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Nutritional and antioxidant potential of seeds from two Cucurbitaceae species from Senegal

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ABSTRACT

Cucurbits are largely grown in tropical and subtropical areas for nutritional and medicinal purposes. In Senegal, two species, watermelon (*Citrullus lanatus)* and pumpkin (*Cucurbita pepo*), are cultivated and their use include consumption of flesh or the whole fruit. In general, people don't give importance to seeds which can have nutritional properties of great interest. Hence, the relevance of this study whose objective is to assess the nutritional and therapeutic properties of seeds. For that purpose, the seeds of watermelon and pumpkin were air-dried, manually shelled, ground, and subjected to assays including physicochemical determination, characterization of oils, phytochemical screening and antioxidant analysis. Proteins (28.46 - 32.85 %), fat (36.3 - 39.7 %) and carbohydrates (23.6 - 13.9 %) were the main chemical components found in watermelon and pumpkin seeds. Micro-elements such as potassium, magnesium, phosphorous, calcium, and iron were also found with potassium showing the highest levels as 1026.07 and 635.00 mg/100 g for watermelon and pumpkin, respectively. Magnesium and phosphorous were the following minerals in terms of level content. The unsaturated fatty acids (UFAs) were predominant in seed oils with the linoleic acid most representative as 73.01 and 35.90% for watermelon and pumpkin, respectively. From the saturated fatty acids (SFAs), the palmitic acid was the most important. Phytochemical components in seeds include the presence of alkaloids, cardiac glycosides, flavonoids, and tannins in the ethanolic extracts of pumpkin and watermelon seeds. Regarding to the radical scavenging activity, relatively close values have been obtained for fractions from the ethanolic watermelon extract, the aqueous fraction showing the highest antioxidant activity (26.82%). For pumpkin, the highest values were registered for ethyl acetate and aqueous fractions as 36.17 and 35.36%, respectively. Therefore, seeds from watermelons and pumpkin cultivated in Senegal exhibited interesting nutritional and antioxidant properties which argue in favor of their use to overcome malnutrition issues.

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1. Introduction

The Cucurbitaceae family encompasses more than 800 species of plants known collectively as gourds or cucurbits, which are found mainly in tropical and subtropical regions of the world [1]. The plants include some important genera: *Trichosanthes*, *Lagenaria*, *Luffa*, *Benincasa*, *Momordica*, *Cucumis*, *Citrillus*, *Cucurbita*, *Brynopsis* and *Corallocarpus* [2]. More than 20 genera are used for culinary purposes, which usually include consumption of mature fruit, flesh, whole immature fruits, and/or seeds. Cucurbits, as some other vegetables, are considered a protective food and highly beneficial for the maintenance of good health and prevention of diseases. They are sources of nutrients such as carbohydrates, proteins, vitamins, fiber, and minerals required for human health [3,4]. Secondary metabolites with antioxidant properties (Phenolic acids, flavonoids, and carotenoids) are also one of the important components of cucurbits. They play a significant role in inhibiting oxidative stress, an imbalance of free radicals and antioxidants in the body which can lead to cell and tissue damage [5]. Free-radical mechanisms have been implicated in the pathology of several human diseases, including cancer, Atherosclerosis, malaria, rheumatoid arthritis, and neurodegenerative diseases [6]. The human body has several mechanisms to counteract oxidative stress by using antioxidants, which are either naturally produced *in situ*, or externally supplied through food and/or supplements. Endogenous and exogenous antioxidants interfere with the oxidation process by reacting with free

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radicals, chelating free catalytic metals, and acting as oxygen scavengers. Therefore, the consumption of cucurbits, which contain polyphenols and terpenoids in a large amount, plays an important role in prophylaxis against oxidative stress [7].

Among the world's vegetable crops, three genera of cucurbitaceae, Cucumis (cucumbers, melons), *Cucurbita* (pumpkin, squash), and *Citrullus* (watermelons), belong to the top ten in terms of economic importance [1]. Cucurbits are also grown for medicinal purposes over several centuries because of their healing power depending on their phytochemical composition. Several studies on common/wild varieties of selective genera of Cucurbitaceae members revealed their therapeutic properties such as insecticidal/wormicidal, anti-hypoglycemic, anti-inflammatory and anti-lipidemic characteristics [5,8,9]. Different vegetable parts like flowers, fruit, leaves, stem, petiole, and roots are used in traditional therapy [10]. Although having its origins in America, cucurbits are largely cultivated in several countries such as the developing ones where the development of nutritional products for fighting diseases and malnutrition is necessary.

In Senegal, two cucurbits, *Citrullus lanatus* (Thunb.) Matsum. & Nakai (Watermelon, genus Citrullus) and *Cucurbita pepo* L., Sp. Pl. (pumpkin, genus Cucurbita), are extensively cultivated in some geographical areas like Saint-Louis, Matam, Kaolack, and Ziguinchor, commercialized and consumed in the whole country [11,12]. The vegetable parts consumed include mature fruit, flesh, or whole immature fruits. Populations don't often, pay attention to seeds which are extracted from flesh and thrown up. As reported by several studies, seeds concentrated a higher proportion of vegetable constituents which are both of nutritional or medicinal interest [13,14]. At the same time, it is known that the phytochemical composition of plants varies largely depending on cultural conditions. The developing countries are facing grievous problems of malnutrition which can be prevented by accepting vegetables as resources and using them to the maximum. Adequate research and education are needed to identify vegetables rich in proteins and minerals.

In this context, our study aims to assess the nutritional value and therapeutic potential of seeds of *C. Lanatus* and *C. pepo* cultivated in Senegal to optimize the benefits of their consumption.

2. Experimental

2.1. Plant material

Watermelon (*C. lanatus)* fruits were purchased from a local market, whereas dried pumpkin seeds (*Cucurbita pepo)* were bought from retailers at Castor Market located in Dakar. The collected samples were sent to the Department of Botany (Faculty of Medicine, Pharmacy and Odontology, Cheikh Anta DIOP University) for botanical identification.

Watermelon seeds were extracted from the flesh and air-dried at room temperature for 72 h. Both watermelon and pumpkin seeds were manually shelled after dryness and ground using a porcelain pestle and mortar.

2.2. Chemicals and reagents

All chemicals and solvents of technical or analytical grades were purchased from local suppliers (Technologies services, Fermon Labo, Sénégal, and Bouattour Equipment Services, Dakar, Senegal). Double distilled water and Class A borosilicate volumetric glassware were used for analysis.

2.3. Physicochemical determination

The physicochemical composition of watermelon and pumpkin seeds was assessed using different parameters. Protein, fat, moisture, ash, and dietary fiber contents of the seeds were evaluated using, respectively, the following methods: International Association for Cereal Chemistry (ICC) method N°105/2 [15], Association of Official Analytical Chemists (AOAC) 920.39 C [16], ISO 712: 2009 [17], ISO 2171: 1993 [18] and ISO 5498: 1981 [19]. Available carbohydrate content was calculated by the following formula: 100 – (weight in grams [protein + fat + water + ash + alcohol + dietary fibre) in 100 g of food). All determinations were done in triplicate.

Minerals such as iron (Fe), magnesium (Mg), calcium (Ca), phosphorous (P), and potassium (K) were determined by atomic absorption spectroscopy (ICE 3300 FL AA System, Thermo Scientific, China) using dry ash obtained by calcining seed powder samples. Sample solutions were prepared from white dry ash by adding 10 mL of 30% hydrochloric acid and completing to 50 mL with distilled water. Determinations were done in triplicate using individual standard solutions of 1000 ppm. Calibration curves were constructed by measuring the absorbance of a series of five standard solutions for each mineral and plotting absorbance (y) versus mineral concentration (x). The amount of mineral was calculated based on the following regression equations: Fe: $y = 0.02831x - 0.00015$; Mg: $y = 0.61116x - 0.00027$; Ca: $y = 0.03356x - 0.00017$; P: $y = 0.18188x - 0.00009$; K: $y = 0.05237x - 0.00027$. The correlation coefficients ranged from 0.991 to 0.999.

2.4. Characterization of seed oils

Parameters such as iodine (IV), peroxide (PV), saponification (SV), and acid (AV) values were evaluated using the following methods: ISO 3961: 2009, ISO 3960: 2007, ISO 3657: 2013, ISO 660: 2009, respectively [20-23].

The fatty acid profile was determined after extraction of seed powder samples by a Dionex 350 Accelerated Solvent Extractor (Dionex corporation, Sunnyvale, USA) with the following conditions: 1,500 psi pressure; 60 °C, 7 min static time, 100% flush, 90 s purge and on static cycle. Lipid extracts in petroleum ether were methylated and converted into fatty acid methyl esters (FAMEs) using the method described by Salimon *et al.* [24].

After brief vortexing and centrifugation at 350 g for 3 min, the petroleum ether phase containing FAMEs was transferred into a GC vial for FA composition analysis using Shimadzu GC-17A gas chromatograph equipped with a flame ionization detector (FID) (Shimadzu Corporation, Kyoto, Japan). A CP SIL88 for FAMEs column (Chrompack-Varian, 50 m × 0.25 mm × 0.2 µm) was used for separation. The run was under an optimized temperature program as follows: the initial column temperature was 80 °C and was programmed to increase at a rate of 10 °C/min up to 160 °C and then at 3 °C/min up to 220 °C. This temperature was maintained for 5 min, increased at 10 °C/min to a final temperature of 260 °C, and held for 5 min. The injector and detector temperatures were 250 and 270 °C, respectively. Helium was used as the carrier gas at a flow rate of 1 mL/min with a split ratio of 1:50. Identification of FAMEs was performed by comparison of retention times with those of a standard mixture of fatty acids subjected to GC under identical experimental conditions. The quantification of each FAME was done using a linear regression equation resulting from the calibration curves obtained by analyzing a series of five standard solutions and plotting the peak area versus concentration.

2.5. Phytochemical screening

Fifty grams (50 g) of seed powder were added to 1 L of ethanol and extracted by heat reflux extraction method for 1 hour. After filtration, the ethanolic extract was evaporated until dryness using a rotary evaporator.

Table 1. Macronutrient composition of watermelon (*C. lanatus*) and pumpkin (*C. pepo*) seeds.

Cucurbit species	Proteins (%)	Fat (%)	Moisture (%)	Ash (%)	Dietary fiber (%)	Carbohydrates (%)	R_1 [a]
C. lanatus	28.46±0.38	36.3±1.42	5.57±0.18	4.05±0.10	2.02±0.14	23.6±1.27	1.27
C. pepo	32.85±0.19	39.7±1.55	5.25±0.16	5.37±0.04	2.93±0.09	13.9±0.13	1.21
Mean (%)	30.65	38.00	5.41	4.71	2.47	18.75	1.24

[a] Fat/Protein ratio.

Table 2. Micronutrient contents (mg/100 g) of watermelon (*C. lanatus*) and pumpkin (*C. pepo*) seeds.

Element	*C. lanatus* (mg/100 g)	*C. pepo* (mg/100 g)
Potassium	1026.07±93.41	635.00±43.69
Magnesium	437.12±28.77	542.00±27.91
Phosphorous	221.63±20.01	242.70±13.68
Calcium	71.47±9.34	109.90±8.40
Iron	7.97±0.04	10.70±0.13

Table 3. Chemical and physical characteristics of watermelon (*C. lanatus*) and pumpkin (*C. pepo*) seed oils.

Cucurbit species	Refractive index (I_R)	Iodine index (I_I)	Saponification index (I_S)	Acidity index (I_A)
C. lanatus	1.467±0.0006	128.28±3.92	177.66±0.10	1.86±0.02
C. pepo	1.471±0.0006	116.00±0.82	178.59±0.74	1.40±0.11

The presence of phyto-chemical components (tannins, flavonoids, saponins, cardiac glycosides, and alkaloids) in ethanol extracts was assessed using methods described by Harborne [25] for the detection of saponins (foaming index), tannins (Ferric chloride and Stiasny tests), flavonoids (Shibata's reaction), cardiac glycosides (Baljet, Kedde and Raymond-Marthoud reagents), alkaloids (Bouchardat, Valser-Mayer and Dragendorff's reagent test).

2.6. Radical scavenging activity

The fractionation of plant ethanolic extracts was done by dissolving the previously dried extracts in hot water and putting them in a separatory funnel before fractionating by solvents from lower to higher polarities (hexane, dichloro-methane and ethyl acetate). For each solvent, extracts from two repetitions were combined and evaporated to dryness. Six concentrations of 5, 25, 50, 100, 150, 200 ppm in ethanol were prepared for each solvent fraction.

DPPH 0.1 mM solution was made by dissolving 3.94 mg DPPH crystals in 100 mL of 96% ethanol solvent. 0.8 mL of solvent fraction sample of each concentration was added to 3 mL DPPH, incubated for 30 minutes in a dark room. Solutions of ascorbic acid, as a positive control, were also prepared and tested at the same concentrations using the same method. The absorbance of a blank solution made by adding 0.8 mL of ethanol to 3 mL DPPH solution was also measured. Absorbance of the samples, positive controls, and blank solution were measured at a wavelength of 517 nm using a UV-visible spectrophotometer (Thermo Fisher Scientific Evolution 300, Madison, Switzerland). The measurement of each sample was repeated three times. DPPH radical scavenging is calculated by the following formula:

$$\% \text{ Inhibition} = ((A_0 - A_1)/A_0) \times 100 \quad (1)$$

where A_0 is the absorbance of the blank solution and A_1 the absorbance of the tested sample.

2.7. Statistical analyses

The statistical analysis was performed using the statistical function of Microsoft Office Excel. For each sample, three determinations have been done (n = 3, where n is the number of replications). The data were presented as mean values± standard deviation (SD). The limit of detection (LOD) of the gas chromatographic (GC) method was expressed as peaks with an area at least three times the mean noise (mean area of the signal obtained by analyzing six blanks). LODs ranged from 0.02 to 0.09 µg/mL.

3. Results

3.1. Seed chemical composition

The main macronutrients in watermelon and pumpkin seeds are proteins (28.46 - 32.85 %), fat (36.3 - 39.7 %) and carbohydrates (23.6 - 13.9 %). Proteins and fat were found at relatively similar levels in seeds of the two cucurbits, while carbohydrates were present at a higher level in watermelon (23.6%) than in pumpkin (13.9%) seeds. The dietary fiber content was 2.02 % in watermelon and 2.93 % in pumpkin. The moisture content, used to estimate free or bound water present in vegetables, was 5.41% on average. The percentage yield of white ash, which is a measure of mineral content, varied between 4.05 (*C. lanatus*) to 5.37 % (*C. pepo*) (Table 1).

The ultimate analysis indicated the selected cucurbits as a good source of micro elements such as potassium, magnesium, phosphorous, calcium, and iron. The higher mineral levels in cucurbit seeds were found with potassium and were 1026.07 and 635.00 mg/100 g for *C. lanatus* and *C. pepo*, respectively. Magnesium and phosphorous were the following minerals in terms of level content, while iron was found at lower levels (7.97 and 10.70 mg/100 g for *C. lanatus* and *C. pepo*, respect-tively) (Table 2).

3.2. Chemical properties and fatty acid profile of seed oil

The chemical and physical characteristic indices of seed oils are presented in Table 3. Quite similar refractive and saponifi-cation indices were found for both oil samples, while iodine and acidity indices were higher for watermelon than for pumpkin seed oil as shown in Table 3.

Data about the fatty acid contents in the seed oils are presented in Table 4. All studied fatty acids were found in watermelon seed oil, whereas in pumpkin seed oil, eleven of them were detected. The unsaturated fatty acids (UFAs) were predominant in seed oils with linoleic acid ($C_{18:2}$) the most representative (73.01 and 35.90% for watermelon and pumpkin, respectively). Another UFA found in relative high levels was oleic acid ($C_{18:1}$) (8.56 and 35.63% for watermelon and pumpkin, respectively). Linolenic acid ($C_{18:3}$) was identified in low quantities (0.26 and 0.73% for watermelon and pumpkin, respectively). For saturated fatty acids (SFAs), the palmitic acid $C_{16:0}$) was predominant (11.39 and 16.05% for watermelon and pumpkin, respectively), followed by stearic acid ($C_{18:0}$) (5.43 and 10.36%, respectively). The SFAs/UFAs ratios were 0.21 and 0.36 for watermelon and pumpkin, respectively, suggesting a high calorific potential of the oils of these two cucurbit species.

Table 4. Fatty acid profile (%) of watermelon (*C. lanatus*) and pumpkin (*C. pepo*) seed oils.

Fatty acids	*C. lanatus* (%)	*C. pepo* (%)
$C_{14:0}$	0.04±0.07	Not detected
$C_{16:0}$	11.39±0.03	16.05±0.40
$C_{16:1}$	0.07±0.01	0.11±0.10
$C_{17:0}$	0.08±0.01	0.12±0.08
$C_{18:0}$	5.43±0.07	10.36±0.25
$C_{18:1\ (n-9)}$	8.56±0.31	35.63±0.13
$C_{18:1\ (n-7)}$	0.59±0.02	0.54±0.08
$C_{18:2\ (n-6)}$	73.01±0.47	35.90±1.63
$C_{18:3(n-6)}$	0.26±0.10	0.73±0.01
$C_{18:3\ (n-3)}$	0.25±0.10	0.12±005
$C_{20:0}$	0.07±0.03	0.12±0.01
$C_{20:1\ (n-9)}$	0.13±0.01	0.31±010
$C_{22:0}$	0.13±0.00	Not detected
UFAs [a]	82.87	73.34
SFAs [b]	17.14	26.65
R_2 [c]	0.21	0.36

[a] Unsaturated fatty acid.
[b] SFAs: Saturated fatty acids.
[c] SFAs/UFAs ratio.

Table 5. Phytochemical groups found in ethanolic extracts of watermelon and pumpkin seeds *.

Phytochemical group	Watermelon (*C. lanatus*)	Pumpkin (*C. pepo*)
Alkaloids	++	++
Cardiac glycosides	++	++
Flavonoids	++	+++
Saponins	-	-
Tannins	++	++

* +++: Positive large; ++: Positive medium; -: Negative.

Table 6. Radical scavenging activity (%) exhibited by different fractions of the ethanolic extracts of watermelon seeds.

Concentration (μg/mL)	HF [a]	DMF [b]	EAF [c]	AF [d]	AA [e]
5	20.48±0.00	19.73±0.04	19.64±0.10	21.16±0.20	31.94±0.10
25	20.63±0.10	19.89±0.04	20.45±0.00	22.13±0.20	71.55±0.10
50	20.79±0.10	20.76±0.32	20.77±0.15	22.40±0.05	96.12±0.07
100	20.90±0.04	21.15±0.10	21.58±0.08	23.48±0.22	Not tested
150	21.00±0.08	21.69±0.20	21.90±0.00	23.75±0.00	Not tested
250	21.32±0.08	22.51±0.10	22.87±0.02	26.82±1.25	Not tested

[a] Hexanic fraction.
[b] Dichloromethanic fraction.
[c] Ethyl acetate fraction.
[d] Aqueous fraction.
[e] Ascorbic acid.

3.3. Phytochemical composition

Average extraction yields of 17.7 (8.86 g) and 36.7 % (18.63 g) were obtained after extraction of 50 g of pumpkin and watermelon seed powder, respectively. The phytochemical screening revealed the presence of alkaloids, cardiac glycosides, flavonoids, and tannins in the ethanolic extracts of pumpkin and watermelon seeds (Table 5).

3.4. Radical scavenging activity

The results of the free radical scavenging potential of different fractions of the ethanolic extract of watermelon and pumpkin seeds are presented in Tables 6 and 7.

An enhancement of the scavenging activity was registered when the fraction concentration increases. Values obtained ranged from 21.16 to 26.82% with the aqueous fraction showing higher scavenging potential (26.82%) than the other fractions. The higher value was 21.32, 22.51, and 22.87% for ethyl acetate, hexanic, and dichoromethanic fractions, respect-tively. Ascorbic acid, the positive control, exhibited better scavenging activity with 31.94% at 5 μg/mL, which increased to reach 96.12% at 50 μg/mL.

For pumpkin, an enhancement of the scavenging activity was registered when the fraction concentration increases. Higher scavenging activities were exhibited by ethyl acetate and aqueous fractions. Values obtained varied between 23.52 to 36.17% and 30.42 to 35.36% for ethyl acetate and aqueous fractions, respectively. However, the scavenging potentials were lower than the reference.

4. Discussion

4.1. Chemical composition

Proteins, fat, and carbohydrates were the main macro-nutrients found in watermelon and pumpkin seeds. Protein content were relatively similar for the two cucurbits with an average of 30.65%, which was lower than the data announced by other authors for these species, which were within the limits from 33.00 to 33.46% [26,27]. This value was higher than that of the conventional oilseeds: copra (20-22%), palm kernel (15-20%), shea (15-16%), sesame (21-22%) and peanut (29-30%) [28,29]. Fat contents of the two cucurbits were approximately identical with a mean value of 38%. The obtained results correspond to the literature sources by other authors regarding the fat content of cucurbit species cultivated in other African countries which were within the range from 33 to 58% [30]. The evaluation of fat-protein ratio gives values of 1.27 and 1.21 for watermelon and pumpkin, respectively, and suggests a high calorific potential of the seeds of these cucurbits.

The carbohydrate contents were 23.60% for watermelon and 13.90% for pumpkin seeds and were higher than the data found in *Cucumis melo* L. (melon) and reported by Petkova and Antova [31] which were in the range 8-13%. In addition, Yanty et *al.* and Obasi *et al.* reported carbo-hydrate contents of 19.80 and 29.47 % in melon, which were different to the values found in this study [32,33]. The differences of results about protein and carbohydrate contents in our study and the data from other investigations were probably due to the geographical regions and agricultural conditions such as temperature, moisture, and fertilizing.

Table 7. Radical scavenging activity (%) exhibited by different fractions of the ethanolic extracts of pumpkin seeds.

Concentration (µg/mL)	HF [a]	DMF [b]	EAF [c]	AF [d]	AA [e]
5	19.33±0.04	19.93±0.08	23.52±0.14	30.42±0.14	31.94±0.10
25	19.60±0.04	20.04±0.09	25.03±0.14	31.57±0.33	71.55±0.10
50	19.82±0.08	20.27±0.00	26.74±0.14	32.62±0.17	96.12±0.07
100	20.47±0.22	20.43±0.00	29.74±0.26	32.89±0.17	Not tested
150	20.63±0.20	20.76±0.00	32.10±0.28	33.22±0.22	Not tested
250	21.28±0.32	22.65±0.09	36.17±0.33	35.36±0.63	Not tested

[a] Hexanic fraction.
[b] Dichloromethanic fraction.
[c] Ethyl acetate fraction.
[d] Aqueous fraction.
[e] Ascorbic acid.

The dietary fiber contents were 2.02 and 2.93 % for watermelon and pumpkin seeds, respectively, and were not within the limits 5.51-24.75% reported in the literature resources for some cucurbit species [32-34]. The moisture content (5.41% on average), which is an estimation of free and/or bound water present in vegetables, was relatively similar for watermelons and pumpkin. This value was within the limits 4.27 to 5.63% found by Yanty *et al.*, 2008; Obasi *et al.*, 2012; Azhari *et al.*, 2014; Ibeto *et al.*, 2012 in cucurbit seeds [32-35]. Ash (mineral) contents of 4.05 and 5.37% were found in the seeds of *C. lanatus* and *C. pepo*, respectively. Petkova and Antova reported mineral contents ranging between 4.6 and 5.1% in melon seeds, which were quite similar to those of this study [31]. In general, the values announced in the literature were within the limits 4 to 6% [27].

The ultimate analysis indicated that watermelon and pumpkin seeds are good sources of minerals such as potassium, magnesium, phosphorous, calcium, and iron with values ranging from 1020.07 to 7.97 mg/100 g. Pumpkin seeds showed higher levels than watermelon seeds for all minerals except for potassium. Among these chemical components, iron was found at the lowest levels (7.97 and 10.70 mg/100 g for watermelon and pumpkin seeds, respectively). Chunduri reported iron levels ranging from 129.73 to 218.93 mg/100 g in fruits of some Cucurbitaceae species, which largely exceeded those in this study [8]. Despite the low iron content, these two cucurbits can help meet nutritional requirements which vary from 11 to 16 mg per day depending on sex, age, and physiological status [36]. The fourth mineral in terms of contents was calcium with values of 71.47 and 109.90 mg/100 g in watermelon and pumpkin seeds, respectively. These values were similar to those found by Chunduri in the fruits of some cucurbit species such as *Momordica charantia, M. dioica*, *Trichosanthes dioica* and *Coccina indica* (74.06-115.7 mg/100 g) [8]. Calcium is very essential in muscle contraction, oocyte activation, building strong bones and teeth, blood clotting, nerve impulse transmission, regulating heartbeat, and fluid balance within cells. The daily body requirement is about 450 mg and increases during growth, pregnancy, and breast feeding. Long term calcium deficiency can lead to osteoporosis in which the bone deteriorates and there is an increased risk of fractures. Therefore, including watermelon or pumpkin seeds can help meet nutritional requirements in a well-balanced diet capable of providing all necessary nutrients [37]. High contents of potassium (1026.07 and 635.00 mg/100 g), magnesium (437.12 and 542.00 mg/100 g), and phosphorus (221.63 and 242.70 mg/100 g) were registered in watermelon and pumpkin seeds, respectively. The magnesium and phosphorus contents of cucurbit seeds found in this study were largely higher than that reported by Rahman *et al.* [38] in fruits of pumpkin (Mg: 15 mg/100 g; P: 32 mg/100 g) and watermelon (P: 7 mg/kg). These values were also very high when compared to those found in other cucurbit species and reported by Chunduri [8]. The high content of Mg in the studied seeds could be related to the temperature, as a high temperature during growth increases magnesium concentration in plant tissue [39]. For potassium and phosphorous, the registered levels are probably associated with the richness of the soil in these elements and with the use of chemical fertilizers [31].

4.2. Phytochemical composition

Phytochemicals are non-nutritive chemical constituents of plants which occur naturally in it. Alkaloids, cardiac glycosides, flavonoids, and tannins were the main phytochemicals found in the ethanolic extracts of pumpkin and watermelon seeds. The phytochemical profiles of seeds from the two cucurbit species were similar with a predominance of flavonoids followed by alkaloids, tannins, and cardiac glycosides. No trace of saponins was revealed by phytochemical screening. Studies on the phytochemical composition of plants belonging to the cucurbittaceae family confirmed the presence of various phytochemicals like tannins, cardiac glycosides, carbohydrates, resins, saponins, carotenoids and phytosterols [40,41]. These phytochemicals play various important roles in living organisms. For example, cardiac glycosides have anti-inflammatory activity, offer protection against lethal endotoxemia, and are used in cardiac treatment of congestive heart failure [42].

Tannins, which were also found in the extracts from other cucurbits like *Cucumis sativa* (Cucumber) and *Praecitrullus fistulosus* (Tinda) have astringent properties and hasten the healing of wounds and inflamed mucous membrane. Tannins are potential metal ion chelators, proton precipitating agents, and biological antioxidants. Ellagitannins have free radical scavenging activity [41].

4.3. Radical scavenging activity

The behavior of the different fractions regarding their scavenging activity was different according the cucurbit species. Relatively close values (21.16 to 26.82%) have been obtained for fractions from the ethanolic watermelon extract; the aqueous fraction showed the highest scavenging potential (26.82%). For pumpkin, the fractions from the ethanolic extract revealed higher scavenging activity with a value ranging between 23.52 and 36.17%. The highest values were registered for ethyl acetate and aqueous fractions (36.17 and 35.36%, respectively). The phytochemical screening by Shibta's reaction showed a higher positivity for pumpkin than for watermelon extract which is due to the high content of flavonoids considered as antioxidants. Furthermore, the dark brown color (a sign of high anthocyanin level) of the oil from pumpkin seeds tends to confirm the great content of flavonoids [43].

In addition, the polar fractions showed greater scavenging activity than the nonpolar ones. Such a result can be explained by the richness in phenolic compounds of the polar fractions; polar compounds exhibit more affinity for polar than nonpolar solvents. Phenolic compounds are natural products of plant origin with great importance as potential antioxidants. Their consumption may significantly contribute to human health and to prevent oxidation of fats and oils [44,45].

The scavenging potentials of seed extracts of *C. lanatus* and *C. pepo* were largely lower than that reported by Chunduri for the unripe fruits of edible Cucurbitaceae vegetables from India. DPPH inhibition percents of 69, 70, 69 and 71% were found for

Momordica dioica, *M. charantia*, *Coccinia indica*, and *Trichosantes dioica*, respectively. The antioxidant activity was also lower than that of the standard ascorbic acid [8].

5. Conclusion

Watermelon and pumpkin seeds are good sources of proteins, fat, and carbohydrates and the analysis reported herein indicated that the seeds of these cucurbits are also rich in potassium, magnesium, phosphorous, calcium and iron. Thanks to their phytochemical composition, they exhibited an interesting antioxidant activity. Therefore, these common, easily available, and affordable vegetable products can be a source of nutrient replenishment and can help prevent malnutrition in developing countries. The exploration of their therapeutic potential can also help overcome health issues, hence the necessity of carrying out studies on their biological activities.

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Conflict of interest: The authors declare that they have no conflict of interest.
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