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ResearchArticle

EFFECT OF DRYING AND FREEZING ON ANTIOXIDANT CAPACITY AND POLYPHENOLIC CONTENTS OF TWO SOUTH ALGERIAN EGGPLANTS CULTIVARS

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ABSTRACT

Objective: The aim of this present study was to evaluate the effect of temperature on polyphenolic contents and antioxidant capacity of different parts (whole fruit, pulp and peel) of dark-purple and white eggplant variety cultivated in different regions of south Algeria.

Methods: Folin-Ciocalteu method and cyclic voltammetry assays have been applied to quantify the polyphenolic contents and antioxidant capacity of dried and frozen dark-purple and white eggplant verities.

Results: High phenolic content was found for peel of dark-purple variety in following order fresh (548.77 mg GA/g) > frozen (106.11) > dry (93.48). The antioxidant capacity of different parts of eggplant was measured using ascorbic acid equivalent antioxidant capacity assays. Antioxidant capacity is in the order, peel of fresh dark-purple eggplant (324.34 mg AA/g) > whole fruit of frozen dark-purple eggplant (182.69 mg/g) > peel of fresh white eggplant (89.52 mg/g).

Conclusion: Our results indicate that antioxidant capacity and phenolics content of eggplant varied depending on the part of the fruit and of the eggplant cultivar analyzed. Correlation of phenolic content and antioxidant capacity shows excellent linearity, which demonstrates that phenolic compounds have a significant contribution to the total antioxidant capacity. Finally, cyclic voltammetry results suggest that ethanolic extract of different parts of eggplant do not reveal similar electrochemical responses to that of ascorbic acid suggesting a different electro-active chemical composition.

Keywords: Eggplant; Solanum melongena L; Antioxidant capacity; Total phenolic content; Cyclic voltammetry.

INTRODUCTION

Eggplant or aubergine (*Solanum melongena L)* a non-tuberous crop of Solanaceae family was first domesticated in southern India from the wild nightshade and can exist under different size, shape, and colour, depending on the cultivar. Fruits are purple, white or striped [1] and are ranked amongst the top ten vegetables in terms of antioxidant capacity due to the fruit phenolic and flavonoic constituents [2]. Extracts from eggplant are effective for curing a number of diseases, including cancer, high blood pressure, and hepatosis due to content of anthocyanins and strychnine [3,4]. The two varieties cultivated eggplant in Algeria are dark purple and white and are widely used in cooking; their highest growing season is from November to January. The total phenolic contents and antioxidant activity of eggplant of many countries have been widely studied by many scientific research groups [5-9], however only a few information concerning the total phenolic contents and antioxidant activity of eggplant from Algeria can be found in literature.

This motivated us to explore the antioxidant capacity and the total phenolic contents of south Algerian eggplants.

The objective of this study is to quantify, using cyclic voltammetry, the polyphenolic content and antioxidant capacity of the ethanolic extract of south Algerian eggplants [10-17].

MATERIALS AND METHODS

Chemical

Ethanol (99%), was purchased from Sigma-Aldrich Co. ascorbic acid (99.7%), sodium carbonate (99%), were both purchased from Merck Co. Folin-Ciocalteu reagent was purchased from biochem chemopharma Co (Canada). all other reagents used were of analytical grade.

Plant material

Dark purple and white eggplant fruits were purchased fresh from a local market in Guemar (Algeria), in November 2011. After collection, the samples were analysed for phenolic contents and antioxidant evaluation within 8 months after harvest.

For each variety of eggplant, we prepared three types of sampling (material to be extracted) as follows: fresh dark purple eggplant labelled as FDPE, fresh white eggplant labelled as FWE, dry dark purple eggplant labelled as DDPE, dry white eggplant labelled as DWE, frozen dark purple eggplant labelled as GDPE and frozen white eggplant labelled as GWE.

Extraction of eggplant constituents

Fresh eggplant samples

Immediately after receipts of fresh eggplant, all samples were peeled using a knife kitchen, the pulp and the peels of the fruit were separated. Each part was chopped into small pieces. The fresh samples (5 g) were then extracted with 100 mL of ethanol for 2 hours using Soxhlet extractor. The samples were then filtered using Whatman filter No. 4 paper; the filtrate was recovered and evaporated at reduced temperature and pressure. All dry fractions were sealed in a glass flask and stored at low temperature until used.

Dry eggplant samples

Each part of fresh eggplant (peel, pulp and whole fruit) was cleaned, air dried for 4 weeks and ground to a powder. The powdered samples were treated in the same manner as fresh eggplant samples.

Frozen eggplant samples

The frozen parts of the fruit (peel, pulp and whole fruit) were ground in a food-mixer and treated in the same manner as fresh eggplant samples.

Total phenolic content

The total phenolic contents of the eggplant samples were measured using a colorimetric Folin-Ciocalteu method [18]. 0.1 mL of the extract was diluted with ultrapure water to 1 mL; 0.5 mL of Folin-Ciocalteu reagent diluted ten fold with ultrapure water was then added. After a period of 3 minutes, 2 ml of saturated sodium carbonate solution was added. The mixture was incubated at room temperature for 30 minutes. The absorbance was measured against a blank at 760 nm using Shimadzu UV-Vis-1800 spectrophotometer. The measurement was compared to a standard curve of prepared gallic acid solutions (10 points from 3 to 300 mg/L) and expressed as milligrams of gallic acid equivalents per 100 g of dry extract.

Evaluation of antioxidant capacity

The measurement of the antioxidant capacity of the studied eggplant samples was performed using an electrochemical method based on cyclic voltammetry techniques. Cyclic voltammetry measurements were performed using PGP301 potentiostat (radiometer analytical SAS) connected to an electrochemical cell with a volumetric capacity of 50 mL containing a glassy carbon working electrode, a Pt wire counter electrode and an Hg/Hg_2Cl_2 reference electrode. The potential was swept in direct scanning mode starting from -200 to +1000 mV with a scanning rate of 100 mV/s. The antioxidant capacity was obtained using the current density of the anodic curve of the voltammogram. The calibration graph is obtained by plotting the current density of the anodic curve of the voltammogram of each sample of the standard versus its concentration. Ascorbic acid was used as a standard in the calculation of antioxidant capacity of the studied sample of eggplant because of its wide spreading in nature and also because its anodic current density displays excellent linearity toward ascorbic acid concentrations [19,20].

RESULTS AND DISCUSSION

Total phenolic content

Table 1: Total phenolic content (mg gallic acid equivalents/100g dry extract) of different parts of eggplant cultivars

Cultivar	Eggplant parts		
	Whole fruit	Pulp	Peel
DDPE	30.88	26.80	66.29
DWE	22.96	35.06	93.48
FDPE	20.14	24.13	548.77
FWE	30.51	25.29	87.82
GDPE	317.36	23.87	106.11
GWE	58.88	7.30	27.33

The Total phenolic content values of different parts extract ranged from 548.77 mg GA/g for fresh peel of dark purple eggplant sample to 7.30 mg GA/g for frozen pulp of white eggplant sample (see Table 1). In general, the phenolic content decreased in the order fresh > frozen > dry. Also the phenolic content of different parts of ethanolic extracts decreased as follows: peel > whole fruit > pulp. [2, 21] found similar results on eggplant cultivars from Japan and Korea.

Evaluation of antioxidant capacities

In order to express the antioxidant capacity of different parts of the eggplant extracts in equivalent terms of ascorbic acid equivalent antioxidant capacity (AEAC), different concentrations of the standards ascorbic acid (0.018 to 0.190 g/L) were plotted verses the anodic current density obtained from different cyclic voltammograms at pH 7 in 0.2 M phosphate buffer solution as a supporting electrolyte using a 3 mm-diameter glassy carbon electrode. The equation obtained from the linear calibration graph in the studied concentration range for ascorbic acid is, y = 126.03x + 1.929 (where y represents the value of the anodic current density and x, the value of standards concentration, expressed as g/L), with a correlation coefficient of $R^2 = 0.998$.

The total antioxidant capacity was calculated based on the following equation:

$$TAC = C_1/C_2$$

Where TAC is total antioxidant capacity, C_1 is the eggplant sample extract concentration (g/mL), C_2 is the sample concentration in the electrochemical cell (g/mL) calculated by replacing the current density obtained from different voltammograms of sample extracts in the equation y = 126.03x + 1.929. Antioxidant capacity of five eggplant varieties from Thailand [8] and Nigeria [22] showed higher antioxidant capacity.

Evaluation of antioxidant capacity of fresh eggplant samples

Figure 1 show different voltammograms of different parts of dark purple and white eggplant, each voltammogram shows one oxidation peak and one reduction peak. This reversible electrochemical behavior may indicate that, under this electrochemical conditions, the ethanolic eggplant extract contain a different polyphenolic content of that of the standard ascorbic acid.

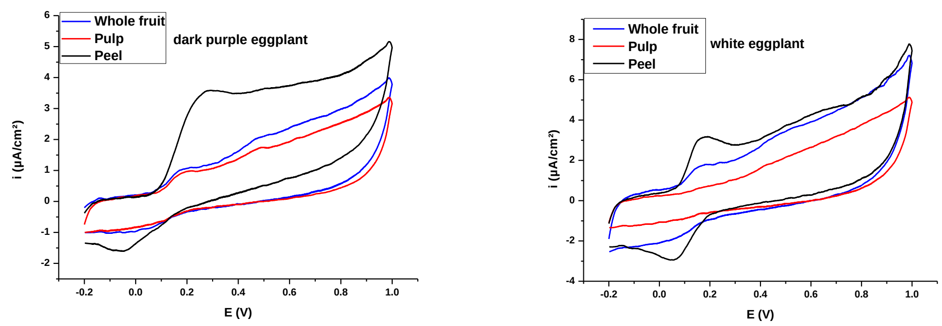

Fig. 1: Cyclic voltammograms of different parts of fresh eggplant in pH 7, 0.2 M phosphate buffer solution at scan rate 100 mV/s.

The total antioxidant capacity expressed as mg AA /100g of dry extract of different parts of eggplant extracts calculated from the equation y = 126.03x + 1.929 obtained from the calibration graphs for ascorbic acid is summarized in Table 2.

Table 2: Antioxidant capacities (mg ascorbic acid/100g of dry extract) of different parts of the two different varieties of eggplant

Variety	Parts	Antioxidant capacities (mg AA/g)
DDPE	Whole fruit	10.91
	Pulp	11.83
	Peel	324.34
FWE	Whole fruit	5.40
	Pulp	-
	Peel	89.52

As it can be seen from table 2, the ethanolic extracts of peel have the highest AEAC values of 324.34 and 89.52 mg/g for dark purple and white eggplant respectively, followed by pulp of dark purple variety and finally 5.40 mg/g for the whole fruit of dark purple variety. However the pulp of white eggplant variety does not have any measurable antioxidant capacity using cyclic voltammetry techniques.

Evaluation of antioxidant capacity of dry eggplant samples

As it can be seen from Figure 2 each voltammogram of different parts of dark purple and white eggplant represent two peaks, one for oxidation and another for reduction.

The AEAC of different parts of studied eggplant extracts calculated in the same manner as for fresh eggplant is summarized in Table 3.

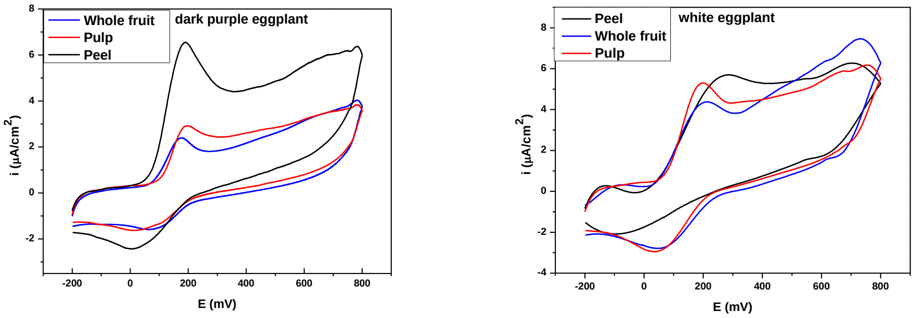

Fig. 2: Cyclic voltammograms of different parts of eggplant in pH 7, 0.2 M phosphate buffer solution at scan rate 100 mV/s

Table 3: Antioxidant capacities (mg ascorbic acid/100g of dry extract) of different parts of eggplant varieties.

Variety	Parts	Antioxidant capacities (mg AA/g)
DDPE	Whole fruit	14.82
	Pulp	16.54
	Peel	66.78
DWE	Whole fruit	21.27
	Pulp	30.56
	Peel	75.62

AEAC values for different parts of studied eggplant indicate that peel extracts of both variety white and dark purple eggplant samples was the most effective with the highest AEAC value equal to 75.62 to 66.78 mg AA/g, followed by the pulp of white eggplant 30.56 to 16.54 mg AA/g and finally the whole fruit around 21.27 to 14.82 mg AA/g. A statistically significant difference in antioxidant capacity was found between ethanolic extracts for peel in one hand and the whole fruit and the pulp of both eggplant varieties in the other hand. No significant difference was found between the ethanolic extracts of the whole fruit and the pulp of eggplant variety.

Evaluation of antioxidant capacity of frozen eggplant sample

Ethanolic extract of different parts of dark purple and white eggplant also shows an oxidation and reduction peaks see Figure 3.

The ascorbic acid equivalent antioxidant capacity (AEAC) of different parts of studied eggplant extracts calculated from the equation $y = 126.03x + 1.929$ obtained from the calibration graphs for ascorbic acid is summarized in Table 4.

AEAC values for different parts of ethanolic extracts of studied eggplant indicate that the whole fruit of the dark purple eggplant samples have the highest AEAC value (182.69 mg/g) followed by the peel of the same variety 62.96 mg/g. No significant difference was found between the other ethanolic extracts of different parts of eggplant variety.

Correlation between total phenolic contents and total antioxidant capacity

A direct correlation between total phenolic contents and total antioxidant capacity was demonstrated by linear regression analysis. The two parameters showed a high correlation coefficient of $R^2 = 0.999$, (see Figure 4).

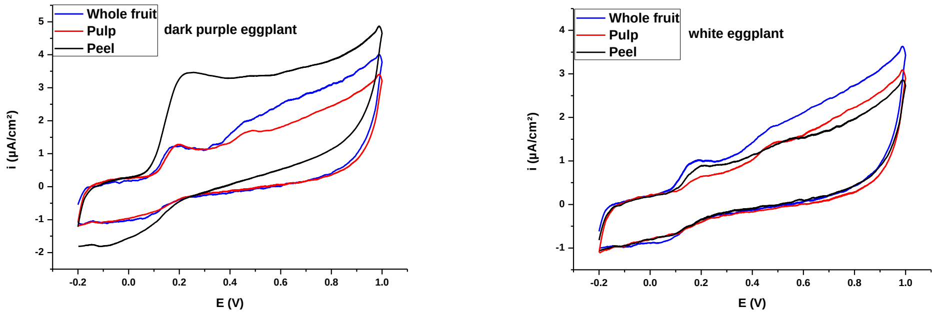

Fig. 3: Cyclic voltammograms of different parts of frozen eggplant in pH 7, 0.2 M phosphate buffer solution at scan rate 100 mV/s.

Table 4: Antioxidant capacities (mg ascorbic acid/100g of dry extract) of different parts of eggplant varieties

Variety	Parts	Antioxidant capacities (mg AA/g
GDPE	Whole fruit	182.69
	Pulp	20.46
	Peel	62.96
GWE	Whole fruit	14.31
	Pulp	6.17
	Peel	16.43

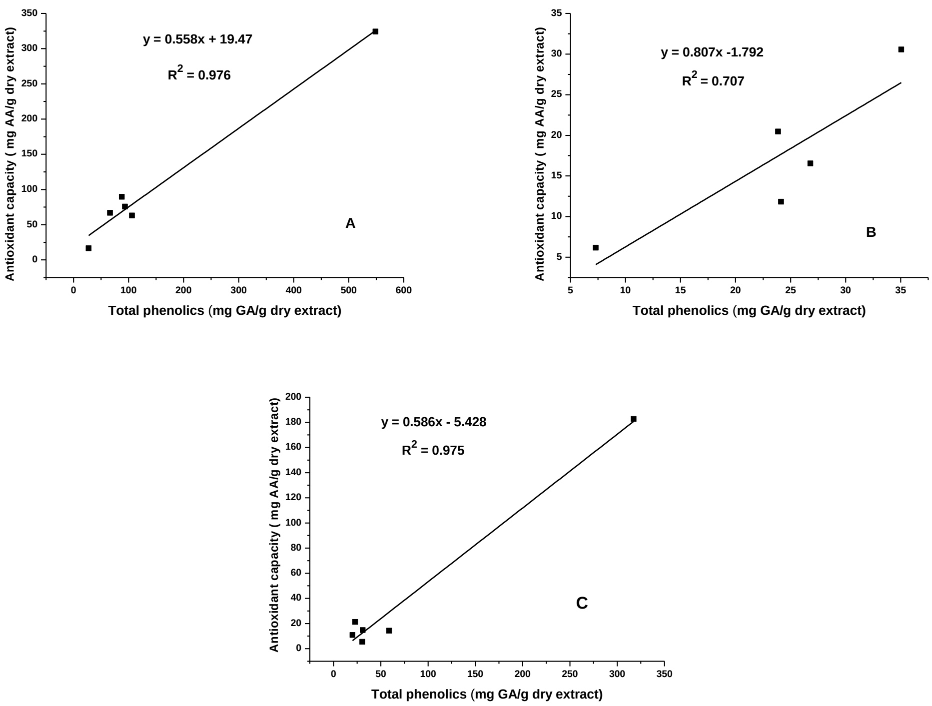

Fig. 4: Correlation of total phenolic content and antioxidant capacity for extract from different parts of eggplant (A) peel extract, (B) pulp extract and (C) whole fruit extract

CONCLUSION

The present study demonstrated the in vitro effect of drying and freezing on antioxidant capacity and polyphenolic contents of dark purple and white eggplant varieties. It is clear from these in vitro assays that drying or freezing eggplant fruits affect antioxidant capacity and polyphenolic contents. The results show that out of two cultivars studied, fresh peel of dark purple eggplant variety appears to have the highest antioxidant capacity followed by the whole fruit of frozen dark purple variety and peel of fresh white.

The total phenolic content was also evaluated; the results show that the peel of fresh dark purple eggplant variety has the highest total polyphenolic contents. Significant correlations were found between antioxidant activities and total amounts of polyphenolic contents.

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REFERENCES

1. Timberlake CF. Anthocyanins in Fruit and Vegetables. In: Recent Advances in the Biochemistry of Fruit and Vegetables. J and M.J.C. Rhodes Eds. Academic Press, New York; 1981 Friend USA. p. 221- 47.
2. Singh AP, Luthria D, Wilson T, Vorsa N, Singh V, Banuelos GS, Pasakdee S. Polyphenols content and antioxidant capacity of eggplant pulp. Food Chem 2009; 114: 955-961.
3. Magioli C, Mansur E. Eggplant (*Solanum melongena* L.): Tissue culture, genetic transformation and use as an alternative model plant. Acta Botanica Brasilica 2005; 19 (1): 139-148.
4. Silva ME, Santos RC, O'Leary MC, Santos RS. Effect of aubergine (*Solanum melongena*) on serum and hepatic cholesterol and triglycerides in rats. Braz Arch Biol Technol 1999; 42: 339-342.
5. Boubekri C, Rebiai A, Lanez T. Study of antioxidant capacity of different parts of two South Algerian eggplant cultivars. Journal of Fundamental and Applied Sciences 2012; 4: 16-25.
6. Matsubara K, Kaneyuki T, Miyake T, Mori M. Antiangiogenic activity of nasunin, an antioxidant anthocyanin, in eggplant peels. J Agric Food Chem 2005; 53(16): 6272-6275.
7. Stangeland T, Remberg SF, Lye KA. Total antioxidant activity in 35 Ugandan fruits and vegetables. Food Chem 2009; 113: 85-91.
8. Akanitapichat P, Phraibung K, Nuchklang K, Prompitakkul S. Antioxidant and hepatoprotective activities of five eggplant varieties. Food Chem Toxicol 2010; 48: 3017-3021.
9. Isshiki S, Okubo H, Fujieda K. Phylogeny of eggplant and related *Solanum* species constructed by allozyme variation. Scientia Horticulturae 1994; 59: 171-176.
10. Rebiai A, Lanez T, Belfar ML. In vitro evaluation of antioxidant capacity of Algerian propolis by spectrophotometrical and electrochemical assays. Int J Pharmacol 2011; 17: 113-118.
11. Rebiai A, Lanez T. Chemical composition and antioxidant activity of *Apis mellifera* bee pollen from Northwest Algeria. Journal of Fundamental and Applied Sciences 2012; 4: 26-35.
12. Guan Y, Chu Q, Fu L, Wu T, Ye J. Determination of phenolic antioxidants by micellar electrokinetic capillary

chromatography with electrochemical detection. Food Chem 2006; 94:157-162.
13. Cosio MS, Buratti S, Mannino S, Denedetti S. Use of an electrochemical method to evaluate the antioxidant activity of herb extracts from the Labiatae family. Food Chem 2006; 97: 725-731.
14. He JB, Yuan SJ, Du JQ, Hu XR, Wang Y. Voltammetric and spectral characterization of two flavonols for assay-dependent antioxidant capacity. Bioelectrochemistry 2009; 75: 110-116.
15. Pisoschi AM, Cheregi MC, Danet AF. Total Antioxidant Capacity of Some Commercial Fruit Juices: Electrochemical and Spectrophotometrical Approaches. Molecules 2009; 14: 480-493.
16. Shah R, Kathad H, Sheth R, Sheth N. In vitro antioxidant activity of roots of tephrosia purpurea linn. Int J Pharmacy Pharm Sci 2010; 2(3): 30-33.
17. Sekhar S, Sampath-Kumara KK, Niranjana SR, Prakash HS. In vitro antioxidant activity, lipoxygenase, cyclooxygenase-2 inhibition and DNA protection properties of memecylon species. Int J Pharmacy Pharm Sci 2013; 5(2): 257-262.
18. Scalbert A, Monties B, Janin G. Tannins in wood: Comparison of different estimation methods. J Agr Food Chem 1989; 37: 1324-1329.
19. Laskar RA, Sk I, Roy N, Begum NA. Antioxidant activity of Indian propolis and its chemical constituents. Food Chem 2010; 122: 233-237.
20. Barros L, Falcao S, Baptista P, Freire C, Vilas-Boas M, Ferreira ICFR. Antioxidant activity of *Agaricus* sp. mushrooms by chemical, biochemical and electrochemical assays. Food Chem 2008; 111: 61-66.
21. Jung EJ, Bae MS, Jo EK, YH Jo, Lee SC. Antioxidant activity of different parts of eggplant. J Med Plant Res 2011; 5(18): 4610-4615.
22. Fategbe MA, Ibukun EO, Kade IJ, Rocha JBT. A comparative study on ripe and unripe eggplant (*Solanum melongena*) as dietary antioxidant sources. J Med Plants Res 2013; 7(6): 209-218.