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Research Article

Comparative Study of Proximate Composition, Mineral and Functional Properties of Two Sudanese Varieties of Guddaim (*Grewia tenax* Forossk) Fiori Fruits Parts

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ABSTRACT

This study was conducted to compare proximate chemical composition, metals contents and some functional properties in three parts of *Grewia tenax* (forssk) fiori fruits of the two Sudanese varieties of south Darfur and north Kordofan regions. Results on moisture, total ash, crude fiber, crude protein, crude fat and carbohydrate contents where in the range between 5.91-5.33, 1.67-4.41, 7.82-15.27, 3.71-7.85, 0.17-8.81, 58.12-77.88 g/100 g DM, respectively, some significant differences ($p<0.05$) were found between the two varieties in the fruits part as crude fiber and protein contents, since the north Kordofan fruits variety had higher values of 13.61% and 7.85% respectively, the pulps of the two varieties were significantly ($p<0.05$) differ on the content of the fiber and carbohydrate, with the highest carbohydrate content value of 77.88% for the south Darfur variety pulps, the seeds of the south Darfur variety had given lower content values for ash 4.03%, protein 7.04% and fat 8.53%, further there were significant differences ($p<0.05$) in mineral contents as the south Darfur variety fruits had higher content values of Ca 89.60, Mg 50.70, Fe 25.60, Zn 4.80, Cu 0.44 and Mn 0.71 (mg/100 g) while the north Kordofan variety fruit had higher values of Na 19.50 (mg/100 g), but no significant difference ($p>0.05$) was observed between the two varieties on the K contents of the fruit which had the highest contents of 810.40 and 812.70 (mg/100 g) for south Darfur and north Kordofan varieties respectively, on comparison the pulps of the two varieties, the results showed that south Darfur variety had significant ($p<0.05$) higher contents values of Ca 85, Mg 59.30, Na 49.60, Cu 0.38 and Mn 0.41 (mg/100 g), likewise the results showed that south Darfur variety seeds had higher values of Ca 138.7, Mg 30.2, Na 30 and Fe 14.3 (mg/100 g) whilst north Kordofan variety had higher content of Mn value of 0.39 (mg/100 g), the obtained results of WAC and OAC showed that there were no significant difference between the two varieties ($p>0.05$) in the WAC and OAC values, pulps of the two varieties had the highest WAC values 3.21 and 3.13 (ml/g) for south Darfur and north Kordofan varieties respectively, whereas fruits of the two varieties had recorded the highest OAC values 1.36 and 1.40 (ml/g) for south Darfur and north Kordofan varieties respectively, the study indicated that there was significant differences between the two varieties on some proximate or mineral compositions and each variety have an individual features to be used in certain food industries or as complementary diet with theirs good functional properties and according to its proximate compositions and mineral contents.

Key words: Comparison; *G. tenax*; Fruit parts; Variety; Proximate; Mineral; Functional properties

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INTRODUCTION

Grewia tenax which is locally named Guddaim is one of the valuable plant species in Sudan, it is known by utilization as medicinal plant and furthermore it has been used in many countries in popular medicine by various ways. Fruits are small berries, round, orange sweetened and may be consumed fresh or dried, it a rich source of carbohydrates, proteins, vitamins, minerals and constituents which are important contributors to improving the nutritional contents of rural and urban people in Sudan. There is commercial potential in using the fruits in beverages, yogurt, ice cream and baby food. Guddaim fruit has been reported to contain a large amounts of iron and it has been used for treatment of anemia and malaria and it has a good taste makes it palatable for human and in traditional treatment for irritations and skin infections in both human beings and animal in Sudan, it consists of large amounts of carbohydrates and calcium, mineral elements are considered to be essential matters for the healthy functioning of an organism [1]. Diet has long been considered as the major source of human exposure to trace elements and consequently the levels in basic foodstuffs, because a number of minerals essential to human nutrition are accumulated in different parts of plants, hence the knowledge of minerals and heavy metals content in edible and medicinal plants is essential to evaluate quality. The reported chemical composition indicated that Guddaim fruits contained higher amounts of crude protein, crude fiber, carbohydrates and minerals. Because the assessment of dietary and medicinal value of Guddaim fruits parts from two regions in Sudan and to take advantage of them in various nutritional applications so this study was conducted to compare the macro and micro metals contents, proximate chemical composition and functional characteristics of seeds, pulp and fruits of two Guddaim crops from two larger production areas in Sudan [2].

MATERIALS AND METHODS

Analytical reagent grade chemicals were employed in the processing of all samples and reagents, also all plastic and glassware's were properly cleaned by soaking with 2M HNO_3 and rinsed thoroughly with deionized water before use [3].

Samples collection

Two recently released Guddaim fruits crop were collected from the zones that are broadly producing and utilizing the crop for diets and medicinal purposes. Fruits sample one was obtained from Nyala local market in southern Darfur state, sample two was obtained from a big crops market in Elobied city of the forest fruits crop production of north Kordofan state, the two local varieties are the main landraces widely grown and used by the specific community, according to the survey study of this research article, the two landraces differed in their color darkness due to soil properties of the two zones and the large periods of times of steadily selective crop improvement practices by the local communities. The fruits samples were sorted to remove debris and residual twigs, then stored in clean sealed plastic bags at room temperature and brought to laboratory [4].

Samples preparation

The fruits were first thoroughly washed under running tap water to remove dust and dirt, followed by distilled water to get rid of any impurities or any foreign matter on their surface. Every sample was divided into three parts, seeds pulp and whole fruits, seeds were separated manually and carefully from the fruits cores, pulps were scratched and clawed from the inner surface of the cores, the three parts were firstly air dried for 4 days followed by oven drying at 40°C for 24 h, after that they were grounded into a powder using laboratory grinder and then passed through a 60 mesh sieve to produce a fine powder, sealed in clean plastic bags and stored in a refrigerator at 4°C until analysis [5].

Analysis of proximate compositions

Determination of moisture content: Moisture content was determined according to AOAC 2005, 930.04 method, firstly the weight of the cleaned and dried aluminum dish was measured and precisely 2 g of homogenized fruit parts sample was transferred and weighed with its content, then the dish and its contents were heated in an air oven at 98°C with partial vacuum pressure for 5 h (LABQUIP, LEICESTER LE67% FT, England). After drying the sample was cooled in a desiccator for 30 min and reweighed until a constant weight is achieved, the moisture content was then calculated using the weight loss by difference [6].

Determination total ash content: Total ash content was determined based on the AOAC 2005, 930.05 method, whereas 2.0 g of the ground air-dried fruits sample was accurately weight in a previously ignited and tarred porcelain crucible. The sample was spread in an even layer and ignited by gradually heat increasing to 55°C and ashing was continued for 6 hours until it had a white appearance which indicating the absence of carbon, then crucibles were cooled in desiccator to prevent moisture absorption and reweight to produce the ash content [7].

Determination of crude fat content: The amount of crude fat was determined using the Soxhlet extraction technique as described in AOAC, method 930.09 where 2 g of each represented sample was firstly purified from carbohydrate and other water soluble components in small filter paper on a funnel and cleaned up by adding five 20 ml portions of distilled water prior to oven drying for fat ether extraction, then it was transferred into a thimble and covered with fat free cotton and then fitted into the Soxhlet extraction apparatus, a weight of pre-cleaned and dried extraction flask was measured and sufficient amount of petroleum ether was poured into the extractor to start the siphon and then filled about half the extractor flask to execute continuous extraction of the sample crude fat, the distilling was proceed for 3 h, after that the solvent was evaporated by reflex condenser, the flask contents was dried at 100°C for 30 min in the oven, the combined weight of the extraction flask and the extract was measured and crude fat content was determined by using the percentage of weight deference's [8].

Determination of crude protein content: The crude protein content was determined by using Kjeldhal technique following AOAC 2005, method 2001.11, as 1 g of the dried grounded

sample was digested in a Kjeldhal flask with 2 catalysts tablets (0.4 g $CuSO_4$ and 3.5 g K_2SO_4 per tablet) and 12 ml of H_2SO_4 98% then the mixtures were held overnight on the block digester at 420°C and fume manifold was placed tightly on digestion flasks and water aspirator was turned on completely, after 10 min water aspirator was turned down until acid fumes are just contained within exhaust hood and the condensation zone was maintained within the flasks and continued digested for 50 min, after cooling water was added to each flask to make up volume of approximately 80 ml. For the mixture distillation 50 ml of NaOH 40% was dispensed in the tank of the distillation unit, then the digestion tube containing diluted digest was attached to the unit, then the condenser tube was immersed in Erlenmeyer titration flask containing 30 ml H_3BO_3 1% solution with indicator, steam was distilled until 180 ml total volume was collected, the receiving flask was removed and its solution was titrated against standard 0.1 M HCl to violet end point and the blank of water was used in replaced of sample, the N content was determined, so protein content was calculated by multiplying N% by 6.25 because most plant tissues' proteins contain 16% N [9,10].

Determination of crude fiber content: According to AOAC 2005, method 930.10 crude fat was determined as follow, 2 g of ground sample was firstly defatted by adding 50 ml anhydrous diethyl ether at 60°C in reflexing condensation system, filtered and the air dried residue was transferred to 600 ml beaker, 200 ml boiling 1.25% H_2SO_4 was added, placed in digestion apparatus and boiled for 30 min, the beaker mixture was filtered through Buchner funnel attached to vacuum flask, before adding the pouring the mixture the vacuum was turned off and after adding it was applied in order to let mixture suspend to settle, the beaker was rinsed with 60 ml boiling deionized water and poured to wash through Buchner and this step was repeated three times with 50 ml portions water, the residue and mat were snapped with spatula and placed quantitatively in a beaker, 200 ml boiling 1.25% NaOH was added and boiled for 30 min, filtered through Buchner and washed with 25 ml boiling 1.25% H_2SO_4 then with three times 50 ml portions water followed by 25 ml alcohol, the residue was transferred to ashing dish and dried at 130°C in an hot air oven for 2 h, cooled in a desiccator and weighed, then ignited at 600°C for 1 h until all carbonaceous matter was burned finally, cooled in a desiccator and reweighed [11].

Determination of carbohydrates content: Carbohydrates as Nitrogen Free Extract (NFE) were determined according to G.F. Alemayehu et al, using Eq (1) (moisture, protein, fat, fiber and ash proportions were added and subtracted from 100).

Carbohydrates content%=100-% of (Crude protein%+moisture %+ash%+crude fat%+crude fiber%) (1)

Gross energy value: The gross energy value (caloric value) was calculated according to Almuez Alsir et al. using Atwater's conversion factors of 4 kcal/g for protein, 9 kcal/g for fat, 4 kcal/g for carbohydrates and as in Eq (2).

Gross energy (Kcal/100 g)=(9 × crude fat%)+(4 × crude protein %)+(4 × total carbohydrates%) (2)

Mineral analysis

Major and minor metals determination: Minerals were extracted by the dry ashing method, one gram of each dried grounded samples (fruits, pulps and seeds) were precisely weighed in a porcelain crucible and placed in a muffle furnace, the temperature was slowly increased to 500°C over 2 hs, then ashing stage was go on at 500°C for 4 hs, cooled and dissolved in 10 ml of 1N HCl, after that the mixture was warmed to dissolve the residues, filtered through an acid-washed filter paper into a 50 ml volumetric flask. The filter paper was washed several times with deionized water, the solution was made up to volume and mixed well [12].

The concentration of elements of interest was determined using the conditions listed in Table 1, working elements standard solutions were prepared by suitable dilution of the stock standard solutions described under the standard conditions for each element, sample solutions were diluted if necessary to brought the concentration of the element of interest into a suitable range for analysis. To avoid interference between elements, a dilution with La_2O_3/HCL was performed to analyse Ca and Mg and with CsCl to analyze Na and K [13].

Table 1: Instrumental conditions methods for the used atomic absorption spectrometer.

Element	Slit (nm)	Relative noise	Characteristic concentration (mg/L)	Wavelength (nm)	Characteristic concentration chuck (mg/L)	Linear range (mg/L)
Ca	0.7	1	0.092	422.7	4	5
Cu	0.7	1	0.077	324.8	4	5
Fe	0.2	1	0.11	248.3	6	6
K	0.7	1	0.043	766.5	2	2
Mg	0.7	1	0.0078	285.2	0.3	0.5
Mn	0.2	1	0.052	279.5	2.5	2

Na	0.2	1	0.012	589	0.5	1
Zn	0.7	1	0.018	215.9	1	1

Analysis of functional properties

Water and oil absorption capacities determination: The WAC and OAC were determined according to the method of Almmuez Alsir et al. As 1 g of dried ground samples were dispersed in 10 ml of distilled water in a pre-weighted centrifuge tubes, the dispersions were stirred occasionally, held for 5 min and then subjected to centrifugation for 20 min at 500 rpm, supernatant of each sample was poured in graduated cylinder for the determination of water absorption capacity and the same method was applied for the OAC [14].

Statistical analysis

The collected experimental results data were analyzed and tabulated statistically and expressed as mean scores, standard deviations of means, critical differences and one way Analysis of Variance (ANOVA) by using statistical Microsoft excel ToolPak to indicate that statistically significant difference $p \leq 0.05$ values were considered [15].

RESULTS AND DISCUSSION

Proximate composition

Table 2 shows the proximate compositions of the three fruit parts of Guddaim two varieties studied, pulps had the highest values of moisture contents 9.33% and 9.10% for north Kordofan and south Darfur varieties respectively followed by fruits values of 2.28% and 2.47% and lastly seeds values 3.31% and 3.21% respectively, there were a significant differences between the three fruits parts moisture contents in the same variety ($p<0.05$) as illustrated in Figures 1-3 for proximate composition diagrams, but no significant differences between the two varieties corresponding fruits parts although the north Kordofan sample variety had a slightly higher values.

The obtained values of this study is somewhat higher than the values of Guddaim fruits 7.45% which reported by and 7.45% that reported by but lower than the values of 11.72% reported by and 12.92% reported by, so these results were accordance with the reported data [16].

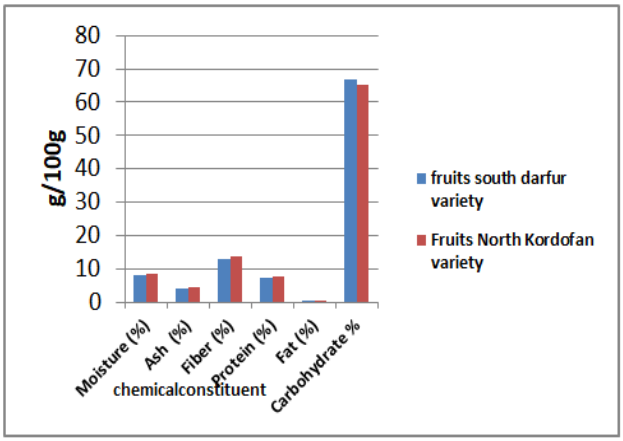

Figure 1: Proximate composition (g/100 g) of the fruits in the two Guddaim varieties.

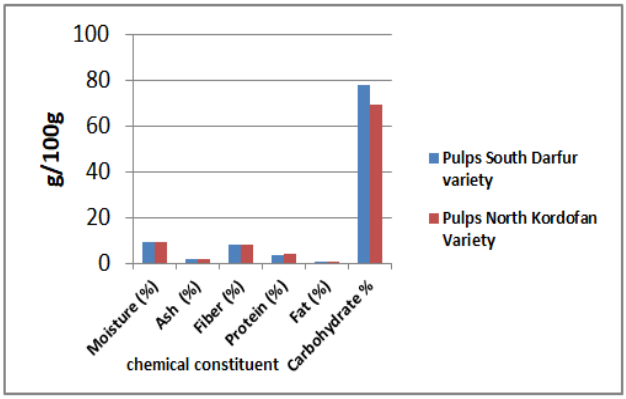

Figure 2: Proximate composition (g/100 g) of the pulps in the two Guddaim varieties.

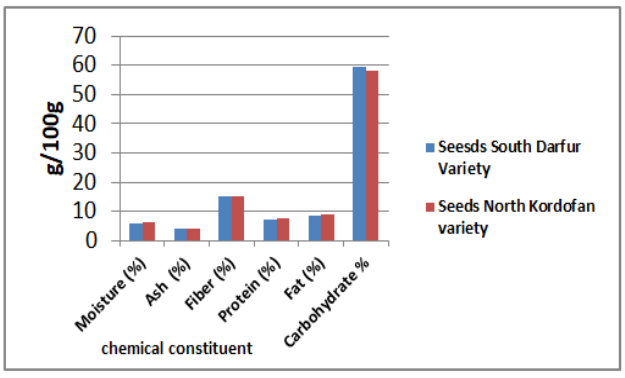

Figure 3: Proximate composition (g/100 g) of the seeds in the two Guddaim varieties functional properties.

Table 2: Proximate composition (g/100 g), DWB* and gross energy (kcal/100 g) for of the three fruit parts of Guddaim samples.

Chemical composition constituent's	South Darfur fruit's variety			North Kordofan fruit's variety		
	Fruits	Pulps	Seeds	Fruits	Pulps	Seeds
Moisture	8.24 ± 0.03^{cd}	9.10 ± 0.02^{ab}	5.91 ± 0.04^{ef}	8.43 ± 0.03^{c}	9.33 ± 0.04^{a}	6.11 ± 0.02^{e}
Total ash	4.41 ± 0.04^{b}	1.67 ± 0.05^{ef}	4.03 ± 0.03^{d}	4.26 ± 0.02^{a}	1.80 ± 0.05^{e}	4.22 ± 0.04^{bc}
Crude fiber	12.82 ± 0.16^{d}	7.82 ± 0.15^{f}	14.95 ± 0.12^{ab}	13.61 ± 0.15^{c}	8.34 ± 0.13^{e}	15.27 ± 0.14^{a}
Crude protein	7.46 ± 0.11^{bc}	3.71 ± 0.08^{ef}	7.04 ± 0.07^{d}	7.85 ± 0.10^{a}	3.84 ± 0.09^{e}	7.47 ± 0.11^{b}
Crude fat	0.42 ± 0.07^{cd}	0.17 ± 0.02^{ef}	8.53 ± 0.06^{b}	0.52 ± 0.03^{c}	0.23 ± 0.04^{e}	8.81 ± 0.05^{a}
Carbohydrates	66.65 ± 0.87^{bc}	77.88 ± 1.20^{a}	59.63 ± 0.68^{e}	65.29 ± 0.92^{cd}	69.53 ± 0.81^{b}	58.12 ± 0.94^{ef}
Gross energy	300.22 ± 1.5^{d}	327.82 ± 1.3^{c}	343.32 ± 1.8^{a}	297.24 ± 1.1^{e}	295.55 ± 2.1^{ef}	341.65 ± 1.7^{ab}

Note: Values are means ± SDs "on dry weight basis" of replicate determinations (n=3), means that do not share the same letter on its row differed significantly ($p \leq 0.05$)

Thus accordingly to whom reported that the shelf life of vegetable food which is negatively correlated to its moisture content because it favors microbial growth and a decline trend in moisture content in storage fruits is observed throughout the storage period and based on small mass of guddaim fruits which is about 0.2125 (g/1 fruit) according to here we can conclude that the two variety had this favorable feature. The ash contents in the two varieties samples were found to be range as fruits value>seeds value>pulps value, south Darfur variety fruits had higher value ($p<0.05$) of ash content 4.41% than the north Kordofan fruit value 4.26%, however these values were comparable to the value of 4.12% reported by and higher than 3.55% and 3.15% values that were found by respectively, but there was no significant variation ($p>0.05$) between the pulps ash contents of the two varieties which were 1.67% and 1.80% for south Darfur and north Kordofan respectively which were higher than the value 1.0%, the results of seeds ash contents showed that there was significant difference ($p<0.05$) between south Darfur variety content value 4.03% and north Kordofan value 4.22%, these results were comparative to that obtained by which was 4.0% and higher than value of 3.0%. According to the literature the ash content is mainly indicates the mineral content of a food sample and minerals are a group of essential macro and micro nutrients, so the south Darfur variety fruits can serve generally as minerals nutritional supplementary more than north Kordofan variety and it can be used fresh or dried directly or as industrial food for dietary supplementary.

The fat contents in the two varieties samples ranged as seeds value>fruits value>pulps value ($p<0.05$) and this range is comparable to that reported [17]. The results showed that the two variety's fruits fat contents had similar values ($p>0.05$) which were 0.42% and 0.52% for south Darfur and north Kordofan varieties respectively, these study results were accordance with the reported values of 0.48%, 0.46% and 0.40% that were obtained by respectively, but less than the values of 1.30% and 1.70% which were found, there was a significant difference between the seeds fat contents values of south Darfur variety 8.53% and north Kordofan variety value 8.81% and these results were lower than the value of 10.70% obtained, the comparative study showed that there were no significant difference ($p>0.05$) between the pulps fat contents of the two varieties which were 0.17% and 0.23% for south Darfur and north Kordofan varieties respectively, as much as these values were comparable with that obtained which was 0.20% and as far as literature the low fat level are beneficial as it insure longer shelf life for the fruits products because all fats and fat containing food contain some saturated fatty acids and hence are susceptible to oxidative rancidity, so the two varieties with its low fat contents could be stored for long shelf life periods, then marketed as fruit beads or powdered, in addition their fruits pulps can contributes less to the health problems related with excess fat intake and might be introduced to industrial food or the diets of vascular or hard diseased [18].

The protein content of the two varieties samples ranged as fruits value>seeds value>pulp value ($p<0.05$) and this comparable to that reported values, protein content of the two varieties fruits had different values ($p<0.05$) as south Darfur value was 7.46% and north Kordofan variety value was 7.85%, this study values were accordance with the reported values of 7.68% and 7.70% that were obtained respectively and higher than the value of 6.70% which was found and lower than the value of 8.15 that was found, also there was significant difference between the seeds protein contents ($p<0.05$) values of south Darfur 7.04% and value of north Kordofan 7.47%, furthermore protein value of south Darfur variety is similar to the value of 7.20% which was obtained and protein value of north Kordofan is similar to

the value of 7.50% which was obtained, the experimental results indicated that there was no significant variation between pulps protein contents in the two studied varieties samples which were 3.71% and 3.84% for south Darfur and north Kordofan varieties respectively and pulps had low protein contents level and these values were accordance with the reported value of 3.58% which was found, thus the variety of north Kordofan which had higher and considerable content of protein that could be used as a potential source of protein and amino acids or as porridge component or with the flour formulation additives for baking or as complementary feed for cattle and poultry specifically in the rural areas [19].

The crude fiber content of the two varieties samples ranged as seeds value>fruits value>pulp value ($p<0.05$) and this study's findings are in line with what was reported, the fruits of the two varieties had given significant difference between them as south Darfur variety value of 12.82% and north Kordofan value of 13.61%, our result is slightly lower than the reported value of 14.22% which was obtained and higher than the value of 9.41% that was reported, but there was no significant difference between the seeds fiber contents values ($p>0.05$) of south Darfur 14.95% and north Kordofan 15.27%, furthermore the two varieties results of seeds fiber content is in close agreement with the value of 14.80% that was reported as long as the two results values of this study are higher than the value of 13.40% that was reported, while there was significant difference between the pulps fiber contents values ($p<0.05$) of south Darfur variety 7.82% and north Kordofan variety 8.34%, thus the south Darfur variety result value was lower than reported pulp fiber content value of 8.13% which was reported, whereas the north Kordofan value was comparable to it, hence and depending on the reported data a high fiber diet may help to reduce the occurrence of certain chronic non-communicable diseases like coronary heart disease, diabetes, colon cancer, high blood pressure, obesity and various gastrointestinal problems, this study results recommend the use of the higher fruit fiber content of north Kordofan further on the diets or as in future industrial food and pharmaceutical formulations for the protection from these health problems, also the seeds residues and fruits with its considerable fiber and protein contents could be used as cattle and sheep feeds component.

The carbohydrate content of the two varieties samples ranged as pulps value>fruits value>seeds value ($p<0.05$) and this study range is comparable with the results reported, there was no significant difference between the fruits carbohydrates contents in the two varieties ($p>0.05$) as south Darfur variety had a value of 66.65% and north Kordofan variety had a value of 65.29% and these values were in close agreement with reported values 66.59%, 66.57% and 66% that were obtained, but there was a significant difference ($p<0.05$) between south Darfur variety pulp carbohydrate content that was 77.85% and much significantly higher than the north Kordofan variety content which was 69.53% and the two values were lower than that of 87.09 which was obtained, but there was no significant difference between the south Darfur variety seeds carbohydrate content of 59.63% and north Kordofan variety content of 58.12%, furthermore the two obtained values of this study were similar to that of 59.56% which was reported and higher than value of 66.50% that was reported, so and based on the reported data of the carbohydrate of the fruit parts of the two varieties in this study make up the largest major nutrient proportion, the results indicated that the pulps and fruits and particularly the pulps of the south Darfur variety with its highest carbohydrate content could be a potential source of energy and should be used in the foods industry like jams, jellies, flavored juices, sweets [20].

There was a significant difference between the fruits gross energy contents in the two varieties ($p<0.05$) as south Darfur variety had a value of 300.22 Kca/100 g and north Kordofan variety had a value of 297.14 Kcal/100 g, the south Darfur variety fruits energy had a similar value of 300.01 (Kcal/100 g) that was obtained but the north Kordofan variety fruit had a lower value than this reported value. Pulps gross energy differed significantly between the two varieties as south Darfur variety have a value of 327.87 which is largely higher than the north Kordofan variety value of 295.55 Kcal/100 g, but there was no significant difference between the seeds gross energy between south Darfur variety which was 343.32 and north Kordofan variety that was 341.65 Kcal/100 g, on comparing the protein, fat and carbohydrate contents in the fruits, pulps and seeds it was found that south Darfur variety fruits and pulps had higher amounts of carbohydrate than the north Kordofan variety and that was let to have higher gross energy, but the highest a amounts in the fat contents of the seeds was lead to have the highest values of gross energy, so and depending in the reported data of and because the results showed that pulps and fruits parts specifically pulps of south Darfur variety were contained higher levels of carbohydrate and energy so it can be introduced in the foods industry of a syrup and natural or soften juices. Whereas the seeds though it had the highest gross energy in the two varieties but it were contained high level of fat, fibers in addition to gross energy so it can be used as only complementary diet or in feed production.

Mineral composition

Table 3 shows the mineral compositions of the three fruit parts of Guddaim two varieties studied, the results revealed that there were a significant differences ($p<0.05$) in the contents of Ca, Mg, Na, Fe, Zn, Cu and Mn which were 89.60 and 80.00, 50.70 and 29.80, 10.20 and 19.50, 25.60 and 13.50, 4.80 and 2.90, 0.44 and 0.25, lastly 0.71 and 0.53 (mg/100 g) for south Darfur variety fruit sample and north Kordofan variety fruit sample respectively those illustrated in Figures 4 and 5, the south Darfur variety fruit sample had given higher values of Ca, Mg, Fe, Zn, Cu and Mn than the north Kordofan variety sample, as long as the Ca values of this study were higher than the reported value of 40.0 mg/100 g which was obtained, the Mg values were lower than the reported values of 135.625 mg/100 g which was obtained, the Na value of north Kordofan is comparable to the value of 22.13 mg/100 g which was reported, but south Darfur variety had a lower value than it, the Fe value of south Darfur is comparable to the value of 25 mg/100 g which was reported and higher than the values of 20.80 mg/100 g which were reported and the two varieties of this study Fe contents were higher than the value of 8.0 mg/100 g that was reported, the Zn values of this study were higher than the values of 2.10 and 1.90 (mg/100

g) which were reported, but our obtained values for Cu were lower than 0.78 and 1.50 mg/100 g those were reported and our results values for Mn were lower than the value of 1.03 that was reported. The Na result value of north Kordofan is similar to the value of 22.13 mg/100 g that reported, but the south Darfur variety value is lower than it.

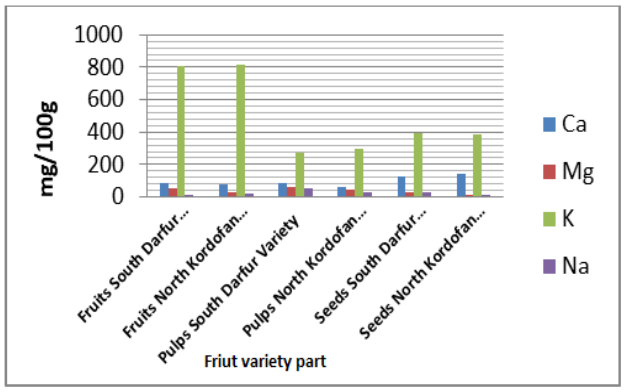

Figure 4: Major metals contents (mg/100 g) in the two Guddaim parts varieties.

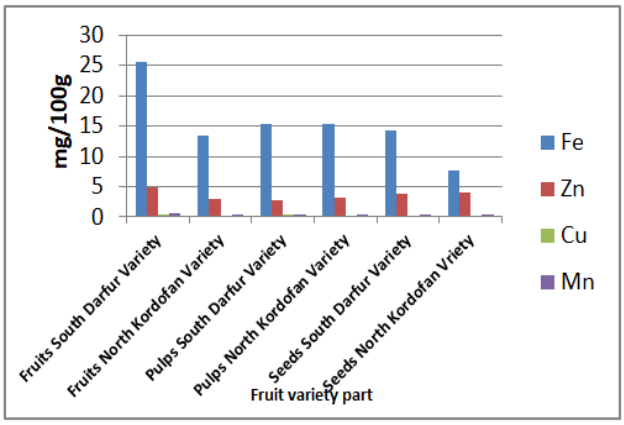

Figure 5: Minor metals contents (mg/100 g) in the two Guddaim parts varieties.

Table 3: Major and minor metals content (mg/100 g), DWB* of the three fruit parts of Guddaim samples.

Guddaim varieties	Fruits parts	Major metals content				Minor metals content			
		Ca	Mg	K	Na	Fe	Zn	Cu	Mn
South Darfur fruit's variety	Fruits	89.6 ± 4.08^{c}	50.7 ± 3.15^{b}	810.4 ± 1.48^{ab}	10.2 ± 0.55^{f}	25.6 ± 0.74^{a}	4.8 ± 0.031^{a}	0.44 ± 0.007^{a}	0.71±0.005^{a}
	Pulps	85 ± 5.17^{cd}	59.3 ± 2.57^{a}	274.0 ± 2.65^{f}	49.6 ± 1.10^{a}	15.4 ± 0.63^{b}	2.8 ± 0.047^{ef}	0.38± 0.009^{b}	0.41 ± 0.008^{c}
	Seeds	130 ± 4.78^{ab}	30.2 ± 2.88^{d}	390.0 ±1.95^{c}	30.0 ± 1.25^{bc}	14.3 ± 0.67^{d}	3.9 ± 0.050^{bc}	0.19 ± 0.006^{df}	0.32 ± 0.006^{ef}
North Kordofan fruit's variety	fruits	80.0 ± 3.89^{de}	29.8 ± 2.36^{de}	812.7 ± 1.76^{a}	19.5 ± 0.85^{d}	13.5 ± 0.48^{de}	2.9 ± 0.038^{e}	0.25 ± 0.01^{c}	0.53 ± 0.008^{b}
	Pulps	60.3 ± 2.30^{f}	45.2 ± 1.82^{c}	295.0 ± 2.83^{e}	30.8 ± 1.06^{b}	15.3 ± 0.51^{bc}	3.3 ± 0.057^{d}	0.21 ± 0.008^{d}	0.36 ± 0.005^{de}
	Seeds	138.7 ± 3.38^{a}	15.0 ± 1.61^{f}	386.0 ± 1.62^{cd}	15.3 ± 0.94^{e}	7.6 ± 0.76^{f}	4.0 ± 0.026^{b}	0.20 ± 0.009^{de}	0.39 ± 0.007^{cd}

Note: Values are means ± SDs "on dry weight basis" of replicate determinations (n=3), means that do not share the same letter down the column differ significantly ($p \leq 0.05$)

On the other hand no significant difference between the K fruits content in the two studied varieties results values which were 810.40 and 812.70 (mg/100 g) for south Darfur and north Kordofan varieties samples respectively, these results values were slightly lower than 817 (mg/100 g) which was reported and much lower than the values of 856.25 and 1260 (mg/100 g) that were reported hence and according to literature data of the two varieties fruits can be considered as a rich source of K, also these study results indicated that Guddaim fruits of south Darfur variety is more rich than the north Kordofan variety fruits with Ca, Mg, Fe, Zn, Cu and Mn and it remarkably contain high amount of iron and this finding support the traditional use of the fruits in the treatment of anemia.

There were a significant differences ($p<0.05$) in the contents of Ca, Mg, K, Na, Zn, Cu and Mn which were 85 and 60.30, 59.30 and 45.20, 274 and 295, 49.60 and 30.80, 2.80 and 3.3, 0.38 and 3.30 lastly 0.41 and 0.36 (mg/100 g) for south Darfur variety pulp sample and north Kordofan variety pulp sample respectively, the south Darfur variety pulp sample had given higher values of Ca, Mg, Na, Cu and Mn than the north Kordofan variety pulp sample, furthermore the Na result values of this study is higher than the value of 11.57 mg/100 g which was reported, for Cu the south Darfur variety pulp result value is higher than the value of 0.27 mg/100 g, in contrast the north Kordofan variety pulp sample value is slightly lower than it, for Mn the two result values of this study were higher than the value of 0.28 mg/100 g which was reported, but there are no reported data on the contents of Ca, Mg and Zn to be compared to this study pulps results values up to the date of this study, these study results indicated that guddaim pulps of south Darfur variety is more rich than the north Kordofan variety pulps with Ca, Mg, Na, Cu and Mn and hence it could be used as complementary nutrients for these metals diet lack. But the north Kordofan variety pulps had higher contents of K and Zn than south Darfur variety pulps so this feature could make it to be used as a good source of K and Zn in diet or pharmaceuticals formulations specifically for Zn because it had higher value than its fruit part however it still lower than the value of the south Darfur variety fruit Zn content of 4.80 mg/100 g which could be a remarkably source of Zn, there was no significant difference between the two varieties pulps Fe contents 15.4 and 15.3 values for south Darfur and north Kordofan varieties respectively, the Fe content in the south Darfur pulp is less than its fruits content which was 25.60 (mg/100 g), although the Fe content in the north Kordofan variety is higher than its fruit content that was 13.50 (mg/100 g), but less than the fruit content of south Darfur variety which is a most rich variety part with Fe and should be used as a favorable source of Fe nutrition supplementary.

There were a significant differences ($p<0.05$) in the contents of Ca, Mg, Na, Fe and Mn which were 130 and 138, 30.20 and 15, 30.0 and 15.30, 14.3 and 7.60 and lastly 0.32 and 0.39 (mg/100 g) for south Darfur variety seeds sample and north Kordofan variety seeds sample respectively, the south Darfur variety seeds sample had given higher values of Mg, Na and Fe than the north Kordofan variety seeds sample, as long as the Na and Fe result values of this study is higher than the value of 5.82 and 3.65 (mg/100 g) respectively which was reported, the Mg contents in the seeds were lower than the pulps and fruits contents and Na contents in the seeds were lower than in the pulps and north Kordofan fruit content, also the two studied varieties Fe contents were lower than pulps and fruits contents, hence these results indicated that the two varieties are poor source of those metals in comparison with pulps although south Darfur variety is relatively better. But for Ca and Mn the results showed that north Kordofan variety had higher contents as illustrated above, Ca content in the seeds was higher than fruits and pulps so north Kordofan variety seeds should be a favorable source of Ca, but for K its seeds contents was lower than the fruits. But Mn seeds contents was lower than in fruits and pulps, in addition there was no significant difference between K, Zn and Cu contents in the seeds of the two varieties, although the K contents were high in the two seeds varieties but it still lower than the fruits contents, also the seeds Zn content was lower than fruits in south Darfur variety sample, although north Kordofan variety had higher contents of Zn than its fruits and pulps the south Darfur variety fruits with their highest Zn content could be the favorable source of Zn supplementary. The Cu contents in the south Darfur variety is lower than its fruits and pulps as in north Kordofan variety is lower than fruits and similar to the pulps contents, so the two variety seeds should not be considered as a rich part with Cu, however the fruits of south Darfur variety is should be seen as the best favorable source of Cu.

Functional properties

WAC and OAC: The obtained results of WAC and OAC that were presented in Table 4 which indicate that there were no significant difference between the two varieties ($p>0.05$) in the WAC and OAC values, pulps of the two varieties had the highest WAC values 3.21 ml/g and 3.13 ml/g for south Darfur and north Kordofan varieties respectively followed by fruits 2.47 ml/g and 2.28 ml/g for the two varieties respectively, lastly by seeds 1.18 and 1.15 ml/g respectively, so there was a significant difference between the fruits, pulps and seeds of the same each variety, these results values were comparable to the reported values of 3.30 ml/g and 1.20 ml/g for pulps and seeds respectively that were reported, hence, based on the reported literature, this study deduce that the pulps of the two varieties are so useful in the food manufacturing. The results showed that the fruits of the two studied varieties had the highest OAC values 1.36 ml/g and 1.40 ml/g for south Darfur and north Kordofan varieties respectively, followed by seeds 1.12 ml/g and 1.17 ml/g for the two varieties respectively and lastly by pulps 0.34 ml/g and 0.41 ml/g for the two varieties respectively, so there was a significant difference between the fruits, pulps and

seeds of the same each variety, these results findings are in line with the reported values of 1.16 ml/g and 0.36 ml/g for seeds and pulps respectively that were found, under the reported literature data of these study results suggests that the fruits of the two varieties would be used properly in the food formulation industry because they had high OAC values which improve their emulsifying capacity and retaining the flavor of the food product.

Table 4: WAC and OAC (ml/g), DWB for of the three fruit parts of Guddaim samples varieties.

Functional property	South Darfur fruit's variety			North Kordofan fruit's variety		
	Fruits	Pulps	Seeds	Fruits	Pulps	Seeds
WAC	2.47 ± 0.04^{c}	3.21 ± 0.05^{a}	1.18 ± 0.06^{e}	2.28 ± 0.07^{cd}	3.13 ± 0.05^{ab}	1.15 ± 0.08^{ef}
OAC	1.36 ± 0.06^{ab}	0.34 ± 0.08^{ef}	1.12 ± 0.07^{cd}	1.40 ± 0.06^{a}	0.41 ± 0.04^{e}	1.17 ± 0.06b^{c}

Note: Values are means ± SDs "on dry weight basis" of replicate determinations (n=3), means that do not share the same letter on its row differed significantly ($p \leq 0.05$)

CONCLUSION

The proximate chemical, mineral and functional properties that comparatively studied had showed some differences between the south Darfur and north Kordofan Guddaim fruits varieties. Fruits parts from north Kordofan were found richer on fiber and protein contents and could be used further to enhance diet protein and fiber contents and feeds production, its pulps should be used as a good source of K. While the carbohydrate of the fruit parts of the two varieties in this study make up the largest major nutrient proportion, the results was shown that the pulps and fruits particularly the pulps of the south Darfur variety with its highest carbohydrate and gross energy content could be a potential source of energy and should be used in the foods industry. As well this variety is richer with Ca, Mg, Zn, Cu and Mn and contain considerably amount of Fe. Besides the higher OAC value for the fruits and WOA value for the pulps of the two varieties make them to be future in used in the food industries like jams, jellies and sweets or may be applied to the pharmaceutical formulations based on the characteristic composition of each variety.

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