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Physicochemical Evaluation and Bioactive Compounds in Fruits of Solanum Nigrum L.

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SUMMARY: Brazil stands out as a major fruit producer. However, many fruits are not yet produced in large scale due to the lack of knowledge of their cultivation practices. *Solanum nigrum L.* is a plant that produces small fruits known as Black-Mary. In this work, we evaluated the following characteristics: titratable acidity (TA), soluble solids (SS), TA / SS ratio, pH, vitamin C, crude protein, lipids, ashes (minerals), mineral quantification, reducing and total sugars and staining characterization (parameters a, b, C, G, H), phenolic compounds content evaluation, anthocyanins and their antioxidant activity. The results were satisfactory, especially regarding its antioxidant activity and phenolic compounds, which presented the values of 40.09% and 1036.32 mg per 100 g of sample, respectively. We can also highlight its 0.06% lipids content, 81.05% moisture and 2.25% protein content, along with significant amounts of macronutrients and micronutrients.

KEYWORDS: *Solanum nigrum L.*, physicochemical, bioactive compounds.

INTRODUCTION

Solanum nigrum belongs to the family Solanaceae, commonly known as "black mary", it is an annual herbaceous plant, 10-60 cm tall, with a semi climber stem, green and smooth, it grows like a weed, it is found mainly in the most arid parts of India, and other parts of the world such as Africa and America. It has long medicine history and has been used as a traditional remedy for various diseases related to pain, inflammation, fever and liver disorders (Latiff, 2002).

Section Solanum, also known as the *S. nigrum* complex, is composed of 50 species and it is one of the mostvariable groups of the genus (Child, 2001). Polyploidy and hybridizationis often reported as an important source of diversity, while members of the group are phenotypicallydiverse.

Most Solanum species are toxic and *Solanum nigrum* is no exception, in fact, it has the reputation of being very toxic due to its high concentrations of alkaloids such as solanine, solamargine, and solasodine, which are produced by the plant, presumably as a defense against predators (fungi and insects). These alkaloids are concentrated especially in the green parts of the plant which, according to certain currents of opinion, is very harmful to humans and livestock; it can even be fatal when ingested.

In addition to many local uses inAfrica the species of sect. Solanum are potentially globally important for agriculture, human health, plant breeding andbiotechnology. The leaves and berries are a potentialsource of coloring plant extracts, inks and dyes (Lehmann, 2007) andthey are rich in proteins, fibers, vitamins and amino acids (Manoko, 2004).

In spite of that, *Solanum nigrum* is cultivated as a vegetable in many regions of Africa and North America where the young leaves and shoots are eaten in soups and stews, always well cooked, and also included in traditional dishes in Ethiopia, Ghana, South Africa and Indonesia. Even in Europe, including Crete, Greece and Turkey, the young leaves are used in vegetable salads, after cooked.

The "black mary" is usually very rich in nutritional values, capable of supplying minerals, vitamins, proteins and some hormones precursors (Dhellot, 2006). This herb produces a broad range in medicinal properties, anticancer functions, antioxidant, neuroprotective, anti-microbial, among others (Zakaria, 2004). It is often said that *Solanum nigrum* fruits, in particular, are excellent remedies for liver disorders and they also have the ability to find hydroxyl radicals and inactivate its oxidative damage (Kumar, 2001). *S. nigrum* has several components that are responsible for its various activities. Most active components are glycol alkaloids, glycol proteins and polysaccharides (Sikdar, 2008). The *S. nigrum L.* seeds have a high fat content. Its protein and mineral contents, especially magnesium (Mg), are substantial (Dhellot et al., 2006).

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The physicochemical quality can be assessed by its main attributes, especially regarding size, weight, shape, presence and type of defects, color, brightness, acidity, soluble solids, sugars, volatile compounds, vitamin C, among others. The size and weight are inherent physical characteristics of the species or cultivars, but are used as a quality attribute for products selection and classification, according to the consumers` convenience. The coloration is also used as a parameter for selection (Chitarra; Chitarra, 2005).

The Brazilian fruit farming is one of the most important activities in the food sector and contributes to economic development, to fresh fruits market expansion and to the industrialization of juices, pulps, purees, among others (Kechinski, 2011). Fruits with high content of phenolic compounds have been widely investigated to evaluate its action as natural antioxidants (Melo et al., 2008).

MATERIALS AND METHODS

The fruits of Black-Mary *Solanum nigrum L.* were collected on April 04/2012, in Maringá-Paraná region. The evaluations were performed in the laboratory of Food Biochemistry at Universidade Estadual de Maringá - UEM, Maringá-Paraná. The analyses were performed in triplicate.

The fruits were evaluated for physicochemical and biochemical composition.
We evaluated the color with a colorimeter by reflectance, brand Konica Minolta, obtaining the lightness parameters (L) ranging from 0% (white) to 100% (black) and propensity to colors green (a-), red (a+), blue (b -) and yellow (b +) and chromaticity (C). The colorimeter was positioned on the sample and the button was triggered to discharge the light rays on it, so that those which have been reflected by the sample and analyzed by the machine. The readings of four sample points were made. The values of L, a, b and C were read directly from the colorimeter display.

The quantification of the moisture content was performed by kiln drying at 105 ° C to constant weight (IAL, 2005) and the pH value was determined using a digital potentiometer.

The titratable acidity (TA) was performed by the titration method with the methodology described by the Instituto de Tecnologia de Alimentos (Institute of Food Technology) - ITAL (1990) and the soluble solids (SS) contends were determined with the aid of digital refractometer. The values are expressed in degrees Brix. Through these analyses we were able to do the relation TA/SS (ratio) (AOAC, 1997).

The ashes contend were quantified by incineration in Muffle furnace at 550 ° C for six hours (IAL, 2005). And the mineral components were quantified by nitro-perchloric digestion. The minerals calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P), sodium (Na), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn) were determined using 0. 5 mL of the sample to Ca; 0.1 mL for Mg, Mn, Na, Fe, Cu and Zn, and 0.01 mL for K. For these determinations it was added 25 ml of 0.1% lanthanum to the samples. These determinations were performed by the method of atomic absorption spectrophotometry (brand Varian, mod. 10 Plus). For the P determination, it was used 1.0 mL of the sample with addition of 10 mL of ammonium molybdate solution and 0.05 g of ascorbic acid according to the method described by Pavan et al. (1992), using UV-Vis spectrophotometry (Hitachi, mod. 2,001).
The total and reducing sugars were determined using the Lane-Eynon titration method, with the use of factored A and B Fehling Solutions (IAL, 2005).

The protein contend was performed according to the IAL methodology (2005), Semi-Micro-Kjeldahl method and the lipid content was obtained by the cold extraction method, according to Bligh and Dyer (1959).

The ascorbic acid determination was made by the titration method, performed accordingly to Tillmans (ITAL 1990). Ascorbic acid neutralization by titration, in a solution of 2,6 – diclorobenzeno-indophenol, expressed in milligrams of ascorbic acid per 100 mL. The samples extraction was done with a solution of oxalic acid at 1%.

In the determination of phenolic compounds, 5 g of sample were used and diluted to 25 mL in a volumetric flask. From this, it was taken an aliquot of 0.1 mL, added 5 mL of distilled water and 0.5 ml of Folin-Ciocauteau reagent. It was kept static for 3 min and then 2 ml of sodium carbonate at 15% was added, and the volume was completed with distilled water to a 10 mL volumetric flask. It was left in the dark for two hours. After two hours, the reading was performed in a UV/Vis spectrophotometer at 765 nm. The blank was prepared with the substitution of the sample volume by distilled water.

The extraction of total anthocyanin was performed according to Lee and Francis methodology (1972), with some modifications. 10 g of the sample were weighed. Fruits were homogenized for 2 minutes in a blender, with 100 mL of the solvent solution (70% ethanol acidified to pH 2.0 with 0.1% HCl). After that, the volume was completed to 200 ml in a beaker, and covered with parafilm and stored in refrigerator at 4 o C for 12 hours. Then, the material was filtered on Buchner funnel with the aid of a vacuum pump, and the filtrate received in bottle. 50 mL of the filtrate was removed and completed with

the solvent to 100 mL. From this, 2 mL were taken and the volume was completed to 100 mL in a volumetric flask. After that, it was left in the dark for two hours, by covering the volumetric flask with aluminum foil and storing it in a locked cabinet. Then, the reading was done in a spectrophotometer at 535 nm, using only the solvent as blank (BUCIC-KOJIC, 2007).

The procedure used to determine the antioxidant activity was the method of free-radical capture DPPH according to Rufino et al (2007) adapted from Larrauri et al. (1997). As the antioxidant compounds concentration varies from fruit to fruit, prior tests were performed. The sample was weighed in a 100 mL beaker and diluted with 40 mL of 50% methanol, resting for one hour at room temperature. After that, it was centrifuged at 15,000 rpm for 15 minutes. From the first extraction residue, 40 mL of 70% acetone were added, homogenization was performed and then it rested for another hour. It was again centrifuged for 15 minutes and the supernatant transferred to the volumetric flask. In the dark, an aliquot of 0.1 mL of each extract dilution was transferred to test tubes with 3.9 mL of the 0.06 mM DPPH radical and then, homogenized. We used 0.1 mL of the methanol control solution, acetone and water with 3.9 mL of the DPPH radical. Methanol was used as blank to calibrate the spectrophotometer at 515 nm.

RESULTS AND DISCUSSION

The results of the black mary fruit color characterization can be observed in Table 1. The samples were analyzed by taking the parameters of lightness (L), ranging from 0% (white) to 100% (black) and trends to green (a-), red (a+), blue (b-) and yellow (b +) and chromaticity (C).

Table 1 – Black Mary fruit color characterization.

Parameters	Average values (δ)
A	+4.43±0.23
B	-2.50±1.18
C	4.40±0.95
L	20.60±1.08

δ = standard deviation

The values obtained for the coordinates 'a' and 'b' indicate that the Black Mary fruits present discolored blackish purple (red + blue), varying according to their maturation. It presents low lightness accordingly to parameter L.

Table 2 – Chemical parameters of the Black- Mary fruits

Parameters	Average values ± (δ)
pH	4.91±0.14
AT[1] (mg citric acid 100g fruit)	0.319±0.07
Soluble solid (°Brix)	12.90±0.21
Ratio (SS/AT)	40.44±0.40
Ascorbic acid (g ascorbic acid $100g^{-1}$)	98.28±1.03
Moisture (%)	81.05±0.42
Ashes (%)	0.91±0.11
Protein (g protein $100g^{-1}$)	2.25±0.02
Lipids (g de lipids $100g^{-1}$)	0.06±0.00
Reducing sugar (%)	9.21±0.72
Total sugar (%)	19.48±0.39
Anthocyanin (g $100g^{-1}$)	2.90±0.02
Phenolic compounds (mg $100g^{-1}$)	1036.32±2.45
Antioxidant activity (%)	40.09±1.89

[1]AT – titratable acidity; δ = standard deviation

From the obtained results we can highlight mainly the phenolic content of the "black mary" and its antioxidant activity. Both are relevant as to the nutritional character and medicinal properties of *Solanum nigrum* fruits. It is also highlighted, from the moisture analysis, the water content the fruits have and the presence of vitamin C.

Compared with the eggplant (*Solanum melongena*), which also belongs to the family Solanaceae, the moisture is relatively low because, on this account, the eggplant contains moisture of approximately 93.8% (Unicamp, 2006), while the fruits of *Solanum nigrum L*. present humidity of 81%. In contrast, the ashes related to such species show little difference, being 0.8% eggplant and 0.9% of the "black mary".

Relating the proteins and lipids present in both species there are also differences. The amount of protein provided by UNICAMP (2006) to protein was 1.2 g and 0.1 g of lipids per 100g sample of eggplant, while in the present study we found values of 2.25 g for protein and 0.06 g for lipids for the fruits of *Solanum nigrum*.

Table 3 – Quantification of minerals

Macronutrient	Average values ($g.kg^{-1}$) ± (δ)
Mg	2.14±0.02
Ca	3.55±0.04
K	24.97±1.21
N	20.57±1.01
P	1.99±0.20

δ = standard deviation

Table 4 – Quantification of minerals

Micronutrients	Average values ($mg.kg^{-1}$) ± (δ)
Fe	58.6±2.01
Cu	134±4.51
Mn	32.9±0.76
Zn	17±0.32
B	2.29±0,12

δ = standard deviation

Regarding the presence of minerals, we observe the abundance of potassium (K) among macronutrients and copper (Cu), present among the micronutrients. The fruits of *Solanum nigrum L.* present relevant values as to mineral levels.

CONCLUSION

From the results we can conclude the fruits produced by the plant *Solanum nigrum* L. are very rich in nutritional components, capable of meeting the daily diet of minerals, vitamins, proteins, besides presenting components with medicinal properties, anticancer functions, antioxidant, neuro-protective, antimicrobial and they should therefore, be part of the human diet.

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