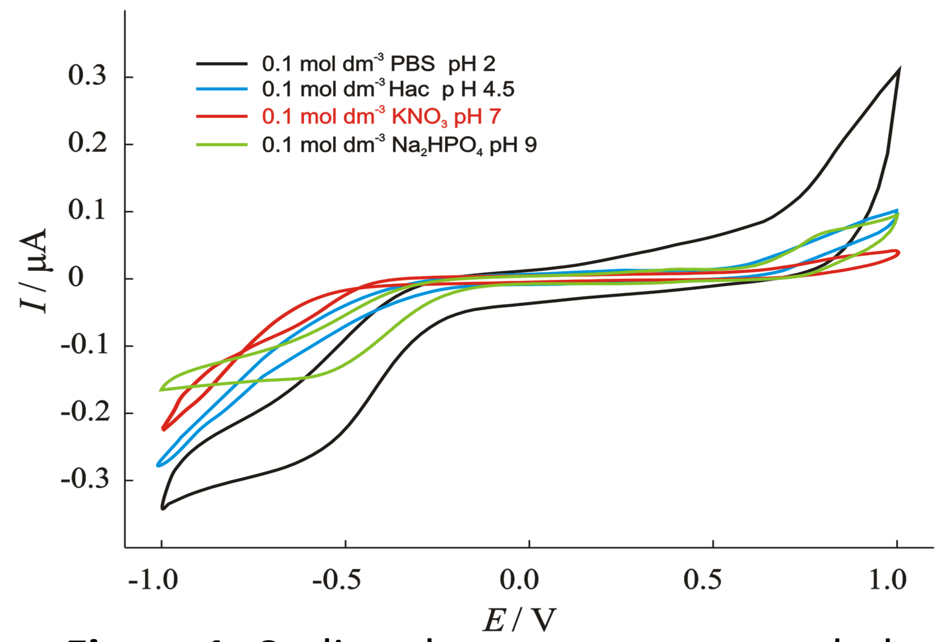


Figure 1. Cyclic voltammograms recorded at PGS electrode in different electrolyte, v = 25 mV s^{-1}.

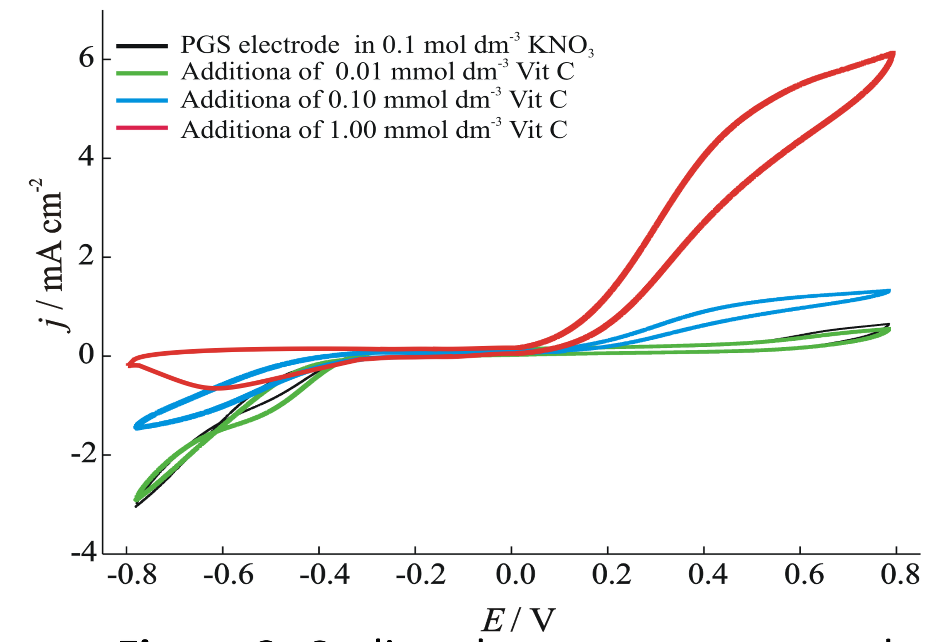


Figure 2. Cyclic voltammograms recorded at PGS electrode in 0.1 mol dm^{-3} KNO_3 with addition of VitC; v = 25 mV s^{-1}.

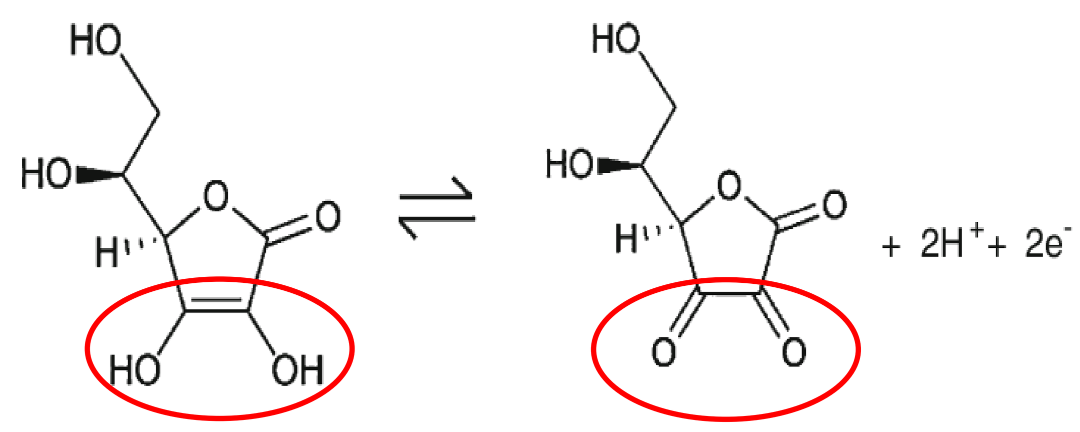


Figure 3. Structures for VitC - ascorbic acid and for the reduced form (dihydroascorbic acid).

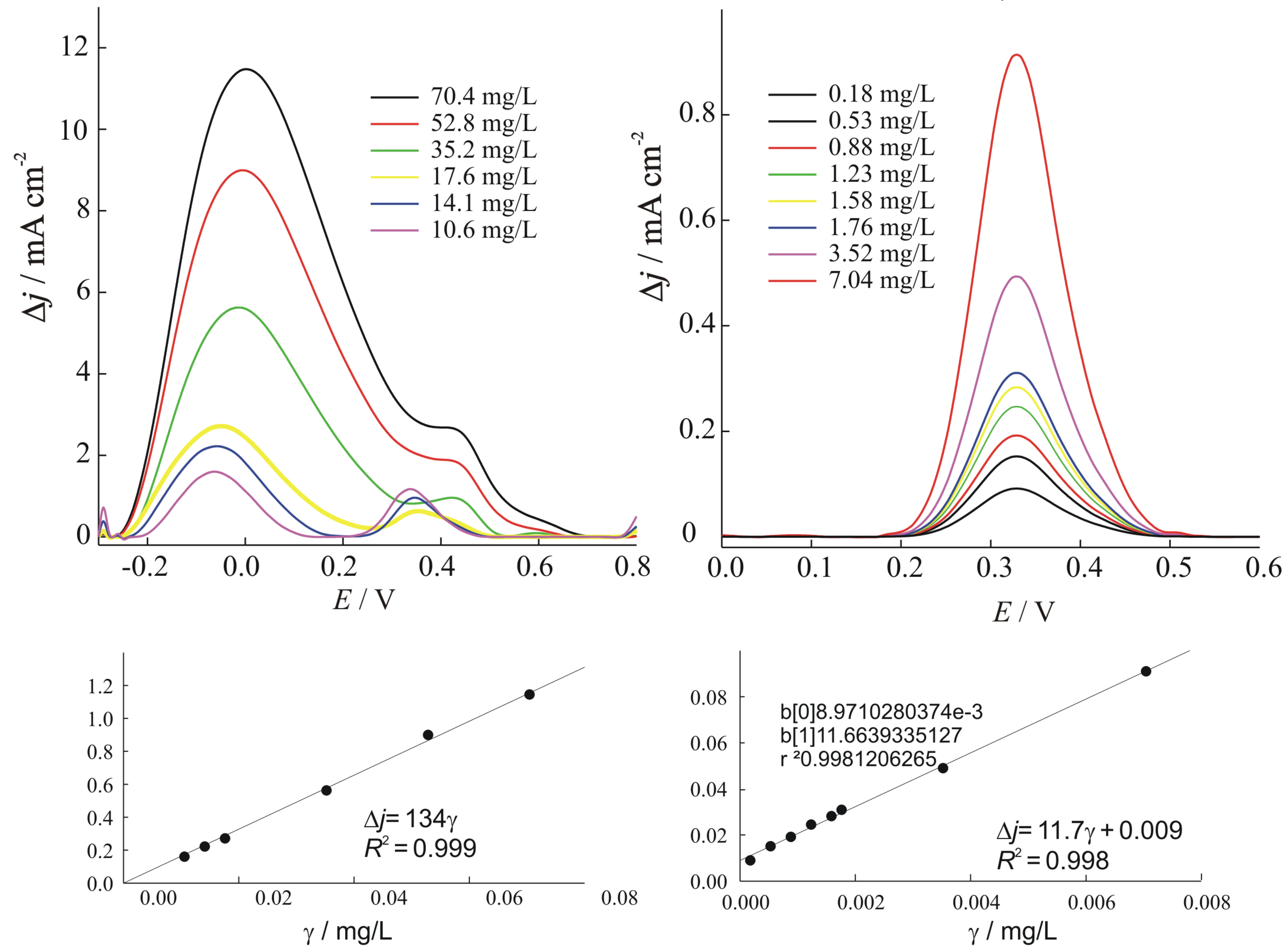
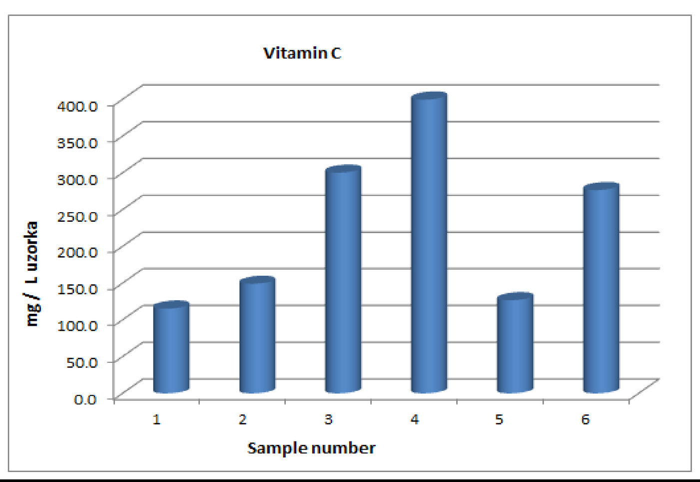
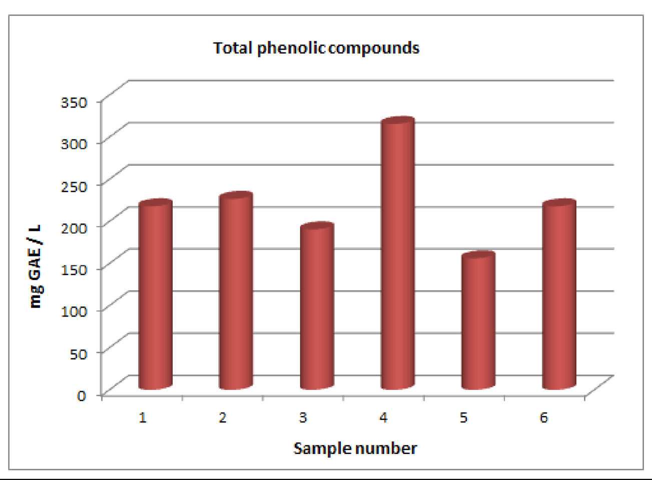


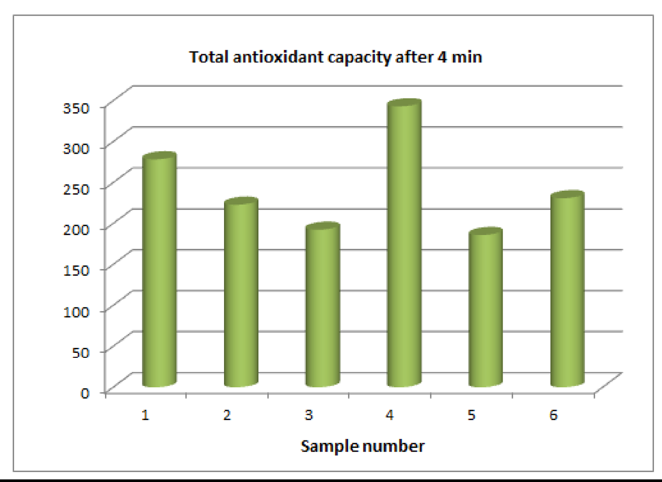
Figure 4. SWCSVs recorded at PGS electrode in 0.1 mol dm^{-3} KNO_3; with sequential addition of VitC . (E_{acc}=−0.300 V; t_{acc}=120 s)

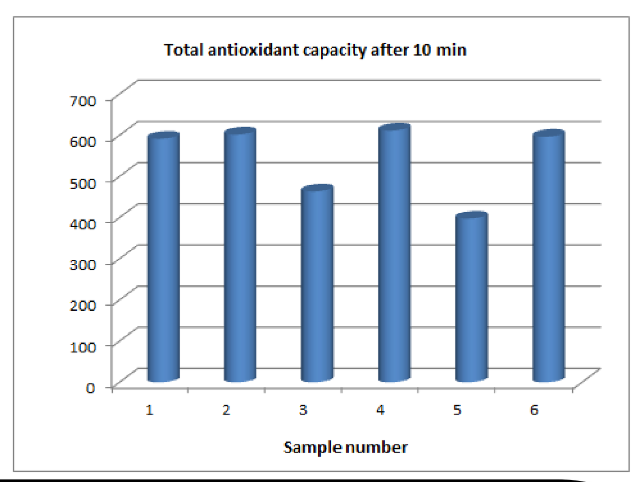
Table 1. Content of VitC, total phenols and antioxidant activity of arugula - after three weeks period of outdoor cultivation. (A volume of 1 L corresponds to 100 g of raw material).

Sample – arugula substrate	SWCSV results	Vitamin C determination by Iodine Titration				Total phenolic compounds Folin-Ciocalteu reagents				Antioxidant activity after 4 minute FRAP method				Antioxidant activity after 10 minute FRAP method			
Soil with addition of	mg/L sample	mg/L sample			Mean value	mg GAE/L			Mean value	µM TE			Mean value	µM TE			Mean value
peanut shells	**128**	111	115	120	**115.3**	222	216	216	**218**	211	305	318	**278**	555	601	617	**591**
paper	**155**	150	147	150	**149.0**	216	232	232	**227**	248	198	222	**223**	595	606	604	**602**
peel of banana and kiwi	**421**	301	300	300	**300.3**	199	186	186	**190**	165	205	207	**192**	486	504	399	**463**
coffee ground	**504**	360	415	424	**399.7**	333	302	311	**315**	318	345	366	**343**	604	615	614	**611**
eggshells	**136**	120	130	130	**126.7**	160	166	142	**156**	166	186	205	**186**	389	401	402	**397**
WITHOUT ADDITIVES	**399**	280	270	280	**276.7**	222	232	199	**218**	224	226	242	**231**	588	601	599	**596**









CONCLUSION

- ➢ As an electron donor, ascorbic acid serves as one of most important small-molecular-weight antioxidants which contributes to the total antioxidant capacity. PGS electrode serves as a good material for electrochemical application. In this work the preliminary study on the relevance of PGS electrode for the determination of VitC are presented.
- ➢ A square wave stripping voltammetry (SWCSV) was optimized and analytical determination was performed in quiescent solutions from −0.30 towards 0.80 V, with potential scan frequency (f) of the 8 Hz, pulse height (ΔE_p) of the 200 mV, and potential increment (ΔE_s) of the 5 mV. The results for the obtained samples of arugula planted in different substrates are in good agreement with the classical methods of determination in the case of lower concentrations of VitC in the sample. At higher concentrations of VitC, the results are slightly higher, suggesting a possible reduction of some phenolic compounds, which also have antioxidant activity and results are in line with the trend of increasing total antioxidant activity for these samples. So, change in the oxidation mechanism is observed for higher concentration of VitC, with respect to the higher antioxidative activity.
- ➢ Also, the addition of black coffee grounds makes the soil slightly alkaline, which results in a significant increase in the content of VitC, total phenols and antioxidant activity, and has a beneficial effect on arugula growth. The addition of egg shell to the substrate did not show a positive effect, neither on growth nor on the content of VitC, total phenols and antioxidant activity after period of three weeks.

Acknowledgment
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