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Evaluation of the Antioxidant Activity of Stalk and Fruit of *Solanum aethiopicum* L. (Solanaceae)

Kady Diatta[1*], William Diatta[1], Alioune Dior Fall[1], Serigne Ibra Mbacké Dieng[1], Amadou Ibrahima Mbaye[1], Abdou Sarr[1] and Mourchidath Adjoke Adegbindin[1]

[1]Laboratory of Pharmacognosy and Botany, FMPO, UCAD, Dakar, Senegal.

Authors' contributions

This work was carried out in collaboration among all authors. Author KD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors WD and ADF managed the analyses of the study. Authors SIMD, AIM, AS and MAA performed the statistical analysis. Author ADF managed the literature searches and approved the final corrections. All authors read and approved the final manuscript.

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ABSTRACT

Background: The use of plants for healing dates back to very remote times. Nowadays with the accession of new diseases plants are increasingly used for the formulation of new drugs able to overcome the many diseases (cancer, atherosclerosis) often caused by the disorder of the system prooxidant/antioxidant.
Aim/Objective: On the strength of this observation, the research of an antioxidant plant is essential, hence the aim of this study, which is to determine the antioxidant activity of the stalk and the fruit of *Solanum aethiopicum* L.
Methods: The fruits and stalk were washed, cut into fine slats, then dried in the incubator for three days and finally crushed into powder. An extraction by decoction with ethanol (stalks and fruits) and water (fruit) was subsequently carried out to obtain three extracts (ethanol and water). Antioxidant activity was evaluated through the FRAP method, and the trapping of radical DPPH.
Results: For the FRAP method, at the highest concentration (1 mg/ml) the aqueous extract of the

**Corresponding author: E-mail: khadydiose@yahoo.fr;*

fruit (74.84±2.97%) has a higher reducing power compared to those of the ethanolic extracts of the fruit (70.15 ± 5.72%) and the stalk (49.85 ± 2.11%). These reducing powers, although significant, remain lower than those of tannic acid (89.95±0.007%). And finally, for the DPPH method, the aqueous extract of the fruit is more effective in reducing free radical DPPH with a IC_{50}= 162±33 µg/ml, follow up by ethanol extract from the stalk (IC_{50}= 360± 90 µg/ml) and finally ethanol extract from the fruit (IC_{50}= 362.5± 23.5 µg/ml). These results confirm the *in vitro* antioxidant activity of the studied parts of *Solanum aethiopicum.*

Conclusion: Prospective studies could focus on acute and subacute toxicities and the determination of the molecules responsible for the activity.

Keywords: Stalks; fruit; Solanum aethiopicum; antioxidant activity; DPPH; FRAP.

1. INTRODUCTION

Molecular oxygen is an essential element for living beings in aerobic conditions. This crucial element is toxic in certain situations by the production of secondary species called reactive oxygen species (ROS). These ROS are not always toxic because at low doses they contribute to the good functioning of the body by intervening in important mechanisms such as signal transduction or the regulation of the activity of certain enzymes. The control of ROS is provided by antioxidants because their overproduction induces oxidative stress at the origin of various diseases ranging from cardiovascular diseases to cancer via metabolic pathologies. ROS are also incriminated in accelerating the aging process. For the preservation of the capacities and the performances of the organism, a return to the balance between the antioxidant system and oxidant becomes necessary [1]. An exogenous antioxidant supply proves to be a solution. Side effects related to the use of synthetic antioxidants raises many questions as to the relevance of the risk/benefit ratio and will lead more and more to the search for substances more bearable by the body [1]. Antioxidants are currently the subject of many studies because, in addition to a certain interest in the conservation of edible foods, they could be useful in the prophylaxis and treatment of diseases in which oxidative stress is incriminated [2]. It is in this context that the development of the use of so-called natural substances rich in antioxidants is included. The selection of vegetables with improved content of bioactive phenolic compounds is one of the objectives of a growing number of breeding programs aimed at developing new varieties with improved functional properties [3]. Thus, medicinal plants are an inexhaustible source and easily accessible in natural antioxidants. Their uses in indigenous medicine range from weight reduction to the treatment of many ailments including asthma, allergic rhinitis, nasal catarrh, skin infections, rheumatic diseases and swollen joint pains, gastroesophageal reflux, constipation, dyspepsia [3]. Several studies support the folkloric use of plants in local foods and medicinal preparations; For example, various investigators reported significant analgesic, anti-inflammatory, anti-asthmatic, anti-glaucoma, hypoglycemic, hypolipidemic and weight loss effects of eggplants, particularly *S. melongena*, on test animals and animals human beings [4]. Pharmacological properties have been attributed to the presence of certain chemical substances in plants, such as fibers, ascorbic acid, phenols, anthocyanins, glycoalkaloids and α-chaconine [5,6].

This is what motivates the aim of this study, which is to evaluate the antioxidant of the peduncle and fruit of *Solanum aethiopicum* L.

2. MATERIALS AND METHODS

2.1 Plant Material

The plant material was bought in the suburbs of Dakar more precisely in Camberene in June 2015 and the fruits and peduncles were identified at the Pharmacology Laboratory of the Faculty of Medicine of Pharmacy and Odontology of Dakar by Dr. Diatta (Botanist). The harvested plant parts were washed and dried in an oven at 60°C for four days before being reduced to powder.

2.2 Methodology

2.2.1 Preparation of plant extracts

The extraction was carried out by decoction of 25 g of fruit powder, boiled under reflux in 450 ml of water for 30 minutes. After filtration, the aqueous extract thus obtained was evaporated with

Rotavapor to obtain a dry residue. Finally, 25 g of the fruit powder and 25 g of peduncle powder were extracted successively with 450 ml of ethanol by decoction several times. The extractive solutions were then evaporated to dryness.

2.2.2 Phytochemical screening

The presence of the main chemical groups in the extracts was sought using the tests described by Bassene [7]: Flavonoids (Shibata test), tannins (Stiasny reaction followed by that of ferric chloride), alkaloids (Dragendorff's reagent), cardiotonic glycoside reducing compounds (reactions of Baljet, Kedde, and Raymond-Marthoud) and saponosides (foam number).

2.2.3 DPPH• test

The antioxidant capacity was evaluated according to the method described by Molyneux [8]. The extract was tested at different concentrations (0.13, 0.2, 0.3, 0.45 and 1 mg/ml) with DDPH and ascorbic acid was used as the reference antioxidant. Absorbance measurement was performed at 517 nm spectrophotometer after 30 minutes incubation (T30) using ethanol as a blank. Three tests were performed for each test portion concentration (n = 3). The antioxidant activity related to the $DPPH^{\cdot}$ trapping effect is expressed as a percentage inhibition (PI) using the following formula:

$$PI = 100(A0-A1)/A0$$

A0: Absorbance DPPH A1: Sample absorbance. The IC_{50} (sample concentration required to neutralize 50% free radicals) was obtained using the Statgraphics Plus 5.0 software. Then the EC_{50} (Effective concentration) calculated from the IC_{50} divided by the molecular mass of DPPH and PA (antiradical power) equal to the inverse of the effective concentration.

2.2.4 FRAP test (Ferric Reducing Antioxidant Power)

The reducing capacity of the extracts of the peduncle and the fruit was evaluated according to the method described by Bassene, [7]. Briefly, different concentrations of each extract (0.2, 0.3, 0.45, 0.67 and 1 mg/ml) were diluted half in distilled water and then mixed with 2.5 ml of the phosphate buffer solution. (0.2M, pH 6.6) and 2.5 ml of 1% potassium ferricyanide $[K_3Fe(CN)_6]$. The mixtures obtained were incubated at 50°C for 30 minutes, 2.5 ml of trichloroacetic acid (10%) was added. After centrifugation at 3000 rpm for 10 min, 2.5 ml of the supernatant of each concentration was mixed with 2.5 ml of distilled water and 0.5 ml of $FeCl_3$ (0.1%). Absorbance was measured at 700 nm using a spectrophotometer (BTS 350, biosystems). The antioxidant activity related to the reducing power of the extracts is expressed in reducing power (RP) using the following formula [7]:

$$RP = 100(Aa-Ab) /Aa$$

Aa: Absorbance of the extract, Ab: Absorbance of the blank

2.2.5 Statistical analysis

Statview software was used for statistical analysis. Thus, a normal analysis of variance followed by the Fisher test was performed. The difference is considered significant if $p < 0.05$ compared to the negative control (DPPH solution). Statgraphics 5.0 software was used to generate inhibitory concentrations.

3. RESULTS AND DISCUSSION

3.1 Phytochemical Screening

Phytochemical screening revealed the presence of flavonoids, condensed tannins, reducing compounds and cardiotonic glycosides both in the aqueous and ethanolic extracts of the fruit. Saponosides are present at the level of aqueous extracts of the fruit and ethanolic peduncle alkaloids, present in the ethanolic extracts of the fruit and peduncle. The hydrolyzable tannins were not found in both parts of the plant studied.

3.2 DPPH Test

At all concentrations tested, the hydroethanolic extracts of the fruit and peduncles significantly inhibited the $DPPH^{\cdot}$ radical in a dose-dependent manner ($p < 0.05$ versus negative control). The aqueous extract of the fruit showed higher activity than the other extracts. Indeed, the aqueous extract of the fruit reaches almost its maximum activity at 1 mg/ml with a percentage inhibition (PI) of 89.65 ± 0.31%. As for the ethanolic extracts of the fruit and peduncles, their most important PI are respectively, (83.80 ± 0.73% and 85.89 ± 4.08%) at the concentration of 1 mg/ml. Vitamin C used as a reference inhibited the DPPH radical by 90.38 ± 0.21% at the concentration of 0.067 mg/ml (Fig. 1).

To better compare the activities of the different plant extracts tested, the IC_{50}, EC_{50}, and PA were determined. Thus, the aqueous extract of the fruit has an IC_{50} higher than that of the other extracts (confers Table 1). Vitamin C showed an IC_{50} equal to 30.28 ± 1.88 as shown in Table 1.

3.3 FRAP Test

The evaluation of the reducing power of the extracts also showed a better activity of the aqueous extract of the fruit compared to those of the others as shown in Fig. 2. Indeed, the aqueous extract of the fruit, at concentrations of 0.2; 0.3; 0.45; 0.67 and 1 mg/ml gave respective reducing powers of 2.42 ± 0.86%; 17.43 ± 7.06%; 37.85 ± 4.27%; 64.36 ± 1.61% and 74.84 ± 2.97%. At the same concentrations, respective reducing powers of 8.48 ± 1.52%; 16.45 ± 11.5%; 25.81 ± 2.37%; 42.64 ± 0.82% and 70.15 ± 5.72% for the ethanolic extract of the fruit. The ethanolic extract of the peduncle has lower reducing powers of 7.2 ± 5.64%; 18.33 ± 0.6%; 22.11 ± 4.39%; 35.85 ± 1.86% and 49.85 ± 2.1% at the same concentrations. A strong reducing power was noted with the reference with values of the order of 15.64 ± 1.77%; 40.7 ± 1.27%; 59.74 ± 2.31%; 74.98 ± 1.23% and 89.95 ± 0.007% at concentrations (0.02, 0.03, 0.045, 0.067 and 0.1 mg/ml).

3.4 Discussion

This study aimed to search for antioxidant potentials in the peduncles and fruits of eggplant (*Solanum aethiopicum* L.). At the level of phytochemical screening, we found flavonoids, saponosides, condensed tannins, alkaloids, and

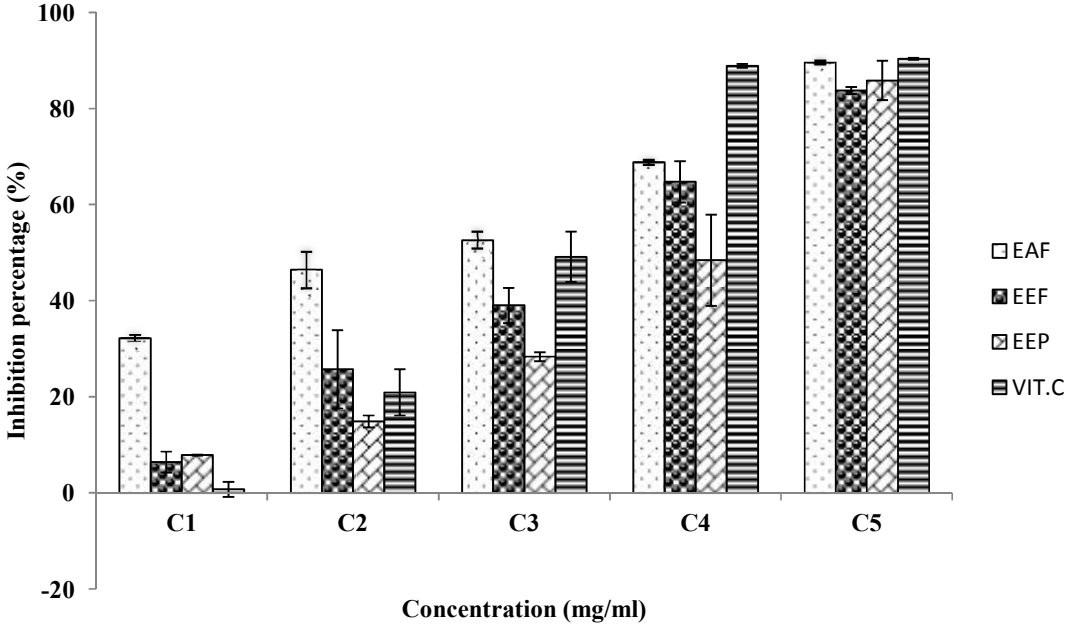

Fig. 1. Variation of the percentage inhibition of DPPH according to the different extracts tested
Ethanolic extract of the fruit and peduncle (EAF and EEF) : C1 = 0.13 mg/ml; C2 = 0.2 mg/ml; C3 = 0. mg/ml; C4 = 0.45 mg/ml; C5 = 1 mg/ml. Vitamin C (Vit C) : C1 = 0.013 mg/ml; C2 = 0.02 mg/ml; C3 = 0.03 mg/ml; C4 = 0.045 mg/ml; C5 = 0.067 mg/ml

Table 1. Concentrations of inhibitions and effective at 50% (IC_{50} and EC_{50}) and the antiradical power (AP) of the extracts and the Vitamin C

	EE fruit	EA fruit	EE stalks	Vitamin C
IC_{50} (µg/ml)	162±33*	362,5± 23,5*	360± 21,52*	30,28±1,88*
EC_{50} (g/mol)	1620±330*	3625±235*	3600±215,2*	302,8±18,8*
AP	$61,73.10^{-5}$ ±0,003*	$27,59.10^{-5}$ ±0,004*	$29,63.10^{-5}$ ±$4,4.10^{-5*}$	$33,15.10^{-4}$± 2.10^{-4*}

EEF = Ethanolic fruit extract ; EAF = aqueous fruit extract; EEP: Ethanol extract stalk and tannic acid
** : significant difference versus negative control (DPPH solution) ; n = 3 for each concentration tested*

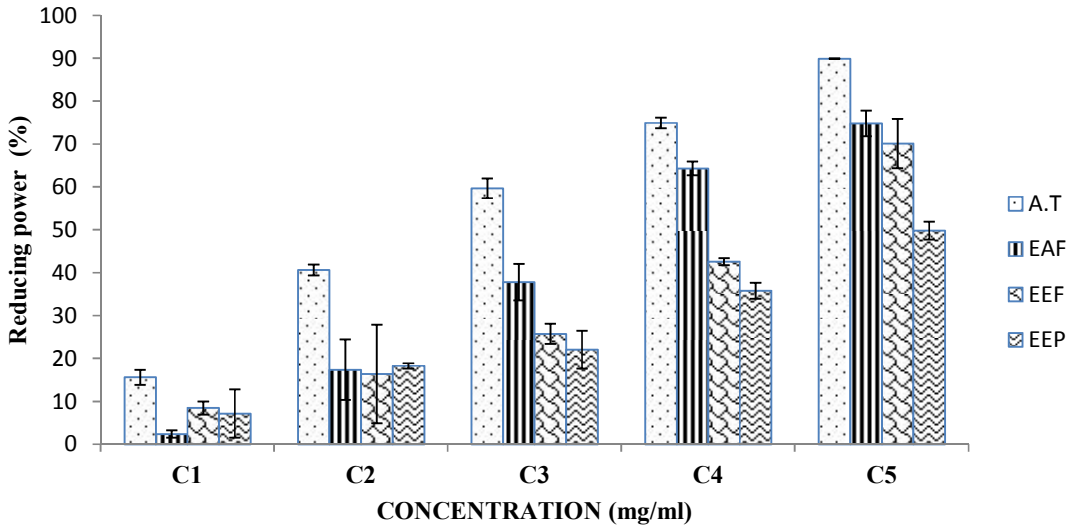

Fig. 2. Reducing power extracts and tannic acid

Ethanolic extract of the fruit and peduncle (EAF and EEF): C1 = 0.13 mg/ml; C2 = 0.2 mg/ml; C3 = 0.3 mg/ml; C4 = 0.45 mg/ml; C5 = 1 mg/ml. Aqueous extract of tannic acid (AT): C1 = 0.02 mg/ml; C2 = 0.03 mg/ml; C3 = 0.045 mg/ml; C4 = 0.067 mg/ml and C5 = 0.1 mg/ml

these results are in correlations with those found by Ogunka et al. [9]. In addition to the flavonoids and tannins of other polyphenolic compounds present in the fruit and peduncle would be responsible for the antioxidant activity. Thus, the works of Stommel and Whitaker [10], as well as those of Sunseri et al. [11] ,evaluated the amount of chlorogenic acid (polyphenol) contained in different varieties of *Solanum aethiopicum* L. in the search for antioxidant activity. These studies were confirmed in 2014 by Mariola et al. [12]. which showed that *Solanum aethiopicum* L. contained 1.51 g/kg of ACG against 1.66 g/kg for *Solanum macrocarpon*. African eggplants such as common aubergines (*Solanum melongena*) contain a high level of ACG with a high reducing capacity expressed at 7.45 g/kg of equivalent chlorogenic acid (concentration of pure ACG necessary for a reducing activity) [12]. Polyphenolic compounds are known to be good natural antioxidants. This antioxidant activity could be attributed to the presence of polyphenols. Since the latter is much more present in the aqueous phase than in the ethanolic phases, it is understood that the antioxidant activity of the aqueous extract is greater than the activity observed in the ethanolic extracts. Moreover, the flavonoids which are powerful antioxidants have their ability to donate hydrogen which increases with the increase of the hydroxylation of their phenolic cycles [13] therefore with their hydrophilicity; which would explain the more marked efficiency of the aqueous extract compared to the ethanolic extracts of the various studied parts of the plant. It has been demonstrated that the phenolic food compounds of vegetables and other herbal products had bioactive properties beneficial to human health, resulting in particular from free radical scavenging properties, the regulation of enzymatic activity or the modulation of several cell signaling pathways [14,15]. The results obtained on the antioxidant activity show that our extracts significantly inhibit the DPPH at all the concentrations tested ($P < 0.05$) and this in a dose-dependent manner. Regarding the antioxidant activity, the results obtained showed that the aqueous extract of the fruit of *S. aethiopicum* is more active than that of the other extracts on all 2 tests carried out with lower IC_{50}. Moreover, at the same concentrations tested, the PIs obtained by the DPPH test are higher than those of the FRAP method. This could be explained by the difference in actions at the level of mechanisms [16,17,18].

The value of IC_{50} is inversely related to the antioxidant capacity of a compound, as it expresses the number of antioxidants needed to decrease 50% of the radical concentration. The lower the IC_{50}, the higher the antioxidant activity of the compound, Villaño et al. [19].

It appears from the determination of IC_{50} that for the ethanolic extract of the fruit, only 362.5 ± 23.5 mg / ml is required to trap 50% of free radicals, as well as 162 ± 33 mg/ml and 360 ± 90 mg/ml respectively for the aqueous extract of the fruit and the ethanolic extract of the peduncle to trap 50% of the free radicals. The aqueous extract of the fruit, however, presents the best activity. This result could be correlated with those Shalom et al. [20] who describe that *Solanum aethiopicum* L. as a good source of vitamin C. The FRAP test has shown a better reducing power of the ferric ion of the aqueous extract of the fruit compared to the ethanolic extracts of the fruit and peduncle. The results obtained for FRAP are consistent with those obtained for DPPH. It is deduced that *Solanum aethiopicum* L. has antioxidant activity which is significant only when higher or lower concentrations of extracts are used.

4. CONCLUSION

In conclusion we can say that peduncles and fruits have very important antioxidant power. This is even confirmed by its use of the populations to cure various affections but also to feed. The results confirm that these parts of the plant can be used as a food additive supplemented with antioxidant intake of vegetable origin. Besides, with the high cost of antioxidant products of synthetic origin, the use of fruits and peduncles more accessible could be an alternative for the equilibration of the balance prooxidant/antioxidant in poor populations. Finally, studies in perspective could guide to isolate and identify antioxidant molecules by the bio-guided method but also to determine the acute and subacute toxicity of fruits and peduncles.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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