Scientific Papers. Series B, Horticulture. Vol. LXIII, No. 1, 2019
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

PHENOLIC CONTENT AND ANTIOXIDANT ACTIVITY OF SKINS FROM EGGPLANTS GROWN IN ORGANIC ENVIRONMENTAL CONDITIONS

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Abstract

The aim of this work is to evaluate the phenolic content and antioxidant activity in the skin of three varieties of eggplant (''Mirval'' - dark purple, 'Bibo' F1 – white and ''Black Pearl'' - dark purple) grown under organic conditions. The total phenolic content (TPC) was determined by the Folin-Ciocalteu method and the total anthocyanin content was performed by a spectrophotometric method. The antioxidant activity was evaluated by using DPPH (2,2-diphenyl- 1-picrylhydrazyl) radical scavenging test. The total phenolic content, as well as total anthocyanin content in ''Mirval'' and ''Black Pearl'' varieties, was higher than in 'Bibo' F1. The lower total anthocyanins in 'Bibo' F1 could result from their white color. Similar to TPC, among the three varieties, ''Mirval'' variety showed the highest antioxidant activity, followed by ''Black Pearl'' variety and 'Bibo' F1 variety. Results from this study indicated that skins of the organic eggplants are suitable for valorization as sources of natural phenolic compounds with significant quality attributes and antioxidant activity. It has been shown that these parameters are generally influenced by the eggplant variety.

Key words: *eggplants, organic, antioxidant capacity, polyphenols, anthocyanin.*

INTRODUCTION

Eggplant (*Solanum melongena* L.) is considered being as one of the world`s top vegetable species after tomato, potato, pepper, from agronomically and economically point of view (Gebhardt, 2016).

Eggplant production has an increase in the world in the last years from 46,954,913 tons in 2012 to 52,309,119 tons in 2017. The most important producers worldwide of eggplant crop are China (30,267,726.17 tons) followed by India (12,874,970 tons), Egypt (1,251,250.5 tons), Italy (302,254.83 tons) and Spain (231,230 tons) (FAOSTAT, 2019, accessed 09.05.2019).

Eggplant is a crop well adapted to hot and wet environments. Eggplant is an important source of minerals, polysaccharide, and nutrients (anthocyanins and phenolic compounds being the most important ones) with antioxidant properties. (Gürbüz, 2018).

Chlorogenic acid was found as the predominant acid in eggplant pulp (Plazas et al., 2013).

Others important phenolic compounds are: hydroxycinnamic acids and their derivatives, 3-acetyl-5-cafeoylquinic acid, N-caffeoyl putrescine, quercetin-3-glucoside, quercetin-3-rhamnoside, myricetin-3-galactoside (Nino-Medina, 2017). The eggplant skin is rich in anthocyanins and also in phenolic acids (delphinidin derivatives and chlorogenic acid isomers) in the flesh (Nino-Medina, 2017). Eggplant anthocyanins are represented by delphinidin-glycosides, where delphinidin-3-(p-coumaroyl rutinoside)-5-glucoside and delphinidin-3-rutinoside, have been identified as the major compounds in eggplant peels (Sadilova, 2006, Gürbüz, 2018). Phenolic content in eggplants can vary with the variety, intensity and type of light, temperature, growing conditions, agronomic treatments, processing and storage. (Okmen, 2009). Gürbüz et al. (2018) showed in his study that most of the phenolic compounds decreased from spring to summer, suggesting that high temperatures have a negative effect on phenolic content. Harvesting season also has an effect on phenolic acid content in eggplant. The skin of eggplants grown in the organic system was found to contain higher levels of the phenolic compounds compared to those grown under

conventional conditions (Singh et al., 2017). The amount of phenolic compounds depends more on the cultivar than on growing conditions (Zambrano-Moreno, 2015).
This information might be a guide for the agricultural sector in determining the suitable harvest time or growth conditions of the eggplants with high phenolic compound content.
The aim of the present study is to evaluate the physicochemical quality, as well as the phenolic content, total anthocyanins and antioxidant activity in eggplant skin of three varieties (‘Mirval’, ‘Bibo’ F1 and ‘Black Pearl’), which were growth as in organic environmental conditions.

MATERIALS AND METHODS

The physico-chemical quality analysis has been made on fully ripped eggplant fruits obtained by improving the cultivation technology as organic environment. The eggplants were grown in two experimental variants, in the plastic tunnel and in open field, with and without organic fertilizers (control). Fertilization was done with organic fertilizer VIANO Leguma 150 g/m^2 granules. The novelty in the cultivation technology is the use of this organic fertilizer applied at a dose of 150 g/m^2 during planting and twice during vegetation in fertilized variants and the use of natural predators (Spidex and Swirskii mite) to limit the pests, in organic environmental conditions even though the farm wasn’t organic certified.
All the quality analyses were carried out in the laboratories of the Research Center for Studies of Food and Agricultural Products Quality, University of Agronomic Sciences and Veterinary Medicine of Bucharest.
All the reagents and solvents were analytical grade. All the analyses were performed in triplicate. The results were calculated by using Excel software Data Analysis.

Preparation of the eggplant skin extracts was made by following Stan et al. (2017) procedure.
To 1 g of fresh eggplant skin ground in mortar were added 10 mL of 70% aqueous methanol and incubated in the dark overnight at 4°C. After that, the extracts were shaken at 500 rpm for 1h and then centrifuged at 5000 rpm and 4°C for 10 min. The supernatant was recovered in a centrifuge tube and the residue was re-extracted two more times with 10 ml of 70% aqueous methanol. All three supernatants were combined and then the volume of each extract was adjusted to 30 mL with the extraction solvent.

The total phenolic content (TPC) was determined using Folin-Ciocalteu method according to the procedure described by Bujor et al. (2016).
To 0.50 mL of extract was added 0.25 mL Folin-Ciocalteu reagent (2 N), 1 mL of 10 % Na_2CO_3 solution and 2.5 mL of distilled water. The mixture was left for 90 minutes in the darkness at room temperature. A mixture of water and reagents was used as blank. Then, the absorbance was measured at 765 nm.
The results were expressed as mg of gallic acid equivalents per gram of fresh weight (mg GAE/g FW).
Total anthocyanin content (TAC)
The extract for TAC was prepared as follows:
To 0.3 g of fresh eggplant skin ground in a mortar with pistil were added 5 mL of methanol acidified by 37% HCl (1% v/v). The residue was re-extracted with the extraction solvent until it becomes colorless and the final volume of the extract was adjusted to 15 mL.
The absorbance of the extracts was measured at 530 nm.
Results were calculated based on the formula and expressed in mg 100g^{-1} FW: Total anthocyanins = DO530 x F, where DO530 is absorbance at λ = 530 nm and factor F = 11.16 (Barascu, 2016).
For all spectrophotometric methods, the measurement of the absorbance of the extracts was made by using Specord 210Plus UV/VIS spectrophotometer.

DPPH (2,2-diphenyl- 1-picrylhydrazyl) radical scavenging assay
The DPPH assay was determined after the methods described by Brand-Williams et al. (1995) and Bujor et al. (2016).
Briefly, 0.2 mL of the sample extract was added to 2 mL of 0.2 mM solution of DPPH in methanol. The DPPH solution was prepared daily and protected from the light. The mixture

solutions were put under dark shaking at 500 rpm (IKA KS260 homogenizer) for 30 minutes. Then the absorbance was measured at 515 nm. Methanol was used as a blank reference. The results were expressed as % radical scavenging activity and were calculated using the following formula:

DPPH radical scavenging activity (%) =

$$(A_{control} - A_{sample})/A_{control} \times 100,$$

where $A_{control}$ is the absorbance of control reaction (without eggplant extract), and A_{sample} is the absorbance in the presence of eggplant extract.

RESULTS AND DISCUSSIONS

The results obtained for TPC are presented in Figure 1. The TPC varied between 1.58 mg GAE/g FW for 'BIBO' F1 control variety and 4.66 mg GAE/g FW for 'Mirval' variety grown with fertilizer and in plastic tunnel experimental variant.

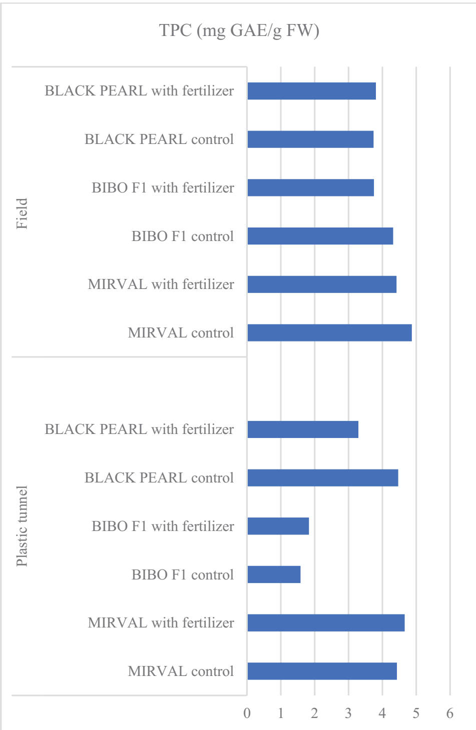

Figure 1. TPC of the eggplants varieties

The results from experimental field varied between 3.74 mg GAE/g FW for 'Black Pearl' variety without fertilizer and 4.87 mg GAE/g FW for 'Mirval' variety, the control variant. It was also found that the TPC was higher for both 'Mirval' and 'Black Pearl' varieties whatever the conditions of growth compared to 'Bibo' F1 variety. The highest TPC content was determined for 'Mirval' variety without fertilizer, grown in the field with 4.87 mg GAE/g FW. All these results are according to those obtained by Kaur et al. (2014) for 22 white and purple cultivars.

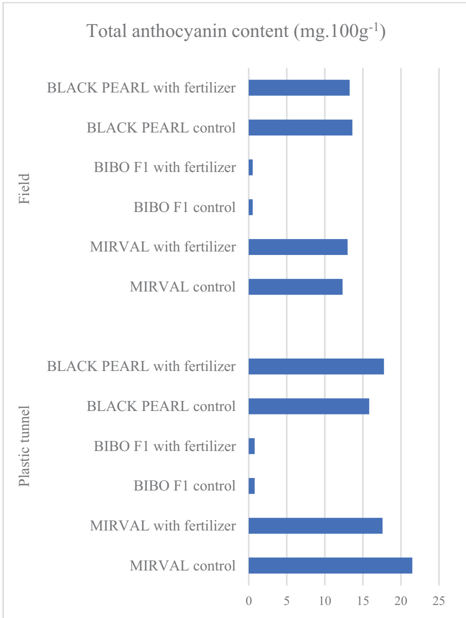

Figure 2. TAC of the eggplant varieties

The highest total anthocyanin content (Figure 2) was found for 'Mirval' variety in control variant (21.50 mg/100 g) and 'Black Pearl' variety with fertilizer (17.78 mg/100 g) in the plastic tunnel experiment.

The radical scavenging activity (Figure 3) varied between 36.47% for 'Bibo' F1 control variant and 66.797% for 'Mirval' variety with fertilizer grown in plastic tunnel experiment. For the field experiment, the DPPH activity was between 46.96% for 'Bibo' F1 variety in control variant, and 59.70% for 'Mirval' variety in control variant. The highest antioxidant activity was found for 'Mirval' and 'Black Pearl' variety in the plastic tunnel grown condition, compared to 'Bibo' F1 variety.

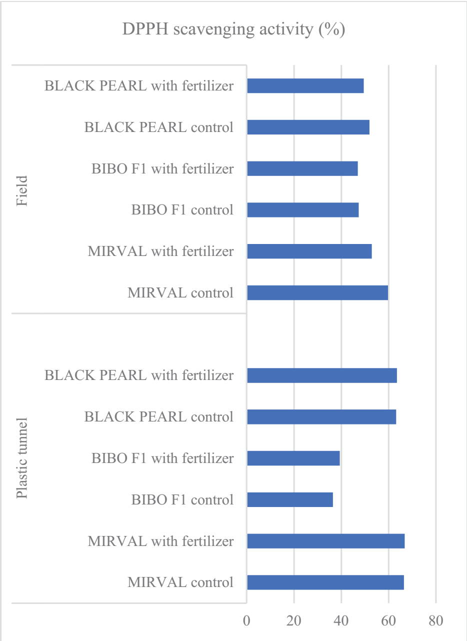

Figure 3. DPPH radical scavenging activity of the eggplant varieties

Table 1 show that it was found a good correlation between the DPPH radical scavenging activity and both TPC and TAC with r of 0.748 and 0.889, respectively (Table 1).

Table 1. Correlation between antioxidant activity, TPC and TAC for the eggplant varieties

	DPPH scavenging activity (%)
TPC (mg GAE/g) FW	0.748
TA (mg.100g^{-1} FW)	0.889

The cultural practices from this experiment affect the total phenolic content, with significant influence especially to the antioxidant activity, between the variants cultivated in the plastic tunnel than in the open field. In the open field, probably due to the environment influence (ex. light, temperature), the total phenolic contents and antioxidant activity are rather influenced by genotype than other cultural practices (ex. fertilization).
Also, the fertilizer showed any significant influence on the radical scavenging activity, in both cultivation systems. The anthocyanin contents are strongly influenced by genotype, both in the plastic tunnel and open field variants, more than phenolic compounds content. 'BIBO' F1, as a white variety, revealed a poor content of anthocyanins, although its antioxidant activity is quite high being correlated with TPC.
All three determined parameters are rather influenced by genotype than other cultural practices, which could be an advantage if these cultivars are sources of natural antioxidants.

CONCLUSIONS

Results from this study indicated that eggplant skins are suitable for valorization as sources of natural phenolic compounds with significant quality attributes and antioxidant activity, especially when are obtained in organic or organic-like conditions. The anthocyanins are quantified in significant amounts in 'Mirval' and 'Black Pearl' skins, which recommend their use in formulation of nutritionally enhanced food products and in natural colorants industry. In addition, it has been shown that quality parameters are generally influenced by the eggplant variety.

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