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# Seed composition, physical characteristics and mineral content of Sudanese landraces of pumpkin

Safaa Ahmed HASSAN [1], Mahdi SHAKAK [1], Abdalbasit MARIOD [2, 3, 4], Salma Elghali MUSTAFA [1]

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**Seed composition, physical characteristics and mineral content of Sudanese landraces of pumpkin**

**Abstract:** The study examined 23 landrace pumpkin seed samples from six Sudanese states (South Kordofan (SK), North Kordofan (NK), Gazira (GZ), Gadarif (GF), White Nile (WN), and Blue Nile (BN)), focusing on their composition and physical characteristics. The results showed significant differences in oil percentages, with SK having the highest percentage. Protein content varied between 16.91 % and 26.13 % in NK. The proximate composition of pumpkin seeds also varied significantly. The study found a significant difference in fatty acids, with polyunsaturated fatty acids having 37.02 % and monounsaturated fatty acids having 27.50 %. The total unsaturated fatty acids ranged from 55.2 % to 70.2 %, while the total saturated fatty acids ranged from 29.45 % to 45.27 %. Seed length, width, and thickness varied, with WN having the highest kernel percentage (78.45 %). Several minerals were extracted from the seeds, with potassium being the most abundant element, ranging from 946 to 1100 mg 100 $g^{-1}$. Analysis revealed that the seeds contained a rich source of zinc (Zn), ranging from 8.4 mg 100 $g^{-1}$ to 16.21 mg 100 $g^{-1}$. The study concluded that Sudanese landrace pumpkin seeds are valuable for edible oil and protein fortification due to their high levels of oil, protein, and minerals.

**Key words:** landrace, North Kordofan, pumpkin seeds, South Kordofan

**Zgradba semen, fizikalne lastnosti in vsebnost mineralov v sudanskih deželnih rasah buč**

**Izvleček:** V raziskavi so bila preučene semena 23 deželnih ras buč, vzorčenih v šestih sudanskih državah (Južni Kordofan (SK), Severni Kordofan (NK), Gazira (GZ), Gadarif (GF), White Nile (WN) in Blue Nile (BN)), s poudarkom na njihovi zgradbi in fizikalnih lastnostih. Rezultati so pokazali značilne razlike v odstotkih vsebnosti olja, kjer ga je akcesija SK vsebovala največ. Vsebnost beljakovin je bila pri akcesiji NK med 16,91 % in 26,13 %. Vsebnost za prehrano pomembnih sestavin se je med semeni buč značilno spreminajala. Ugotovljene so bile tudi značilne razlike pri vsebnostih maščobnih kislin, kjer je vsebnost večkrat nenasičenih maščobnih kislin znašala 37,02 %, enkrat nenasičenih maščobnih kislin pa 27,50 %. Celokupna vsebnost nenasičenih maščobnih kislin je bila v razponu od 55,2 % do 70,2 %, celokupna vsebnost nasičenih maščobnih kislin pa med 29,45 % in 45,27 %. Dolžine, širine in debeline semena so bile spremenljive, akcesija WN je imela največji odstotek jedrca (78,45 %). V analizi semen so bili določeni številni elementi, kjer je bil kalij najpogostejši, z vsebnostjo od 946 do 1100 mg 100 $g^{-1}$. Analiza je tudi odkrila, da so semena bogat vir cinka z vsebnostjo od 8.4 mg 100 $g^{-1}$ do 16.21 mg 100 $g^{-1}$. Zaključek raziskave je, da so semena lokalnih sudanskih ras buč zaradi njihove sestave primerna za jedilno olje in za obogatenje hrane z beljakovinami in minerali.

**Ključne besede:** deželne rase, Severni Kordofan, semena buč, Južni Kordofan

1 Sudan University of Science & Technology, College of Agricultural Science, Department of Food Science & Technology, Khartoum North, Sudan
2 University of Jeddah, College of Science, Jeddah, Kingdom of Saudi Arabia
3 Ghibaish College of Science and Technology, Indigenous Knowledge and Heritage Centre, Ghibaish, Sudan
4 Corresponding author, e-mail: basitmariod58@gmail.com

## 1 INTRODUCTION

Among the most important cucurbits grown in Sudan are pumpkins, which belong to the genus *Cucurbita* and are economically and nutritionally important members of the Cucurbitaceae family, known locally as "Graa assaly". With respect to regional distribution, the central state is by far the most important production area of variable landraces of pumpkins, followed by the southern and western states where these landraces are extensively grown during the rainy season in Kordofan. Pumpkins are usually produced in Sudan by small farmers in rainfed areas, irrigated private farms, and big government schemes. Compared with cash crops like cotton, little attention has been paid so far to pumpkin production. Therefore, reliable data on the area and production of pumpkins is challenging to obtain. Also, there is no improved cultivar of pumpkin for commercial cultivation in Sudan, and the production of cucurbits is based on local accessions and landraces. According to FAOSTAT (2020), pumpkin production in Sudan has fluctuated substantially in the recent year. It tended to increase through the 2014–2020 period, ending at 33,396 tons in 2020 on an area of 201 hectares.

Although the pumpkin itself has various benefits, the pumpkin seeds have been the focus of interest in the last few years in the field of diet and disease research due to their various active components and chemical composition as well as the health benefits. Studies by Odoemelam (2005) and Ardabili et al. (2011) indicated that pumpkin seeds have nutritive and calorific values and are also a rich source of edible oils and fats. Stevenson et al. (2007) studied that pumpkin seeds have high nutritional value and rich in nutraceutical components such as unsaturated fatty acids, especially oleic acid and linoleic acid, palmitic acid, and stearic acid.

Landraces provide genetic diversity and are important genetic resources for plant breeders. Reza et al. (2018) investigated twenty-one accessions of *Cucurbita pepo* L. and eleven accessions of *Cucurbita moschata* Duchesne for their fruit and seed characteristics, which differed significantly ($p < 0.001$) among accessions in terms of mass, width, length, thickness, and 100 seed mass. Balkaya et al. (2010) studied 40 populations of *C. moschata* and showed a wide diversity of seed characteristics. For example, a range of 13.8–24.3 mm for seed length, 7.5–15.3 mm for seed width, and 1.6–4.7 mm for seed thickness.

In Sudan, the major sources of oil seeds are groundnut (*Arachis hypogoea* L.), cotton seeds (*Gossypium barbadense* L.), sesame seeds (*Sesamum indicum* L.) and sunflower seeds (*Helianthus annuus* L.). Ziyada and El-Hussien (2008) suggested looking for new sources of oil-bearing seeds. The most promising, unconventional, and new sources of seed oil in the Sudan are the available species of the family Cucurbitaceae. To date, little research has been carried out on the physicochemical properties and mineral content of pumpkin seeds obtained from different states in Sudan. In this study, the proximate composition, physical characteristics, and mineral content of pumpkin seeds collected from six states in Sudan are examined. The results of this study are expected to improve the documentation of landrace pumpkin seeds collected from Sudan, thereby enhancing their utilization by different users, especially oil producers.

## 2 MATERIALS AND METHODS

### 2.1 PLANT MATERİAL

Twenty-three samples of landrace pumpkin seeds (approximately 500 g of each) were collected from the six major pumpkin-producing states in Sudan. The states included South Kordofan (ten samples 1–10), North Kordofan (two samples 11–12), Gazira (four samples 13–16), Gadarif (three samples 17–19), White Nile (two samples 20–21), and Blue Nile (two samples 22–23). Pumpkin landraces and areas abbreviated (SK, NK, GZ, and GF), (A), and number of fallow areas: (SK, NK, GZ, and GF / A1, 23). Dried pumpkin seeds were obtained from each state's local market.They were manually sorted to remove damaged seeds, undersized, immature seeds, and other extraneous materials. Then they were dehulled manually. The samples were then sealed in airtight plastic bags and kept in the refrigerator at 4 °C for analysis.

### 2.2 PROXIMATE ANALYSIS

Moisture content was determined at 105 °C. Ash content was determined at 550 °C. Crude protein, lipid, and fiber were also determined according to the procedures of AOAC, (1990).

### 2.3 PHYSICAL CHARACTERISTICS

The length, width, and thickness of whole pumpkin seeds were measured with an accuracy of 0.01 mm (0.25 mm) using a Vernier EBH (Germany). The measurement was performed on 100 randomly selected seeds from the test samples.

## 2.4 FATTY ACID COMPOSITION

The fatty acid composition (FA) of oil samples was determined according to AOCA method no Ce 1-62 (1991) by using (GC/MS) technique model (GC/MS-QP 2010- Ultra, Shimadzu, Japan), with capillary column (RTx-5 ms-30 m × 0.25 mm × 0.25 µm), 2 ml of sample was mixed thoroughly with 7 ml of alcoholic sodium hydroxide (NaOH) that prepared by dissolving 2 g in 100 ml methanol. 7 ml from alcoholic sulfuric acid (1 ml $H_2SO_4$ to 100 ml methanol) was then added. The mixture was then shaked for 5 minutes. The content of the test tube was left to stand overnight. 1 ml of super saturated sodium chloride (NaCl) was then added and contents being shaken. 2 ml of normal hexane was added and the contents were shaked throughly for three minutes. Then the *n*-hexane layer (the upper layer of the test tube) was taken using disposable syringe.5 µl from the n-hexane extract was diluted with 5 ml of diethyl ether. Then the mixture was filtered through syring filter 0.45 µm and dried with 1g of anhydrous sodium sulphate as drying agent 1 µl of the diluted sample was injected in the GCMS instrument.

## 2.5 SEED INDEX

From each pumpkin seed sample, 100 seeds were weighted using an electronic balance (Shimadzu, Japan, $p$ = 0.001 g). This was repeated three times with the same number of seeds. An average of these mass was recorded. This method was applied to determine the mass of the whole seed, kernel, hull, and mass of 100 whole seeds (g) according to the method described by Jafari et al. (2012).

## 2.6 HUSK RATE

Husk content was estimated by dehulling 100 g of pumpkin seed manually and weighted according to Manda (2018). The percentage of mass of the whole pumpkin seed and kernel was used to figure out how much husk as per the following expression:

*Husk rate* (%) = (*mass of hull*) / (*mass of whole pumpkinseed and kernel*) ×100

## 2.7 DETERMINATİON OF MINERAL CONTENT

AOAC method no. 986.24 (1995) and the Atomic Absorption Spectrophotometer (AAS model GBC 932 plus, Dandenong/Australia) were used to figure out the mineral content. One gram of the sample was put into a porcelain crucible and heated in a muffle furnace to 550 °C. The ash was treated with 10 ml of concentrated hydrochloric acid, then made up to 100 ml.

## 2.8 STATISTICAL ANALYSIS

The data generated were subjected to Statistical Analysis System (SAS) software (GenStat, 2014). The mean ± SE were tested using one-factor analysis of variance (ANOVA), and the means were separated using Duncan's multiple range test (DMRT).

# 3 RESULTS AND DISCUSSION

Table 1 illustrates the ash content of the 23 landraces of pumpkin seeds, which ranged from 1.537 % reported by S. Kordofan (PR/A10) to 3.300 % reported by GZ (PR/A13). The differences observed could be explained by soil conditions, seed status, climate, and mineral presence. These values were close to the 4.64 ± 0.04 % reported by Mohammed (2015) and to the 4.87 % and 4.93 % reported by Can-Cauich et al. (2021), but lower than those obtained by Ardabili et al. (2011), who reported 5.34 %.

The protein content ranged from 16.91 % to 26.13 %. Landrace from NK (PR/A12) had the highest values; these values are within the range of 23.70–30.68 % reported by Olaofe et al. (1994) for melon, pumpkin, and gourd seeds. The crude protein in the pumpkin seed compared favorably with high protein seeds and nuts like cowpeas (22.7 %) and soybeans (35 %). The protein content of the pumpkin seed suggests that it can contribute to the daily protein need of 23–100 g for adults, as recommended by some authorities (Ajayi et al., 2006).

The total crude oil content of pumpkin seeds varied between localities and ranged from 17.77 % to 49.91 %; landraces from SK (PR/A10) had the highest yield of seed oil with 49.91 %, while landraces from GZ (PR/A13) had the lowest value with 17.77 %. These values fell in the range reported for different species of Cucurbita (9.8–52.1 %), different varieties of *C. pepo* (31.2–51.0 %) reported by Stevenson et al. (2007), and Egyptian varieties (50.1–51.01 %) reported by El-Adawy and Taha (2001). They were also like those reported by Amin et al. (2019) for native and hybrid pumpkin seeds, which were 23.5 and 17.6 %, respectively, and to those reported for Eritrean pumpkin seeds (22.2–35 %) (Younis et al., 2000). These findings show that landrace pumpkin seeds can be considered a potential source of vegetable oil for domestic and industrial purposes. The value of crude fiber ranged from 5.17 % to 15.745 %; the landrace from SK (PR/A3) had the lower value, while the landrace from SK (PR/A10) had the highest. This result was in accordance with the findings published by Al-Anoos et al. (2015) for three pumpkin varieties (*C. Maxima* Duchesne), which ranged from 4.12–9.69 %, and Alfawaz (2004), who reported 2.13 ± 0.57 16.48 ± 0.81 for kernel and whole seed, respectively. These values were lower than those obtained by Rezig et al. (2012), who reported 21.97 %, and higher than the value of 2.49 % reported by Ardabili et al. (2011), but moderately less compared to the result reported by Steiner-Asiedu et al. (2014), which was less than 2.5 %.

The total carbohydrate content of landrace seeds ranged from 2.56 % to 45.98 %. The SK landrace (PR/

**Table 1**: Proximate analysis of 23 pumpkin landraces seeds collected from different areas in Sudan*

| | | Proximate Analysis | | | | | |
|---|---|---|---|---|---|---|---|
| Location | Pumpkin Race per Area | Moisture (%) | Ash (%) | Oil content (%) | Protein (%) | Fiber (%) | Carbohydrate (%) |
| S.Kordfan | SK/A1 | 6.947$^{ij}$ | 2.417$^{df}$ | 24.55$^{g}$ | 20.70$^{f}$ | 7.48$^{hi}$ | 37.91$^{bcd}$ |
| S.Kordfan | SK/A2 | 7.307$^{i}$ | 1.743$^{ij}$ | 37.04$^{bc}$ | 22.60$^{bd}$ | 5.92$^{jk}$ | 25.49$^{h}$ |
| S.Kordfan | SK/A3 | 6.967$^{ij}$ | 1.950$^{gi}$ | 37.08$^{bc}$ | 25.56$^{a}$ | 5.17$^{k}$ | 23.28$^{h}$ |
| S.Kordfan | SK/A4 | 8.940$^{dh}$ | 2.833$^{bc}$ | 28.37$^{e}$ | 21.65$^{de}$ | 8.36$^{gh}$ | 29.85$^{g}$ |
| S.Kordfan | SK/A5 | 9.487$^{cd}$ | 2.773$^{bd}$ | 20.77$^{kl}$ | 18.60$^{gh}$ | 13.20$^{bc}$ | 35.17$^{ef}$ |
| S.Kordfan | SK/A6 | 8.793$^{eh}$ | 2.143$^{fh}$ | 24.53$^{g}$ | 18.91$^{g}$ | 12.07$^{ce}$ | 33.56$^{f}$ |
| S.Kordfan | SK/A7 | 8.510g$^{h}$ | 2.283$^{eg}$ | 36.13$^{cd}$ | 22.49$^{bd}$ | 12.68$^{bd}$ | 17.91$^{ij}$ |
| S.Kordfan | SK/A8 | 9.370$^{ce}$ | 2.350$^{eg}$ | 22.52$^{hi}$ | 18.50$^{gh}$ | 13.50$^{b}$ | 33.76$^{f}$ |
| S.Kordfan | SK/A9 | 9.270$^{cf}$ | 2.163$^{fh}$ | 36.70$^{bd}$ | 22.28$^{cd}$ | 11.26$^{df}$ | 18.32$^{i}$ |
| S.Kordfan | SK/A10 | 12.000$^{a}$ | 1.537$^{j}$ | 49.91$^{a}$ | 23.37$^{b}$ | 15.74$^{a}$ | 2.56$^{l}$ |
| Mean (SK) | | 8.76 | 2.23 | 31.76 | 21.466 | 10.538 | 25.781 |
| N.Kordfan | NK/A11 | 8.550$^{gh}$ | 2.220$^{fh}$ | 37.26$^{bc}$ | 25.25$^{a}$ | 10.82$^{ef}$ | 15.91$^{j}$ |
| N.Kordfan | NK/A12 | 9.510$^{cd}$ | 2.283$^{eg}$ | 38.01$^{b}$ | 26.13$^{a}$ | 10.35$^{f}$ | 13.71$^{k}$ |
| Mean (NK) | | 9.030 | 2.2515 | 37.635 | 25.69 | 10.585 | 14.81 |
| Gezira | GZ/A13 | 10.883$^{b}$ | 3.303$^{a}$ | 17.77$^{n}$ | 16.91$^{i}$ | 13.62$^{b}$ | 37.51$^{ce}$ |
| Gezira | GZ/A14 | 8.597$^{gh}$ | 2.253$^{eg}$ | 25.97$^{f}$ | 21.83$^{d}$ | 11.44$^{df}$ | 29.91$^{g}$ |
| Gezira | GZ/A15 | 8.707$^{fh}$ | 2.780$^{cd}$ | 20.30$^{kl}$ | 18.52$^{gh}$ | 12.51$^{bd}$ | 37.18$^{ce}$ |
| Gezira | GZ/A16 | 8.737$^{fh}$ | 2.343$^{eg}$ | 27.22$^{ef}$ | 23.02$^{bc}$ | 10.47$^{f}$ | 28.21$^{g}$ |
| Mean (GZ) | | 9.231 | 2.66975 | 22.815 | 20.07 | 12.01 | 33.2025 |
| Gedarif | GF/A17 | 6.727$^{j}$ | 2.320$^{eg}$ | 18.25$^{mn}$ | 17.80$^{hi}$ | 8.93$^{g}$ | 45.98$^{a}$ |
| Gedarif | GF/A18 | 9.527$^{cd}$ | 2.417$^{ef}$ | 23.66$^{gh}$ | 20.80$^{ef}$ | 8.03$^{gi}$ | 35.56$^{df}$ |
| Gedarif | GF/A19 | 10.917$^{b}$ | 3.147$^{ab}$ | 19.94$^{kl}$ | 19.08$^{g}$ | 6.95$^{i}$j | 39.97$^{b}$ |
| Mean (GF) | | 9.057 | 2.628 | 20.61667 | 19.22667 | 7.97 | 40.50 |
| W. Nile | WN/A20 | 9.060$^{cg}$ | 2.647$^{c}$ | 22.16$^{i}$j | 18.68$^{gh}$ | 11.29$^{df}$ | 36.16$^{de}$ |
| W. Nile | WN/A21 | 8.520$^{gh}$ | 1.840$^{hj}$ | 35.52$^{d}$ | 21.82$^{d}$ | 8.53$^{gh}$ | 23.77$^{h}$ |
| Mean (WN) | | 8.79 | 2.2435 | 28.84 | 20.25 | 9.91 | 29.965 |
| Blue Nile | BN/A22 | 8.357$^{h}$ | 2.377$^{ef}$ | 20.96$^{jk}$ | 18.25$^{gh}$ | 11.94$^{ce}$ | 38.91$^{bc}$ |
| Blue Nile | BN/A23 | 9.600$^{c}$ | 2.413$^{df}$ | 19.51$^{lm}$ | 18.46$^{gh}$ | 12.58$^{bd}$ | 36.53$^{ce}$ |
| Mean (BN) | | 8.9785 | 2.395 | 20.235 | 18.355 | 12.26 | 37.72 |
| Overall mean | | 8.93 | 2.37 | 28.22 | 20.9 | 10.56 | 29.44 |
| ± SE | | 0.16 | 0.12 | 0.45 | 0.32 | 0.43 | 0.76 |
| C.V% | | 3.6 | 8.9 | 2.8 | 2.6 | 7.1 | 4.5 |

*Means followed by the same letter/s are not significantly different using DMRT

A10) had the lowest value, while the GZ landrace (PR/A17) had the highest value. These values were within the range of 19 % reported by Ardabili et al. (2011) for pumpkin seeds and within the range of the same value obtained by Elinge et al. (2012), which was 28.03 %, and the value of 25 % reported by Qamar et al. (2019).

Fatty acid compositions of seeds belonging to different landraces and locations are shown in Table 2. According to obtained results, dominant fatty acids of landraces pumpkin seed oils were linoleic, oleic, palmitic, and stearic acids. Other fatty acids (palmitoleic acid, myristic acid, arachidic acid and behenic acid) were determined in small quantities. The major and most representative fatty acid in all analyzed landraces is linoleic which was exhibited in high percentage 41.58 % obtained by White Nile landrace (WN/A20) and low percentage 33.39 % obtained by Blue Nile landrace (BN/A23) and followed by oleic acid which was ranged from 11.03 % to 33.59 obtained by W. Nile landrace (WN/A20) and N. Kordofan landrace (NK/A11), palmitic which was ranged from 16.71 % to 27.56 % obtained by N. Kordofan landrace (NK/A11) and Gazira landrace (GZ/A13), and stearic acid which was ranged from 2.24 % to 15.69 % obtained by Gazira landrace (GZ/A13) and Gedarif landrace (GF/A19), respectively.

In the present study the content of most the fatty acids in the analyzed landraces pumpkin seed oils mainly affected by soil type in which the plants are grown, climate and state of ripeness; interaction between these factors was found to be significant for the content of polyunsaturated fatty acid (PUFA) percentage (37.02 %) and monounsaturated fatty acid percentages (27.50 %) ;and the total of unsaturated fatty acid (TUFA) which was ranged from 55.2 % to 70.2 %; while the total of saturated fatty acids (TSFA) content amounted in all landraces was ranged from 29.45 % to 45.27 %, that indicate the landraces pumpkin seeds oil in almost all samples collected from different locations in Sudan is highly unsaturated oil. It worth mention that the Sudanese landraces pumpkin seeds oil had a significant amount of squalene content in the all investigated landraces, which was ranged from 0.34 % to 1.29 % these values highly lower than values registered by Gorjanović et al. (2011), this non-glyceride component has been proposed to be an important part of the diet as it may be a chemo-preventative substance that protects people from cancer (Smith, 2000); that makes it contributes to the significant nutritive and medicinal value of the of the Sudanese landraces pumpkin seeds oil. With regard to location no significant difference in the percentages of fatty acids among the samples from same area but slightly differ from area to another, oil extracted from Gedarif samples (GF/A17, GF/A18 and GF/A19) had a lower average of linoleic acid content (34.07 %) and oil extracted from White Nile samples (WN/A20 and WN/A21) had a higher average of linoleic acid content (39.90 %). White Nile area had the lowest average on the oleic acid (14.51 %), while North Kordofan area had the highest average (29.05 %) in the investigated races. Palmitic acid average was lowest in the investigated races from South Kordofan (18.94%), while highest in the Gedarif races (24.93 %). Stearic acid was lowest on the average of investigated races from Gazira which had (10.855 %), while was highest in investigated races from Gedarif (14.50 %). The variability in the fatty acid composition is very high resulting from a broad genetic diversity; Study of the average fatty acid compounds studied by Soltani, (2016) on different accessions of *Cucurbita pepo* L. in Iran showed that oleic acid (39.24 %) was higher than linoleic (38.76 %), palmitic (11.09 %), and stearic (5.37 %), other study reported by Aktaş et al. (2018) on two types of pumpkin seeds belonging to *C. pepo* species, revealed that linoleic acid is an essential fatty acid followed by oleic acid which were ranged from (40.04 %-43.19 %) and (37.48 % -39.66 %) respectively, which were conforms with the present study. Linoleic acid is an essential fatty acid for humans as it is required for the formation of cellular membranes, vitamin D, and various hormones (Fruhwirth & Hermetter, 2007).

**Table 2**: Means (%) of fatty acids composition of 23 pumpkin landraces collected from different areas of Sudan

| Location | Race | Myristic C14:0 | Pentadecanoic C15:0 | Palmitoleic C16:1n-7 | Palmitic C16:0 | Margaric C17:0 | Linoleic C18:2 | Oleic C18:1 | Others* |
|---|---|---|---|---|---|---|---|---|---|
| South Kordfan | SK/A1 | 0.25 | 0.02 | 0.16 | 20.41 | 0.22 | 36.16 | 21.10 | 21.68 |
| South Kordfan | SK/A2 | 0.17 | 0.03 | 0.26 | 17.70 | 0.37 | 33.62 | 33.20 | 14.65 |
| South Kordfan | SK/A3 | 0.12 | 0.02 | 0.18 | 16.87 | 0.36 | 39.98 | 28.84 | 13.63 |
| South Kordfan | SK/A4 | 0.17 | 0.02 | 0.12 | 21.11 | 0.20 | 38.38 | 23.85 | 15.70 |
| South Kordfan | SK/A5 | 0.17 | 0.02 | 0.12 | 20.68 | 0.19 | 36.11 | 26.89 | 15.82 |
| South Kordfan | SK/A6 | 0.17 | 0.01 | 0.13 | 21.29 | 0.23 | 34.95 | 28.32 | 14.90 |
| South Kordfan | SK/A7 | 0.14 | 0.02 | 0.23 | 17.56 | 0.30 | 37.77 | 29.74 | 14.24 |
| South Kordfan | SK/A8 | 0.13 | 0.01 | 0.16 | 19.08 | 0.21 | 35.96 | 30.62 | 13.83 |
| South Kordfan | SK/A9 | 0.21 | 0.02 | 0.19 | 17.68 | 0.36 | 35.95 | 30.70 | 14.89 |
| South Kordfan | SK/A10 | 0.13 | 0.02 | 0.22 | 17.04 | 0.31 | 34.87 | 32.50 | 14.91 |
| Mean (SK) | | 0.17 | 0.02 | 0.18 | 18.87 | 0.28 | 36.38 | 28.58 | 15.52 |
| North Kordfan | NK/A11 | 0.24 | 0.03 | 0.18 | 16.71 | 0.29 | 34.39 | 33.59 | 14.57 |
| North Kordfan | NK/A12 | 0.31 | 0.03 | 0.21 | 22.44 | 0.34 | 34.14 | 24.52 | 18.01 |
| Mean (NK) | | 0.28 | 0.03 | 0.20 | 19.58 | 0.32 | 34.27 | 29.10 | 16.22 |
| Gezira | GZ/A13 | 0.35 | 0.03 | 0.25 | 27.56 | 0.41 | 36.03 | 22.7 | 12.67 |
| Gezira | GZ/A14 | 0.40 | 0.03 | 0.26 | 24.57 | 0.43 | 35.31 | 18.02 | 20.98. |
| Gezira | GZ/A15 | 0.45 | 0.04 | 0.30 | 22.16 | 0.43 | 34.06 | 23.7 | 18.86 |
| Gezira | GZ/A16 | 0.44 | 0.04 | 0.27 | 24.45 | 0.32 | 36.81 | 16.28 | 21.39 |
| Mean (GZ) | | 0.41 | 0.07 | 0.27 | 24.69 | 0.39 | 35.55 | 20.18 | 18.44 |
| Gedarif | GF/A17 | 0.49 | 0.03 | 0.29 | 22.97 | 0.4 | 33.62 | 23.38 | 18.82 |
| Gedarif | GF/A18 | 0.39 | 0.04 | 0.22 | 25.74 | 0.28 | 34.9 | 17.07 | 21.36 |
| Gedarif | GF/A19 | 0.37 | 0.03 | 0.22 | 26.08 | 0.32 | 33.69 | 16.67 | 22.62 |
| Mean (GF) | | 0.41 | 0.03 | 0.24 | 24.93 | 0.33 | 34.07 | 19.04 | 20.95 |
| White Nile | WN/A20 | 0.42 | 0.04 | 0.3 | 24.3 | 0.38 | 41.58 | 11.03 | 21.95 |
| White Nile | WN/A21 | 0.36 | 0.05 | 0.53 | 21.28 | 0.91 | 38.23 | 18.00 | 20.64 |
| Mean (WN) | | 0.39 | 0.05 | 0.42 | 22.64 | 0.65 | 39.91 | 14.51 | 21.43 |
| Blue Nile | BN/A22 | 0.59 | 0.05 | 0.4 | 24.25 | 0.44 | 38.62 | 13.37 | 22.28 |
| Blue Nile | BN/A23 | 0.65 | 0.05 | 0.43 | 23.32 | 0.54 | 33.39 | 22.09 | 19.53 |
| Mean (BN) | | 0.62 | 0.05 | 0.42 | 23.79 | 0.49 | 36.00 | 17.73 | 20.90 |
| Overall mean | | 0.31 | 0.03 | 0.25 | 21.53 | 0.36 | 36.02 | 23.75 | 17.75 |
| SD | | 0.15 | 0.01 | 0.10 | 3.25 | 0.15 | 2.19 | 6.57 | 01.77 |

*Other fatty acids include Stearic (C18:0), Linolenic (C18:3), and Gadoleic (C20:1)

**Table 2:** Means (%) of fatty acids composition of 23 pumpkin landraces seed collected from different areas of Sudan

| Location | Race | Stearic | Arachidic | Behenic | Squalene | PUFA | MUSAF | SFA |
|---|---|---|---|---|---|---|---|---|
| South Kordfan | SK/A1 | 12.44 | 1.30 | 0.50 | 1.25 | 37.22 | 22.00 | 36.53 |
| South Kordfan | SK/A2 | 11.38 | 1.07 | 0.30 | 0.46 | 34.21 | 34.06 | 31.21 |
| South Kordfan | SK/A3 | 10.94 | 0.76 | 0.24 | 0.35 | 40.73 | 29.47 | 29.45 |
| South Kordfan | SK/A4 | 12.80 | 0.99 | 0.26 | 0.49 | 39.52 | 24.32 | 35.67 |
| South Kordfan | SK/A5 | 12.34 | 0.97 | 0.24 | 0.41 | 37.56 | 27.42 | 34.61 |
| South Kordfan | SK/A6 | 12.20 | 0.99 | 0.23 | 0.38 | 35.69 | 26.81 | 36.60 |
| South Kordfan | SK/A7 | 12.03 | 1.01 | 0.23 | 0.34 | 37.77 | 30.37 | 31.52 |
| South Kordfan | SK/A8 | 11.43 | 0.86 | 0.22 | 0.39 | 36.43 | 31.09 | 32.09 |
| South Kordfan | SK/A9 | 12.77 | 0.95 | 0.18 | 0.49 | 35.95 | 31.30 | 32.26 |
| South Kordfan | SK/A10 | 11.95 | 1.05 | 0.33 | 0.46 | 35.21 | 34.21 | 30.06 |
| Mean (SK) | | 12.028 | 0.939 | 2730. | 0.513 | 37.02 | 29.10 | 33.00 |
| North Kordfan | NK/A11 | 12.01 | 0.83 | 0.32 | 0.39 | 34.73 | 34.18 | 30.62 |
| North Kordfan | NK/A12 | 12.85 | 1.72 | 0.34 | 0.52 | 35.92 | 25.35 | 38.21 |
| Mean (NK) | | 12.43 | 1.275 | 0.33 | 0.455 | 35.325 | 29.765 | 34.415 |
| Gezira | GZ/A13 | 2.24 | 1.94 | 0.57 | 0.71 | 37.14 | 23.66 | 38.39 |
| Gezira | GZ/A14 | 14.41 | 1.78 | 0.48 | 0.68 | 36.44 | 20.42 | 42.46 |
| Gezira | GZ/A15 | 12.65 | 2.09 | 0.54 | 0.89 | 35.58 | 24.81 | 36.44 |
| Gezira | GZ/A16 | 14.12 | 2.05 | 0.50 | 0.88 | 38.16 | 18.81 | 42.15 |
| Mean(GZ) | | 10.855 | 1.965 | 0.522 | 0.790 | 36.83 | 21.92 | 39.86 |
| Gedarif | GF/A17 | 12.81 | 2.27 | 0.56 | 0.96 | 34.96 | 24.34 | 39.74 |
| Gedarif | GF/A18 | 15.04 | 1.76 | 0.47 | 0.80 | 35.9 | 19.3 | 44.00 |
| Gedarif | GF/A19 | 15.67 | 1.95 | 0.48 | 0.81 | 34.53 | 19.39 | 45.27 |
| Mean (GF) | | 14.50 | 1.99 | 0.50 | 0.85 | 35.13 | 21.01 | 43.00 |
| White Nile | WN/A20 | 13.62 | 1.96 | 0.47 | 0.93 | 43.34 | 14.4 | 41.59 |
| White Nile | WN/A21 | 12.90 | 1.91 | 0.37 | 0.97 | 39.65 | 21.29 | 38.09 |
| Mean(WN) | | 13.26 | 1.93 | 0.42 | 0.95 | 41.49 | 17.84 | 39.84 |
| Blue Nile | BN/A22 | 13.43 | 2.52 | 0.6 | 1.18 | 40.33 | 16.34 | 42.15 |
| Blue Nile | BN/A23 | 12.12 | 2.79 | 0.83 | 1.29 | 34.43 | 23.49 | 40.79 |
| Mean (BN) | | 12.27 | 2.65 | 0.715 | 1.24 | 37.38 | 19.92 | 41.47 |
| Overall mean | | 12.35 | 1.544 | 0.403 | 0.697 | 37.02 | 25.08 | 36.95 |
| SD | | 2.487 | 0.0 | 0.162 | 0.304 | 2.352 | 5.738 | 4.824 |

Table 3 shows the dimensions of whole landrace pumpkin seeds. The length of seeds ranged from 11.00 mm to 20.00 mm, which was observed between the GZ (GZ/A13) and the SK (PR/A10). The width of the seeds ranged from 4.30 cm, which was obtained by the GZ (GZ/A15) and the GF (GF/A17), to 9.30 cm, which was obtained by the GF (GF/A19). The thickness of the seeds ranged from 1.333 mm, which was obtained by the BN (PR/A23), to 4.667 mm, which was obtained by the SK (SK/A9) and the NK (NK/A12). Milani et al. (2007) reported that seeds had lengths ranging from 12 to 14 mm, widths between 7 and 13 mm, and thicknesses ranging from 2.0 to 4.0 mm, which is moderately lower than current results.

As shown in Table 3, sample from Blue Nile (BN/A23) recorded a minimum 100 seed mass of 12.55 g. The maximum 100-seed mass was obtained from SK (SK/A7) and SK (SK/A2), with 32.2 g and 27.52 g, respectively. These results were higher than the range of 1000-seed mass recorded for different genotypes reported by Türkmen et al. (2017), which ranged from 168.9 to 196.6 g. Can-Cauich et al. (2021) reported that two pumpkin species had values of 12.00 and 25.01 g per 100 seeds, which is in accordance with the current study. Furthermore, the minimum and maximum mass of whole seed, kernel, and hull of landraces were determined by BN (BN/A22) and SK (SK/A7), which ranged from 0.125 g WN (WN/A22) to 0.322 g for SK (SK/A7), 0.0802 g WN (WN/A22) to 0.2471 g for SK (SK/A7), and 0.0342 g SK (SK/A7) to This difference is attributed to the seeds' dimensions and to embryo quality. According to the calculation of the hull to kernel ratio, the lowest ratio was observed in BN BN/A23 (1.9:1), while the highest ratio was observed in BN BN/A22 (4.02 : 1). The variability in seed index parameters between the studied samples can be attributed to the variability of production area, soil type, and location genotype.

The content of kernel and hull differed significantly ($p$ < 0.001), as shown in Table (3): the highest percent of kernel with WN WN/A20 (78.45 %) and the lowest percent with BN BN/A23 (63.92 %), as it had a lower percent of kernel; BN BN/A23 had the highest percent of hull (32.36 %), while WN landrace WN/A22 had the lowest percent (18.68 %).The variation in physical characteristics of landrace seeds may be due to location, type of soil, and climate. Manda et al. (2018) discovered that the husk content of pumpkin seeds was 26.75 %.

According to Table 4, the seeds from 23 landrace pumpkin seeds were a significant source of minerals. The most dominant minerals were potassium (K), phosphorus (P), calcium (Ca), sodium (Na), iron (Fe), zinc (Zn), magnesium (Mg), and manganese (Mn), respectively ($p$ < 0.05%). Potassium is the most abundant element found in the seed. The highest level of K was determined in the GF (GF/A17) at 1100 mg 100 g$^{-1}$, and the lowest level was found in the GZ (GZ/A14) at 946 mg 100 g$^{-1}$. These values are higher than those reported by Rezig et al. (2012), which were 886.56 g 100 g$^{-1}$. Phosphorus (P) and calcium (Ca) were the most abundant minerals, with values varying from 209 mg 100 g$^{-1}$ for the GF (GF/A17) to 374 g 100 g$^{-1}$ for the SK (SK/A5) and from 130 g 100 g$^{-1}$ for the BN (BN/A23) to 147 g 100 g$^{-1}$ for the SK (SK/A1), respectively. Phosphates play key roles as buffers that prevent changes in the acidity of body fluids. Calcium has an important role in preventing rickets, osteoporosis, and tachycardia (Mergedus et al., 2015). The values of phosphorus and calcium obtained from landrace pumpkin seeds were higher than those reported by Elinge et al. (2012), which were 47.680.04 mg 100 g$^{-1}$ and 9.78 mg 100 g$^{-1}$, respectively, and within the range of values reported by Amoo et al. (2004) for P (224.14 mg 100 g$^{-1}$) and Ca (29.47 mg 100 g$^{-1}$). The concentration of sodium (Na) in landrace samples ranged from 26.99 mg 100 g$^{-1}$ to 38.6 mg 100 g$^{-1}$ determined by GZ (GZ/A13) and SK (SK/A4), respectively; this element is needed by the body to regulate blood pressure and blood volume.

The values obtained were within the range of the result reported by Amoo et al. (2004), 29.69 mg 100 g$^{-1}$, and lower than that reported by Rezig et al. (2012), which was 356.75 mg 100 g$^{-1}$.

Iron contents (Fe) were found to range from 11.2 mg 100 g$^{-1}$ to 17.3 mg 100 g$^{-1}$ for the NK (NK/A12) and the GZ (GZ/A16). Iron has important functions in the body. It carries oxygen through the blood (as a part of the red blood cell) to muscles and the brain, making it crucial for both mental and physical health and performance (Abbaspour et al., 2014). According to a joint FAO/WHO report (2005), iron deficiency is the most common nutritional disorder in the world. The daily value (DV) of iron is 18 mg, and one ounce (28 g) of pumpkin seeds contains 2.5 mg of iron, which is 14 % of the DV according to the FDC (2019). As a result, the iron content values obtained from this study corresponded to the DV. The values obtained in this study were higher than those reported by Elinge et al. (2012), which were 3.75 mg 100 g$^{-1}$, and Amoo et al. (2004), which were 4.27 mg 100 g$^{-1}$, and within the ranges of 13.66 mg 100 g$^{-1}$ and 15.37 mg 100 g$^{-1}$ reported by Alfawaz (2004) and Rezig et al. (2012), respectively.

Landraces showed respectable amounts of magnesium (Mg), which had a lower value in the SK (SK/A8), which was 3.9 mg 100 g$^{-1}$, and a higher value in the WN (WN/A22), which was 16.9 mg 100 g$^{-1}$. According to the Office of Dietary Supplements (ODS, 2022), seeds are rich sources of magnesium. Mg has a role in the regulation of blood sugar levels and is involved in energy metabolism and protein synthesis (Mir-Marqures et al., 2015). The values obtained were lower than those reported by Elinge et al. (2012) and Rezig et al. (2012), which were 67.41 mg 100 g$^{-1}$ and 146.13 mg 100 g$^{-1}$, respectively.

This study determined the zinc (Zn) content of landrace seeds ranged from 8.4 mg 100 g$^{-1}$ to 16.2 mg 100 g$^{-1}$, which were obtained from the GF (GF/A19) and the SK (SK/A6), respectively. Zinc is a vital component of white blood cells (WBC), which fight infections and prevent susceptibility to flu, colds, and other viral infections such as COVID-19. Several clinical trials are currently investigating the use of zinc supplementation alone or in combination with hydroxychloroquine for the prevention and treatment of COVID-19 (Neha et al., 2020). The Recommended Dietary Allowance (RDA) for elemental zinc is 11 mg daily for men and 8.0 mg for non-pregnant women, according to the Office of Dietary Supplements (OSD, 2022). Therefore, Sudanese landrace pumpkin seeds are a rich source of zinc. These results were higher than those reported by Alfwaz et al. (2004) (1.09 g 100 g$^{-1}$) and Amoo et al. (2004) (3.98 mg 100 g$^{-1}$), but lower than the 25.19 mg 100 g$^{-1}$ reported by Rezig et al. (2012).

Manganese (Mn) was found to be the least abundant among all the minerals studied in these samples, which ranged from 3.3 mg 100 $g^{-1}$ to 6.8 mg 100 $g^{-1}$ obtained by the GZ (GZ/A15) and the SK (SK/A10) seeds, respectively. The values obtained were higher than those obtained by Elinge et al. (2015) (0.060.01 mg 100 $g^{-1}$) and Amoo et al. (2004) (1.79 mg 100 $g^{-1}$), and within the range of the value (3.42 mg 100 $g^{-1}$) obtained by Rezig et al. (2012). The differences in mineral composition could be due to the climate, species, or soil type.

**Table 3**: Means of seed characters of 23 pumpkin landraces collected from different areas of Sudan

| Location | Pumpkin Race pear Area | Length mm | Thickness mm | Width mm | Mass 100 Seed (g) | Mass Whole Seed (g) | Mass Kernel (g) | Mass Hull (g) | % Kernel | % hull | Hull: Kernel |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S.Kordfan | SK/A1 | 13.00$^{eh}$ | 2. 667$^{d}$ | 5. 70$^{d}$ | 17.40$^{jk}$ | 0.1740$^{jk}$ | 0.1314 | 0.0372 | 75.57$^{ad}$ | 21.39$^{gh}$ | 3.5:1 |
| S.Kordfan | SK/A2 | 17.00$^{b}$ | 3. 667$^{ad}$ | 6. 00$^{d}$ | 27.52$^{b}$ | 0.2752$^{b}$ | 0.1794 | 0.0828 | 65.19$^{h}$ | 30.09$^{b}$ | 2.1:1 |
| S.Kordfan | SK/A3 | 15.00$^{be}$ | 2. 667$^{d}$ | 5. 00$^{e}$ | 25.19$^{d}$ | 0.2519$^{d}$ | 0.1905 | 0.0626 | 75.60$^{ad}$ | 24.85$^{d}$ | 3.1:1 |
| S.Kordfan | SK/A4 | 13.67$^{dg}$ | 2. 667$^{d}$ | 4. 70$^{e}$ | 15.71$^{l}$ | 0.1571 $^{l}$ | 0.1191 | 0.0365 | 75.83$^{ad}$ | 23.24$^{e}$ | 3.2:1 |
| S.Kordfan | SK/A5 | 12.33$^{gh}$ | 2. 667$^{cd}$ | 5. 70$^{d}$ | 18.25$^{hi}$ | 0.1825$^{hi}$ | 0.1300 | 0.0449 | 71.31$^{fg}$ | 24.63$^{d}$ | 2.8:1 |
| S.Kordfan | SK/A6 | 15.67$^{bd}$ | 3. 333 $^{bd}$ | 5. 00$^{e}$ | 20.21$^{g}$ | 0.2020$^{g}$ | 0.1475 | 0.0463 | 73.06$^{cf}$ | 22.93$^{ef}$ | 3.1:1 |
| S.Kordfan | SK/A7 | 19.67$^{a}$ | 4. 333$^{ab}$ | 8. 30$^{b}$ | 32.21$^{a}$ | 0.3222$^{a}$ | 0.2471 | 0.0751 | 76.69$^{ab}$ | 23.31$^{e}$ | 3.2:1 |
| S.Kordfan | SK/A8 | 16.33$^{bc}$ | 4. 333$^{ab}$ | 7. 30$^{c}$ | 15.45$^{i}$ | 0.1544 $^{l}$ | 0.1175 | 0.0362 | 76.10$^{ac}$ | 23.44$^{e}$ | 3.2:1 |
| S.Kordfan | SK/A9 | 19.67$^{a}$ | 4. 667$^{a}$ | 9. 30$^{a}$ | 26.03$^{c}$ | 0.2605$^{c}$ | 0.1873 | 0.0736 | 71.90$^{eg}$ | 28.27$^{c}$ | 2.5:1 |
| S.Kordfan | SK/A10 | 20.00$^{a}$ | 3. 333$^{bd}$ | 9. 00$^{a}$ | 24.40$^{e}$ | 0.2440$^{e}$ | 0.1841 | 0.0621 | 75.93$^{ac}$ | 25.45$^{d}$ | 2.9:1 |
| Mean (SK) | | 16.234 | 3.433 | 6. 60 | 22.237 | 0.22238 | 0.163 | 0.055 | 73.718 | 24.76 | |
| N.Kordfan | NK/A11 | 12.67$^{fh}$ | 3. 667$^{ad}$ | 5. 00$^{e}$ | 22.92$^{f}$ | 0.2291$^{f}$ | | | 74.10b$^{f}$ | 22.92$^{ef}$ | 3.2:1 |
| N.Kordfan | NK/A12 | 12.67$^{fh}$ | 4. 667$^{a}$ | 5. 30$^{e}$ | 23.42$^{f}$ | 0.2342$^{f}$ | 0.1697 | 0.0525 | 74.84$^{be}$ | 22.08$^{fg}$ | 3.3:1 |
| Mean(NK) | | 12.67 | 4.167 | 5. 15 | 23.17 | 0.23165 | 0.1752 | 0.0517 | 74.47 | 22.5 | |
| Gezira | GZ/A13 | 11.00 $^{h}$ | 4. 00$^{abc}$ | 4. 70f | 20.22$^{g}$ | 0.2022$^{g}$ | | | 73.00$^{cf}$ | 20.47 $^{i}$ | 3.5:1 |
| Gezira | GZ/A14 | 11.33 $^{h}$ | 3. 33$^{bd}$ | 5. 00$^{e}$ | 17.58$^{ik}$ | 0.1757$^{ik}$ | 0.1467 | 0.0414 | 72.74$^{df}$ | 23.69$^{e}$ | 3.07:1 |
| Gezira | GZ/A15 | 11.00$^{h}$ | 3. 00$^{cd}$ | 4. 30$^{f}$ | 16.12 $^{l}$ | 0.1612 $^{l}$ | 0.1277 | 0.0407 | 71.49$^{fg}$ | 22.30$^{f}$ | 3.2:1 |
| Gezira | GZ/A16 | 12.33$^{gh}$ | 3. 00$^{cd}$ | 5. 00$^{e}$ | 16.89$^{k}$ | 0.1689$^{k}$ | 0.1151 | 0.0359 | 69.23$^{g}$ | 22.27$^{f}$ | 3.1:1 |
| Mean(GZ) | | 11.4 | 3.33 | 4. 75 | 17.70 | 0.177 | 0.1169 | 0.0376 | 71.615 | 22.18 | |
| Gedarif | GF/A17 | 12.00$^{gh}$ | 3. 667$^{ad}$ | 4. 30$^{f}$ | 15.71 $^{l}$ | 0.1575 $^{l}$ | | | 74.75$^{be}$ | 23.29$^{e}$ | 3.2:1 |
| Gedarif | GF/A18 | 11.67$^{gh}$ | 3. 000$^{cd}$ | 4. 70$^{f}$ | 15.84$^{l}$ | 0.1584 $^{l}$ | | | 76.77$^{ab}$ | 22.10$^{fg}$ | 3.4:1 |
| Gedarif | GF/A19 | 12.67$^{fh}$ | 3.000$^{cd}$ | 5. 00$^{e}$ | 14.02$^{m}$ | 0.1402$^{m}$ | 0.1177 | 0.0375 | 74.13$^{bf}$ | 25.06$^{d}$ | 2.9:1 |
| Mean (GF) | | 12.1 | 3. 22 | 4. 66$^{f}$ | 15.19 | 0.15 | 0.1216 | 0.035 | 75.21 | 23.48 | |
| W. Nile | WN/A20 | 12.33$^{gh}$ | 3. 000$^{cd}$ | 6.00$^{d}$ | 17.98$^{hj}$ | 0.1797$^{hj}$ | 0.1039 | 0.0349 | 78.45$^{a}$ | 20.64 $^{hi}$ | 3.8:1 |
| W. Nile | WN/A21 | 14.67$^{cf}$ | 3. 333$^{bd}$ | 5. 70$^{d}$ | 27.30$^{b}$ | 0.2729$^{b}$ | | | 75.75$^{ad}$ | 23.23$^{e}$ | 3.2:1 |
| Mean(WN) | | 13.5 | 3. 16 | 5. 85$^{d}$ | 22.64 | 0.2263 | | | 77.1 | 21.94 | |
| Blue Nile | BN/A22 | 12.00$^{gh}$ | 3. 000$^{cd}$ | 4. 70$^{d}$ | 18.38$^{h}$ | 0.1838$^{h}$ | 0.141 | 0.0371 | 75.24$^{bd}$ | 18.68$^{j}$ | 4.02:1 |
| Blue Nile | BN/A23 | 12.00$^{gh}$ | 1. 333$^{e}$ | 4. 70$^{d}$ | 12.55 $^{n}$ | 0.1255 $^{n}$ | 0.2067 | 0.0634 | 63.92$^{h}$ | 32.36$^{a}$ | 1.9:1 |
| Mean(BN) | | 12.00 | 2.16 | 4. 70$^{d}$ | 15.46 | 0.1546 | | | 69.58 | 25.52 | |
| Overall mean | | 13.94 | 3. 32 | 0.5681 | 20.05 | 0.2006 | | | 73.55 | 23.77 | |
| SE± | | 0.0656 | 0.039 | 0.044 | 0.233 | 0.002 | 0.1382 | 0.0342 | 0.92 | 0.28 | |
| C.V% | | 8.1 | 20.2 | 13.5 | 2.0 | 2.0 | 0.0802 | 0.0406 | 2.2 | 2.1 | |

*Means followed by the same letter/s are not significantly different using DMRT

**Table 4:** Means of minerals of 23 pumpkin landraces seeds* collected from different areas of Sudan (mg 100 g$^{-1}$)

| Location | Pumpkin | Ca | Fe | K | Mg | Mn | Na | P | Zn |
|---|---|---|---|---|---|---|---|---|---|
| South Kordfan | SK/A1 | 147$^{a}$ | 13.9$^{be}$ | 992$^{b}$ | 7.3$^{cd}$ | 4.8$^{bf}$ | 35.9$^{ae}$ | 370$^{a}$ | 12.5$^{bg}$ |
| South Kordfan | SK/A2 | 143$^{ab}$ | 15.4$^{ad}$ | 989$^{b}$ | 7.1$^{de}$ | 6.2$^{ac}$ | 37.7$^{ac}$ | 373$^{a}$ | 13.4$^{ae}$ |
| South Kordfan | SK/A3 | 143$^{ab}$ | 15.4$^{ad}$ | 989$^{b}$ | 7.1$^{de}$ | 5.3$^{ae}$ | 37.7$^{ac}$ | 373$^{a}$ | 15.5$^{ab}$ |
| South Kordfan | SK/A4 | 138$^{ch}$ | 14.2$^{ae}$ | 959$^{b}$ | 5.5$^{df}$ | 4.9$^{bf}$ | 38.6$^{a}$ | 367$^{a}$ | 13.6$^{ae}$ |
| South Kordfan | SK/A5 | 141$^{bc}$ | 14.7$^{ae}$ | 981$^{b}$ | 4.6$^{df}$ | 4.9$^{bf}$ | 36.4$^{ad}$ | 374$^{a}$ | 14.6$^{ad}$ |
| South Kordfan | SK/A6 | 139$^{be}$ | 15.4$^{ad}$ | 954$^{b}$ | 6.0$^{df}$ | 6.2$^{ac}$ | 35.3$^{ae}$ | 264$^{g}$ | 16.21$^{a}$ |
| South Kordfan | SK/A7 | 140$^{bd}$ | 12.6$^{df}$ | 955$^{b}$ | 5.6$^{df}$ | 5.9$^{ac}$ | 36.2$^{ad}$ | 276$^{fg}$ | 14.8$^{ac}$ |
| South Kordfan | SK/A8 | 137$^{ch}$ | 15.1$^{ad}$ | 978$^{b}$ | 3.9$^{f}$ | 4.8$^{bf}$ | 38$^{ab}$ | 282$^{eg}$ | 12.8$^{bf}$ |
| South Kordfan | SK/A9 | 136$^{dh}$ | 12.8$^{df}$ | 982$^{b}$ | 5.7$^{df}$ | 6.4$^{ab}$ | 33.2$^{af}$ | 325$^{bc}$ | 12.0$^{ch}$ |
| South Kordfan | SK/A10 | 139$^{be}$ | 9.85$^{f}$ | 977$^{b}$ | 5.6$^{df}$ | 6.8$^{a}$ | 30.3$^{eg}$ | 304$^{ce}$ | 12.4$^{bg}$ |
| Mean (SK) | | 140.3 | 13.935 | 975.6 | 5.84 | 5.62 | 35.93 | 330.8 | 13.781 |
| North Kordfan | NK/A11 | 134$^{gi}$ | 12.8$^{df}$ | 1042$^{a}$ | 4.5$^{ef}$ | 5.6$^{ad}$ | 32.8$^{bf}$ | 314$^{cd}$ | 12.2$^{ch}$ |
| North Kordfan | NK/A12 | 135$^{fi}$ | 11.2$^{ef}$ | 978b | 5.7$^{df}$ | 4.4$^{cf}$ | 28.5$^{fg}$ | 272$^{fg}$ | 9.8$^{fi}$ |
| Mean (NK) | | 134.5 | 12 | 1010 | 5.1 | 5 | 30.65 | 293 | 11 |
| Gezira | GZ/A13 | 137$^{ch}$ | 12.1$^{df}$ | 987$^{b}$ | 5.6$^{df}$ | 3.6$^{ef}$ | 26.99$^{g}$ | 285$^{eg}$ | 9.9$^{fi}$ |
| Gezira | GZ/A14 | 137$^{ch}$ | 12.7$^{df}$ | 946$^{b}$ | 4.5$^{ef}$ | 5.2$^{af}$ | 31.2$^{dg}$ | 320$^{c}$ | 10.6$^{ei}$ |
| Gezira | GZ/A15 | 139$^{be}$ | 16.9$^{ab}$ | 983$^{b}$ | 5.9$^{df}$ | 3.3$^{f}$ | 34.8$^{ae}$ | 265$^{fg}$ | 9.9$^{fi}$ |
| Gezira | GZ/A16 | 136d$^{h}$ | 17.3$^{a}$ | 977$^{b}$ | 4.8$^{df}$ | 3.4$^{f}$ | 32.5$^{cf}$ | 271$^{fg}$ | 9.4$^{gi}$ |
| Mean (GZ) | | 137.25 | 14.75 | 973.25 | 5.2 | 3.875 | 31.3725 | 165.1857 | 9.95 |
| Gedarif | GF/A17 | 133$^{hi}$ | 16.4$^{ac}$ | 1100$^{a}$ | 6.2$^{df}$ | 3.4$^{f}$ | 33.98$^{af}$ | 209$^{h}$ | 16.22$^{a}$ |
| Gedarif | GF/A18 | 133$^{h}$i | 14.7$^{ae}$ | 987$^{b}$ | 5.8$^{df}$ | 3.9$^{df}$ | 34.4$^{ae}$ | 319$^{c}$ | 8.99$^{hi}$ |
| Gedarif | GF/A19 | 134$^{gi}$ | 14.5$^{ae}$ | 982$^{b}$ | 6.2$^{df}$ | 4.4$^{cf}$ | 35.5$^{ae}$ | 303$^{ce}$ | 8.4$^{i}$ |
| Mean (GF) | | 133.3 | 15.2 | 1023 | 6.06 | 3.9 | 34.62 | 277 | 11.203 |
| White Nile | WN/A20 | 138ch | 14.9$^{ad}$ | 987$^{b}$ | 9.5$^{c}$ | 5.1$^{af}$ | 30.9$^{dg}$ | 348$^{ab}$ | 11.11$^{ei}$ |
| White Nile | WN/A21 | 135ei | 12.2$^{df}$ | 992$^{b}$ | 13.9$^{b}$ | 3.6$^{ef}$ | 32.95$^{bf}$ | 352$^{a}$ | 11.5$^{di}$ |
| Mean(WN) | | 136.5 | 13.55 | 989.5 | 11.7 | 4.35 | 31.9 | 350 | 11.305 |
| Blue Nile | BN/A22 | 134$^{gi}$ | 12.0$^{df}$ | 961$^{b}$ | 16.9$^{a}$ | 3.4$^{f}$ | 30.8$^{dg}$ | 291$^{df}$ | 8.67$^{i}$ |
| Blue Nile | BN/A23 | 130$^{i}$ | 13.0$^{cf}$ | 1015$^{a}$ | 13.0$^{b}$ | 3.6$^{ef}$ | 34.4$^{ae}$ | 350$^{a}$ | 9.53$^{fi}$ |
| Mean (BN) | | 132 | 12.5 | 988 | 14.95 | 3.5 | 32.6 | 320.5 | 9.1 |
| Overall mean | | 137.4 | 13.91 | 986.8 | 7.00 | 4.75 | 33.88 | 313.3 | 11.90 |
| SE± | | 1.51 | 1.01 | 31.17 | 0.78 | 0.545 | 1.65 | 8.26 | 0.97 |
| C.V% | | 1.9 | 12.6 | 5.5 | 19.4 | 19.9 | 8.5 | 4.6 | 14.2 |

*Means followed by the same letter/s are not significantly different using DMRT

## 4 CONCLUSİONS

The results of this study show that Sudanese landrace pumpkin seeds are rich in oil, protein, and minerals. The data revealed that there were significant differences in seed characteristics and mineral content among landraces from six states; the results of the oil content determination revealed that pumpkin seeds can be used as a promising source of edible oil and protein for food fortification. More studies are recommended on pumpkin seeds, and more attention and care should be taken for pumpkin cultivation to produce seeds for oil production.

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