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Antioxidant Activity and Phenolics Content of the Seeds of Eighteen Varieties of Edible Cucurbitaceae of Niger

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ABSTRACT

Cucurbit seeds are commonly consumed in Niger. In previous studies we determined the protein, fat, minerals, fatty acids, tocopherols and β-carotene contents. The aim of this study was to determine the polyphenol, total flavonoids, condensed tannins contents and the antioxidant capacity of the seeds of the 17 varieties of *L. siceraria* species and a single variety of *C. colocynthis* belonging to the Cucurbitaceae family. The variance analysis showed a very significant difference between the varieties for the parameters studied. Indeed, in all of the seeds, the results showed the existence of an antioxidant activity that vary from 3.7-114 μmol EAA/100 g. The phytochemical screening showed fluctuating levels of phenolics from 79.2-203 mg/100 g, flavonoids from 0.08-17.9 mg kg^{-1} and tannins from 0.05-1 mg kg^{-1}. There is a positive correlation between the antioxidant activity and the polyphenol content ($r = 0.79$) on the one hand and on the other hand between the polyphenol and flavonoids content ($r = 0.76$). This study on Cucurbitaceae seeds, highlights their biological potentialities and can therefore contribute to the fight against proliferative diseases such as (type 2 diabetes and hypertension) in Niger.

Key words: Cucurbitaceae, seeds, Niger, antioxidant activity, phenolics

INTRODUCTION

In Niger, the protein and energy malnutrition (PEM), vitamin and mineral deficiencies represent major public health problems (Sara and Hassoumi, 2011). The valorization of alternative sources of nutrients and micronutrients (less or unknown) is therefore a prospective way that can contribute to the qualitative improvement of the nutritional status of malnourished populations and rebalancing their diet. Cucurbitaceae belong to this category of foods and they are widely consumed. Depending on the species, all parts of the plant can be used as food (Ng, 1993). However, some varieties are grown less frequently for food but in a strictly utilitarian purpose to get utensils. As such, Cucurbitaceae constitute also a potential source of income (Mohammed, 2011). In previous studies we have shown that the seeds of various varieties of Cucurbitaceae of Niger may be potential sources of nutrients and micronutrients which deficiency is acute in Niger (Sabo *et al*., 2005a, b; Sadou *et al*., 2007). While PEM continues to be a public health problem, morbidity and mortality due to excess or imbalance of supply continue to grow. This time, it is the fringe of the society relatively well-off that is the victim.

In recent years, fruits and vegetables played an important or significant role in the prevention and treatment of chronic nutritional diseases (WHO., 2002, 2004a). The beneficial role of fruits and vegetables is linked to their secondary metabolites content, including antioxidants (WHO., 2004b). Antioxidants are compounds that protect cells against the damaging effects of reactive oxygen species such as singlet oxygen, superoxide, peroxyl radicals, hydroxyl radicals and peroxynitrite (Parke, 1994). Antioxidants play a crucial role in the prevention of chronic ailments such as heart disease, cancer, diabetes, hypertension, stroke and Alzheimer's disease by combating oxidative stress (Lamien-Meda *et al*., 2008). One of the major groups of antioxidants from nutritional origin is constituted of phenolics (Scalbert *et al*., 2005; Mudgal *et al*., 2010). Fruits and vegetables together with drinks, constitute, the main source (Blazovics *et al*., 2003; Hue *et al*., 2012).

Three main families (flavonoids, anthocyanins and tannins) show increasing interest for their alleged role in their protective effects against non-communicable chronic diseases. These molecules intervene in the prevention and treatment of atherosclerosis and cardiovascular diseases (Lee *et al*., 2003), some cancers (Hammerstone *et al*., 2000), high blood pressure (Grassi *et al*., 2005) as well as type 2 diabetes (Hussain and Morouf, 2013).

In Niger, type 2 diabetes and hypertension are more and more, a national concern (WHO., 2007). Animal experiment and clinical studies show that phenolics play a protective role against these two diseases. Unfortunately, at this stage of our research and so far as dietary survey carried out in Niger are consened it is not possible to estimate the daily intake of phenolics since we don't know up till now, what is the precise content of total phenolics of various fruits and vegetables locally or spontaneous grown. The study was centered on the seeds of two species of Cucurbitaceae, *Citrullus colocynthis* (Linn.) Schrad and *Lagenaria siceraria* species (Molin.) Standl which products and by-products are commonly used as food in Niger. *Citrullus colocynthis* is drought resistant species and thus adapted to our arid regions (Xia *et al*., 2009). The objective of this current study is to assess, (1) The antioxidant power of the 18 seeds extraits, (2) Determine the total polyphenol content and (3) Split phenolics (by or from) flavonoids and determine tannins total contents.

MATERIALS AND METHODS

Plant material: The materiel is composed of 18 varieties including 17 (LS1 to LS17) of the *L. siceraria* species and one variety of *C. colocynthis* species (Table 1). They were very diverse. The berries can be large or small, of various forms (calabash, gourd, ladle ...) and of smooth or rough appearance. The berries were produced at the experimental station of the Abdou Moumouni University, Faculty of Sciences and Technology of Niamey located (13°30'N; 2°08'E; 216 a.s.l). Their Vernacular names were given in the two most spoken languages (Hausa and Zarma) in Niger (Fabregues, 1979).

Extracts preparation: Dehulled seeds were ground and then defatted by hexane percolation. Oilcakes obtained are used for the preparation of extracts for the determination of antioxidants and their activity (Rodriguez-Saona and Wrolstad, 2001). To 5 g of oilcake, were added 10 mL of acetone 100% (PROLABO) and 5 mL of water. After vortexing and centrifugation, the pellet was extracted 3 times with 70% acetone. The three extracts were combined in a separating funnel and then exhausted with chloroform (FISHER SCIENTIFIC). The aqueous phases were collected in a flask, followed by evaporation of chloroform and acetone using a rotary evaporator. The contents of the flask was then transferred into a volumetric flask and make up to 15 mL with distilled water and then kept cool for subsequent analysis.

Table 1: Composition of plant material according to berries form and/or the appearance of berries and vernacular names

Variety	Form and/or berry aspect	Djerma	Haoussa
LS1	Guitar	Souta'n	Chantu
LS2	Rough	Kassakassa	Sana'a
LS3	Smooth	Kassakassa	Sana'a
LS4	Great gourd	Gassu	Koriya
LS5	Great ladle	Gombo	Liddeye
LS6	Small gourd	Zoloo	Gyandama
LS7	Great gourd	Zoloo	Gyandama
LS8	Small ladle	Gassu	Koriya
LS9	Ladle with small bit	Gombo	Liddeye
LS10	Ladle with great bit	Gombo	Liddeye
LS11	Rough	Kassakassa	Sana'a
LS12	Smooth	Kassakassa	Sana'a
LS13	Great gourd	Zoloo	Gyandama
LS14	Cucumber like		Zoungourou
LS15	Rough	Kassakassa	Sana'a
LS16	Rough	Kassakassa	Sana'a
LS17	Rough	Kassakassa	Sana'a
CC	Smooth	Kaney	Kafurdu/Guna

LS: *Lagenaria siceraria* (Molin.) Standl, CC: *Citrullus colocynthis* (Linn.) Schrad

Determination of antioxidant capacity by FRAP method: The Ferric Reducing Antioxidant Power (FRAP) method was used to determine the total antioxidant capacity of each extract (Lamien-Meda *et al*., 2008; Wang *et al*., 2009). This method is based on the ability of extracts to reduce the ferric ion (Fe^{3+}) to ferrous ion (Fe^{2+}). To 1 mL of extract were successively added 2.5 mL of phosphate buffer (DAMAO REAGENT) (0.2 M; pH 6.6) and then 2.5 mL of 1% aqueous solution of potassium hexacyanoferrate ($K_3Fe(CN)_6$) (PROLABO). The mixture is centrifuged at 3000 tr min^{-1} during 10 min. Then, 2.5 mL of the upper layer were mixed with the same water volume and then added 0.5 mL of a freshly prepared aqueous solution of $FeCl_3$ (PROLABO) (0.1%). The absorbencies were read at 700 nm with a spectrophotometer (HELIOS ALPHA NC 9423UVA) dual beam, against (a blank reagent of) 2.5 mL of water. The antioxidant capacity was determined from a calibration curve obtained with standard solutions of ascorbic acid (MELUN) (0-200 mg L^{-1}). The antioxidant capacity was determined three times for each sample. The iron (III) reducing activity determination was expressed in ascorbic acid equivalents (AAE) µmol ascorbic acid per gram of dry extract) considering 1 µM is equal to FRAP of 1 mL of the extract according to the equation:

$$C = \frac{c \times D \times V}{M \times m}$$

Where:

C = Concentration in reducing agent compounds in µmol AAE/g of dry matter
c = Concentration of the sample read
D = Dilution factor of the main solution
V = Volume of the extract obtained
M = Molecular mass of the ascorbic acid (176.1 g mol^{-1})
m = Mass of sample in gram

Determination of total phenolics: The total phenolics compounds were determined according to the method of Singleton and Rossi using the Folin-ciocalteu reagent (Singleton *et al.*, 1999). In each test tube were added, 0.5 mL of extract, 2.5 mL of Folin-ciocalteu reagent (0.2 N) (PROLABO). After 5 min incubation at room temperature, 2 mL of sodium carbonate solution (75 g L^{-1} in water) were added (Lamien-Meda *et al.*, 2008). After vortexing, the extracts were heated during 15 min at 50°C and then cooled (laboratory temperature). Absorbencies were read at 415 nm with a UV-visible spectrophotometer (HELIOS Alpha, NC 9423UVA) dual beam, a blank consisting of 500 µL water. Three measurements are taken per sample. A standard calibration curve was plotted using standard solutions of gallic acid (MERCK) (0-200 mg L^{-1}). The following equation was used to calculate the results expressed as mg Gallic acid equivalent per 100 g of dry matter (mg GAE/100 g).

$$C = \frac{c \times D \times V}{m} \times 100$$

Where:
C = mg gallic acid equivalent in 100 g of dry matter
c = Concentration of the sample read (mg AG L^{-1})
D = Dilution
m = Mass of sample in gram
V = Volume of the extract obtained in mL

Determination of total flavonoids: The total flavonoids were determined according to the method of Dowd modified by Arvouet-Grand *et al.* (1994). Two milliliter of the extract of each sample were mixed with 2 mL of tri aluminum chloride ($AlCl_3$) (DAMAO REAGENT) in methanol (PR0LABO) (2%). After vortexing, the extracts were incubated for 10 min in the dark. The stable yellow color formed was proportional to the total flavonoids content of the extract. Absorbencies were read at 415 nm with a UV-visible spectrophotometer (HELIOS Alpha, NC 9423UVA) dual beam, against a reagent blank consisting of 2 mL of methanol and 2 mL of plant extract without $AlCl_3$ (Stangeland *et al.*, 2009). A calibration curve was plotted with standard solutions of methanolic quercetin (PROLABO).

The results were expressed as mg quercetin equivalent per 100 g of dry matter (mg QE mg)/100 mg). The following equation is used to calculate the concentration of flavonoids in quercetin equivalent (Miliauskas *et al.*, 2004).

$$C = \frac{c \times D \times V}{m} \times 100$$

Where:
C = mg quercetin equivalent in 100 g of dry matter
c = Concentration of the sample read (mg L^{-1})
D = Dilution
m = Mass of the sample in gram
V = Volume of the extract obtained

Determination of condensed tannins: Condensed tannins were determined according to the method proposed by the European Community (Joslyn, 1970). Hundred microliter of extract are mixed with 7.5 mL of water, then added 0.5 mL of Folin Denis Reagent (FDR) (PROLABO) and 1 mL of sodium carbonate (Na_2CO_3,75 g L^{-1}) . After vortexing, the extracts were incubated at room temperature for 30 min. Absorbencies were read at 760 nm with a UV-visible spectrophotometer (HELIOS Alpha, NC 9423UVA) dual beam, against a reagent blank of 100 µL of water. Tannic acid (BIOTHEC) was used as standard:

$$C = \frac{c \times D \times V}{m} \times 100$$

Where:
C = mg tannic acid equivalent in 100 g
c = Concentration of the sample read (mg L^{-1})
D = Dilution
m = Mass of the sample gram
v = Volume of the extract obtained

Statistical analysis: An analysis of variance using the Statitix software has been used for all the parameters. In case of significant difference between the varieties, averages comparison tests (Tukey HSD test) have been carried out for the concerned compounds in order to determine the groups of homogeneous varieties. Then a correlation analysis has been conducted among the various parameters.

RESULTS

The seeds of *L. siceraria* and *C. colocynthis* are commonly consumed by the populations of Niger, either as grids or in sauces. Our ultimate goal was to determine the physicochemical characteristics of these seeds for recovery. In previous studies we determined the protein, fat and minerals content. The composition of the oils in fatty acids, carotenoids and tocopherols was also determined. This study is focused on the determination of total polyphenols, total flavonoids and condensed tannins contents as well as the antioxidant capacity.

Table 2 expressed the results of the analysis of the variance of the studied parameters. The difference is significant ($p<0.01$) between varieties for antioxidant capacity and for the total polyphenols, total flavonoids and condensed tannins contents.

Table 3 depicted the antioxidant capacity and the polyphenols content of the seeds of *L. siceraria* and *C. colocynthis* varieties. The analysis of variance of the capacity reduction of Fe^{3+} ions, revealed 9 groups. The strongest reducing capacities were obtained with CC variety, LS5,

Table 2: Analysis of variance for the determination of total polyphenols, total flavonoids, condensed tannins contents and antioxidant capacity

Component	DF	SS	MS	F	p
Antioxidant activity	17	3.96770	0.23339	171.00*	0.0000
Total phenolics	17	39258.8	2309.34	37.30*	0.0000
Condensed tannins	17	0.03547	0.00209	6.71*	0.0000
Total flavonoids	17	11.3201	0.66589	95.80*	0.0000

DF: Degree of freedom, SS: Score Sum, MS: Mean score, F: Fisher, p: probability, *: Significant at 1% level

Table 3: Assessment of the antioxidant capacity (µmol/equivalent ascorbic acid/g of dry matter) and total polyphenols content (mg/equivalent gallic acid/100 g of dry matter) of the seeds of different varieties

Test	Antioxidant capacity (µmol AAE 100 g^{-1})	Total polyphenols content (mg GAE/100 g)
LS1	21.07±5.20^{gh}	145.80±2.75^{cd}
LS2	39.67±5.10^{cde}	160.00±3.62^{bc}
LS3	26.70±2.70^{fgh}	107.56±16.06^{f}
LS4	24.00±3.90^{gh}	137.20±11.13^{cde}
LS5	43.13±1.70^{cd}	178.00±2.75^{b}
LS6	37.67±7.80^{def}	138.60±13.69^{cde}
LS7	0.31±7.30^{efg}	149.60±7.60^{cd}
LS8	6.33±1.00^{i}	115.60±10.18^{ef}
LS9	6.67±0.80^{i}	139.40±1.93^{cde}
LS10	42.07±0.40^{cde}	181.00±4.33^{ab}
LS11	41.00±0.90^{cde}	159.20±7.23^{bc}
LS12	19.63±3.50^{h}	79.193±11.45^{g}
LS13	50.23±1.70^{c}	140.00±3.08^{cd}
LS14	113.33±2.30^{a}	147.60±6.58^{cd}
LS15	20.93±5.90^{gh}	134.00±4.20^{de}
LS16	31.67±0.40^{efg}	149.00±4.26^{cd}
LS17	3.67±0.40^{i}	141.20±2.11^{cd}
LS average	32.90±24.60	141.35±24.80
CC	92.00±0.20^{b}	202.80±7.50^{a}
Average±SD	36.15±27.6	144.76±27.98

LS: *L. siceraria*, CC: *C. colocynthis*, There is no significant difference between averages which have the same letters in each column, SD: Standard deviation

Table 4: Assessment of the total flavonoids (quercetin equivalent mg kg^{-1}) and condensed tannins (tannic acid equivalent mg kg^{-1}) of the seeds of different varieties

Variety	Total flavonoids (mg quercetin equivalent/kg)	Total tannins (mg tannic acid equivalent/kg)
LS1	0.61±0.00^{i}	0.67±0.30^{abc}
LS2	1.51±0.04^{i}	0.34±0.12^{cd}
LS3	1.04±0.46^{i}	0.24±0.13^{cd}
LS4	12.05±0.10^{b}	0.07±0.05^{d}
LS5	2.61±0.23^{ghi}	0.43±0.41^{bcd}
LS6	5.04±1.71^{efg}	0.65±0.27^{abc}
LS7	4.35±0.16^{fgh}	0.48±0.03^{abcd}
LS8	0.23±0.25^{i}	0.27±0.07^{cd}
LS9	0.08±0.03^{i}	0.05±0.14^{d}
LS10	2.14±1.03^{hi}	0.61±0.01^{abc}
LS11	8.02±2.31^{cd}	0.52±0.28^{abcd}
LS12	0.75±0.36^{i}	0.17±0.05^{cd}
LS13	7.26±0.54^{cde}	0.93±0.08^{ab}
LS14	8.64±1.44^{c}	0.65±0.03^{abc}
LS15	17.85±0.29^{a}	1.00±0.20^{a}
LS16	5.80±0.07^{def}	0.32±0.11^{cd}
LS17	7.55±0.001^{cde}	0.52±0.01^{abcd}
LS means	5.03±4.85	0.47±0.27
CC	6.24±0.02^{cdef}	0.52±0.11^{abcd}
Mean±SD	5.10±4.67	0.47±0.30

LS: *L. siceraria*, CC: *C. colocynthis*, There is no significant difference between the averages which have the same letters in each column

LS13 and LS14. As far as polyphenols are concerned, 10 homogeneous groups were obtained. The richest varieties in polyphenols were: CC, LS2, LS5, LS13, LS14 and LS16. The different extracts of the studied varieties were rich in phenolic compounds. This high content contributes widely to their antioxidant activity as confirmed by the correlation coefficient (r = 0.79) observed between total polyphenols content and antioxidant capacity. From these results we can deduce that the total polyphenols contributed for at least 79% in the antioxidant activity of plant extracts studied. The remaining antioxidant activity was used for other water soluble antioxidants.

Table 4 expressed the total flavonoids and condensed tannins contents of the seeds. The 13 and 8 homogeneous groups were, respectively observed. The LS15 variety remained the richest in flavonoids (17.85 mg kg^{-1}) and condensed tannins (1 mg kg^{-1}) while the LS9 variety is the less rich in flavonoids and tannins, respectively 0.08 and 0.05 mg kg^{-1}. After fractionation of polyphenols, a correlation coefficient r = 0.85 was observed between the reducing capacity of the extracts and flavonoids and condensed tannins contents. Flavonoids and condensed tannins represented therefore the major phenolics compounds which contribute to the antioxidant activity of Cucurbitaceae seeds. The results also showed positive correlations between the levels of polyphenols and flavonoids (r = 0.76) and condensed tannins (r = 0.64).

DISCUSSION

Plant extracts should be substituted to synthetic antioxidants which have a negative influence on humans in long-term use (Martinez-Tome *et al*., 2001). Consumption of fruit is known to provide a wide variety of flavonoids which play a protective role by reducing the risk for cancer and cardiovascular diseases (Lamien-Meda *et al*., 2008). Our results showed that the seeds of the *L. siceraria* and *C. colocynthis* have interesting antioxidant capacity and polyphenols contents. There was a significant difference between varieties for total polyphenols, total flavonoids and condensed tannins contents and for their antioxidant capacity using FRAP method.

If many studies have focused on antioxidant capacity of Cucurbitaceae seeds in relation with their content in fat-soluble vitamins (Sabo *et al*., 2005a, b; Sadou *et al*., 2007; Mariod and Matthaus, 2008) very few studies have focused on their antioxidant activity capacity and the phenolic compounds contents. In addition the extraction duration, the nature and concentrations of solvents affect the extraction rate of phenolic compounds when soil type, geographical origin and maturity of fruits would influence the phenolic compounds contents (Wang *et al*., 2009; Hue *et al*., 2012; Rusak *et al*., 2008; Oloyede *et al*., 2012). Among the few studies conducted on the antioxidant capacity of the Cucurbitaceae family we can note a study which involved 4 varieties of *Cucurbita pepo*. The antiradical activity, ranged from 4.51-6.71 mg mL^{-1} but according to DPPH method (Xanthopoulou *et al*., 2009). In the fruits of *C. maxima* an antioxidant capacity of 0.09 mmol AAE/100 g measured by the FRAP method was reported (Stangeland *et al*., 2009). This value is higher than that we observed in *L. siceraria* and *C. colocynthis* seeds, respectively 32.90 and 92.00 μmol AAE/100 g.

Total phenolic compounds contents were also reported for *C. pepo* and *C. lanatus* species. Thus in the fruits of 4 varieties of *C. pepo*, polyphenols contents ranged from 54.12-63.64 mol EGA/g (Stangeland *et al*., 2009). In this species the polyphenol content depending on the degree of maturity of the fruits. Thus, the polyphenol contents were 23.7 mg/100 g in mature and 8.4 mg/100 g in immature fruits (Oloyede *et al*., 2012). In a study conducted where the fruits of *C. lanatus*, the polyphenol contents ranged from 92-180 mg GAE kg^{-1} depending on the provenance (Tlili *et al*., 2011). The results reported by these authors are often lower but sometimes

similar to the values we observed in *L. siceraria* and *C. colocynthis* seeds. Indeed in *Lagenaria*; seeds the polyphenol contents ranged from 107-181 mg GAE/100 g and in *C. colocynthis* it is 202 mg GAE/100 g.

It is important to note that if all these previous studies were focused on the whole fruit, our resultants in this were centered on seeds are a first new.

Total flavonoids contents observed in the present study ranged from 0.08-17.85 mg QE kg^{-1} in *L. siceraria* seeds and 6.24 QE kg^{-1} in *C. colocynthis* seeds.

When we compare some vegetables or leaves consumed in Niger, variable values were also noted. Thus, in sweet potato leaves of different varieties, total polyphenol contents ranged from 2.78-5.35 mg GAE/100 g (Hue *et al.*, 2012). The total flavonoid content ranged from 96 to 263 mg QE/g and the antioxidant activity from 372.4-597.61 μg mL^{-1} by the DPPH method. In several local spices total polyphenol contents vary from 7.8 (ginger) to 59.7% (Basilica), the antioxidant activity by FRAP method varies from 0.54-0.06 mmol AAE/g (Hinneburg *et al.*, 2006). These values are relatively higher than those observed in our current study.

Also, if compared to some edible fruits used in Niger, the results observed in Niger cucurbit seeds, were well below. In 14 edible fruits from Burkina Faso, notably the polyphenol contents ranged from 190.58 a 5978.33 mg GAE/100 g, flavonoids contents ranged from 1.7 mg QE/100 g to 155.9 mg QE/100 g and antioxidant activity determined by the FRAP method, ranged from 1.21 to 48.45 mmol AEAC/100 g (Lamien-Meda *et al.*, 2008). Phenolic content found in *C. colocynthis* was 202 mg GAE/100 g. It is included in the range obtained for Burkina Faso fruits. However the levels of *L. siceraria* varieties varied from 107-181 mg GAE/100 g; were lower than those of these fruits. The same situation is obtained for flavonoids and antioxidant activity.

We can also affirm that the strong antioxidant cap activity of cucurbit seeds extracts were due to their high phenolic contents. There is a positive correlation between the antioxidant activity and the polyphenol content ($r = 0.79$) on the one hand and on the other hand between the polyphenol and flavonoids content ($r = 0.76$).

These correlations also confirm the values of the Folin-Ciocalteu test as a tool for showing the availability of antioxidant compounds in seeds.

The results from this study highlight the importance of the total polyphenols, total flavonoids and antioxidant capacities of some seeds of Cucurbitaceae, as well as indicating the important need for further investigations into the identification of phenolic and flavonoids and *in vivo* antioxidant activities in these seeds. This study provides data to health professionals and food policy makers in West Africa for encouraging the population to consume more seeds of cucurbits as well as, promoting the preservation of such Cucurbitaceae species.

CONCLUSION

The present study showed a large variability between varieties for antioxidant activity and polyphenol, flavonoids and condensed tannins contents. Cucurbitaceae seeds, due to the phenolics, they contain, showed antioxidant activities. Each correlations were found between the parameters which determine the antioxidant potentials of extracts. The composition in total phenolic showed a very good correlation with the reducing power capacity. The extracts of CC, LS5, LS13 and LS14 varieties gave the strongest reducing power vis-a-vis the Fe^{3+}.

In general, Niger cucurbitaceous are less known. This study is a first new work to highlight the antioxidant activity of seeds according to the varietal aspect. The Cucurbitaceae family is very

complex with a great genetic diversity depending on species. In Niger, many are farmed and others encountered in the wild. Studies should be conducted on all these categories, in order to determine their antioxidant activity and total phenolic we suggest that content. Our results suggest that the Cucurbitaceae seeds are sources of antioxidant compounds. Studies should be conducted to know their bioavailability and their molecular identities.

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