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Chemical Compositions, Nutritional Properties and Volatile Compounds of Guddaim (*Grewia Tenax*. Forssk) Fiori Fruits

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Abstract The chemical analysis and nutritional properties of guddaim fruits were investigated. Proximate compositions, total energy, minerals, vitamins, sugar profile, amino acids and volatile compounds were determined. Content of carbohydrate was 66.59%, while moisture, crude fiber, ash, crude protein and crude fat were 11.72%, 9.41%, 4.12%, 7.68% and 0.48%, respectively. The calorific values of fat, protein, and carbohydrates were 0.043, 0.307, and 2.663 kcal/g; respectively. The content of potassium was the highest minerals (856.25 mg/100 g), while chromium was the lowest (0.063 mg/100 g). The main amino acids were threonine, valine, phenylalanine and leucine 1.99, 2.91, 2.77, 3.62 g/100 g, respectively, which were found to be higher than the level of Daily Recommended Allowance (DRA) of essential amino acids required for child and adult human suggested by FAO/WHO/UNU pattern. Thiaine, riboflavin, pyridoxine, ascorbic acid and folic acid were, 0.185, 0.205, 3.15, 0.415 and 0.765 mg/100 g, respectively. The highest content of sugar was glucose 115.734 mg/g. Volatile compounds were identified to be relatively smaller, that is ; acetic acid 61.04%; hydrazine –methyl 4.78%; 2,3-butanediol 4.06% and hexanoic acid 3.48%. The results following this study showed this fruit contained a lot of important nutrients and nutritional value, beneficial to human health.

Keywords: *Guddaim fruits, vitamins, total energy, volatile compounds, amino acids*

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1. Introduction

Guddaim is the local name of (*Grewia tenax*) is one of the valuable plant species in Sudan. It is largely spread in arid area such as sand and near mountains, especially in the Savanna plantation area of the Northern and Middle of Sudan [15]. *Grewia tenax* is a tree spread in Africa and Southeast Asiatic continents. It belongs to the *Tileacea* family. It is known by utilization as a medicinal plant. In fact, *Grewia tenax* is a plant that has been used in popular medicine in various ways in different countries. Roots are used to treat jaundice, pulmonary infections and asthma. Leaves are used against trachoma. Decoction and fruit juice are used for their tonic and anti-anemic properties. Fruits are small berries, round, orange sweetened and it may be consumed either fresh or dried [6]. There is commercial potential in using the fruits in beverages, ice cream, yogurt, and baby food. In Sudan, beverages are prepared by soaking the fruits in water for 3–4 h followed by hand pressing, sifting, and sweetening. The juice is regarded as a good thirst-quencher, especially during the hot season. Because of its high iron, the fruits are used by tribal members as an iron supplement for anemic children. In Kordofan, the fruit pulp is often mixed with juices of other local underutilized fruit trees such as baobab (*Adansoniadigitata* L.) and tamarind (*Tamarindusindica L.*). Also, a thin porridge called Nesha is prepared by boiling millet flour and fruit pulp of Guddaim and adding custard to the mixture. The sweetened porridge is given to pregnant and lactating women to improve their health and milk production [18]. A light porridge is prepared by the addition of flour or custard to Guddaim drink and served during the fasting month of Ramadan and is also fed to lactating mother to improve their health and lactating abilities. Moreover, the fruits are made into a fermented drink in Sudan and Southern Africa [14]. Proved that guddaim plant is used in traditional medication and treatment in Sudan; it is used to treat flesh irritation and skin inflammation for both human beings and animals. Guddaim fruits may be eaten ripe or kept for later usage because it consists of great proportion of carbohydrates in liquidized form, and a great amount of iron and calcium. Some efforts were made to promote Guddaim fruits and its industrial utilization [13]. In Sudan, Kordofan city, a

drink was prepared by soaking the fruits overnight, hand-pressing, sieving, and sweetening. Nesha was also prepared from this drink, by the addition of custard and flour; the nesha is given to mothers to improve their health and lactation [3]. Guddaim fruits, both fresh and dry, are favored and extensively consumed by the Sudanese population. Moreover, the fruits are made into a fermented drink in Sudan and Southern Africa [17].

Despite that the Guddaim fruits are a good source of nutritional food contains ingredients, but the significant research which is not at the required is also considered the fruits and juice guddaim has a good taste, delicious and beneficial to human health. The objectives of this study are to assess and study the potential macro and micro-nutrients and chemical contents of guddaim fruits, and its contents of some vitamins, amino acids, which can be considered an important for human health and the knowledge the nutritional value of guddaim fruits and to take advantage of them in various nutritional applications.

2. Materials and Methods

2.1. Raw Materials

Guddaim fruits were bought from a big market (Wad Medani City, Gezira State, Sudan), in July 2013. The fruits were put fruits in plastic bags and brought to the Jiangnan University, Wuxi city, People's Republic of China. The fruits were sorted to remove low quality ones and stored in plastic bags at room temperature until use.

2.2. Preparation of Guddaim Fruits Powder

Guddaim fruits was put in a large bowl and washed with tap water first followed with distilled water to get rid of any impurities or dust on their surface. The fruits were sorted to isolate broken or scratched ones followed by 4 days of sun drying. The drying was continued at room temperature in open room for a further two days to achieve complete drying. Dried fruits were ground to a powder using a blender (25000/min), type WK – 1000A (Qing Zhou Jing cheng Machinery Co., LTD- Shandong - china) to get the powder fruits were then sifting the powder through a sieve gauge 60 and we got a good powder of fruits Guddaim. Then was put powder in plastic bags and stored the samples in a refrigerator at temperature of 4°C until use.

2.3. Determination of Proximate Composition

The moisture, Fat, fiber and ash contents were determined using standard AOAC methods 925.09, 932.06, 985.29 and 923.03, respectively according to [5]. Estimated the ash content by weighing of 2 g of the sample to Porcelain crucible and burn at 600°C for 6 hours in an ashing muffle furnace until a white ash was obtained. For crude fiber weighing 2 g sample free moisture and used ether extract sample were digested with dilute H_2SO_4 at first and with KOH solution. Fat was determined by weighing 3 g of the sample extracted with petroleum ether in a Soxhlet apparatus for 6hours. Crude protein was determined using a FOSS nitrogen analyzer (DK-3400 Hilleroed, Denmark). Crude protein was calculated by multiplying the evaluated total nitrogen by 6.25 as constant factor. Total carbohydrate content was calculated by sum of moisture, fat, protein and ash contents were subtracted from 100 to obtain the total carbohydrate according to [12].

2.4. Total Energy (Caloric Value)

Energy was calculated and determined according to the method described by [22,24], using the Atwater factor. 1 g of carbohydrates provides (4 K Calories), 1 g of protein provides (4 K calories) and 1 g of fat provides (9 K calories).

2.5. Minerals Analysis

Minerals were determined in the sample by the dry ashing method described by [9]. About 1.0 g of sample was acid-digested with acid mixture (HNO_3: $HClO_4$, 5:1, v/v) in a digestion chamber until a white residue was obtained. The digested samples were dissolved in double-distilled water and filtered (Whatman No. 42) as reported by [4]. with a slight modification. The filtrate was made to 25 ml with double-distilled water and was used for determination of total minerals. Minerals (Zn, Fe, K, Cu, Mn, Cr, Mg and Na) were determined using (AAS) atomic absorption spectroscopy (Spectra AA220, Varian, US PYT Ltd, USA).

2.6. Amino Acid Composition

Amino acid analysis was performed according to the modified method of AOAC 982.30 a, AOAC [5]. For the total amino acid determination in hydrolysis tube, 1.0 g Dried sample was hydrolyzed with 8 ml of 6 M HCl at 110°C for 24 h under vacuum. After cooling the hydrolyzate was washed with distilled water, filtered by (Whatman No 40) and centrifuged at 10000 rpm for 10 min, then was but into vacuum drying at 60°C by using rotary evaporator, the dried residue was dissolved in 0.02 M HCl. The supernatant was collected. Total amino acid were separated and quantified by injecting 50 µL in to Hitachi 835-50 amino acid analyzer equipped with 2.6 mm×150 mm ion exchange column coated with resin 2619, and the column temperature was 53°C. The amino acid composition was expressed as mg of amino acid per kg powder of guddaim fruits.

2.7. Vitamins Content

Vitamin contents were determined according to [21]. Sample (0.5 g) was extracted with 10 ml hydro alcoholic solution in a sonication device for 20 min at room temperature. The solution was filtered and centrifuged at 5000 rpm for 30 min, and then the supernatant was filtered through 0.45 µm filter before HPLC analysis. Ecosil C18 (4.6 mm×250 mm) column was used for the separation of water-soluble vitamins at room temperature. Solvent A consisted of methanol, and solvent B was sodium 1-heptanesulfonat, the mobile phase flow rate was maintained at 0.8 ml/min. the elution gradient was carried out as follows ; 0 min, 90% B; 15 min, 30 % B; 20 min, 30% B; 22 min 90% B; 26 min, 90% B.

2.8. Sugar profile

A 0.4216 g of sample was extracted with hydro alcoholic solution 10 mL (30/70, v/v) in the sonication

device for 30 min at 60°C, and it was centrifuged for 20 min at 5000 rpm. Then supernatant was filtrated through 0.45 µm filter before injecting into HPLC. Analytical column used was sugarback-1 (6.5 × 300 mm) and the mobile phase was water at 0.4 mL/min flow rate. and the column temperature was keep it at 85°C and injection volume was 10 µL.

2.9. Volatile Compounds

The volatile compound were sampled with an SPAM–fiber and separated with a gas chromatography-mass spectrometry (GC/MSS). Volatile compounds were separated on a CP-Sil-8CB (Varian, Walnut Creek, CA, USA), fused silica capillary column (30 m length, 0.25 mm, id, and 0.25 µm film thicknesses) in a Varian model 3800 gas chromatograph. The split less mode injector was maintained at 220°C and the flame ionization detector (FID) at 250°C, volatile compounds were separated with a capillary column DB WAX (30 m×0.25 µm, J and W Scientific, Folsom, CA, USA).The separation was performed as the follows :the oven temperature was set at 40°C, held for 3 min, ramped up to 100°C at the rate of 6°C /min and then to 230°C at 10°C / min. The constant column flow was 0.9 ml/min. Mass spectra was obtained in the Electron Impact (EI+) mode with an energy voltage of 70eV; the mass range was 33 to 450 m/z. volatile compound identification were carried out by matching their mass spectra of standards compound's found in the wily 130 K and national institute of standards and technology (NIST) 98 library of MS spectra and based on their retention indices.

3. Results and Discussions

3.1. Proximate Analysis

The proximate composition of guddaim fruits is shown in Table 1. The moisture content of guddaim fruits was 11.72% on dry weight basis, this result was lower than that reported by [14], who reported 13% for *grewia tenax* fruits, and higher than result obtained by [3], who reported 7.45% for whole guddaim fruits. Crude fiber content was 9.41%, a result lower when compared with the results by [7], who reported 13.8% for *grewia tenax* fruit, and higher than that reported by [1], at 8.1%. The ash content in the present study was 4.12%, this result was higher than that reported by [3], 3.15% for whole guddaim fruits, and close to that obtained by [1]. who reported percentage 4.50% for *grewia tenax*. Crude protein content was 7.68%, this value was higher than that reported by [1], 6.63%, and similar to [7,14], whose reported of 7.7% percentage. The guddaim fruit contained a low amount of fats (0.48%), this value was similar to that obtained by [1,3], who reported values of 0.4% and 0.46, respectively. Carbohydrate content was 66.59%, this percentage was similar to that obtained by [3], who reported 66.57% and convergent with [14], who reported 66%. Generally, this data shows the guddaim fruit is a good source for nutritional properties. The differences between the results of proximate composition analysis in this study and those in other reports are assumed to be caused by growth stages, harvesting times, method and conditions of experiments.

Table 1. Proximate compositions and total energy of guddaim fruits powder, (Expressed as mg/100g on DW basis)

Contents	Composition (%)	Kcal/g
Moisture	11.72±0.08	_
Crude fiber	9.41±0.15	_
Ash	4.12±0.03	_
Crude protein	7.68±0.05	0.307
Crude fats	0.48±0.02	0.043
Carbohydrate	66.59±0.04	2.663

Values are means ±standard deviation of triplicates.

3.2. Total energy (caloric value)

The total energy content is given in Table 1 Where the calorific value has been calculated for each of the protein, fat and carbohydrates as 0.307, 0.043 and 2.663 kcal/g, respectively, with carbohydrate giving higher energy. From this data, guddaim fruits can be considered good source of calories. A calorie is a measure of energy, foods have calories. That is, foods supply the body with energy, which is released when foods are broken down during digestion. Energy enables cells to do all of their functions, including building protein's and others substances needed by the body. The energy can be used immediately or stored for later use [11].

3.3. Minerals composition

The mineral contents of guddaim fruits are shown in Table 2. The sample was contained macro and micro-minerals. The zinc being higher than other minerals (856.25 and 2.107 mg/100 g), respectively, while manganese and copper were lowest (1.034 and 0.708 mg/100g), respectively, when compared to the result obtained by [14], for grewia tenax dry weight. Iron and sodium were higher (8.22 and 22.135 mg/100 g), respectively and magnesium (135.625 mg/100 g) was lower than that result reported by [2]. From this results, guddaim fruits was found to contain many important minerals which can be used in cereal and cereal product especially flour for bakery products to improve their nutritional properties. Mineral elements are considered to be essential substances for the well-functioning of an organism. They have fundamental roles in regulating the different biological processes of an organism such as: (i) activating the intracellular and extracellular enzyme, (ii) regulating the liquid compartment pH which permits the achievement of metabolic reaction and (iii) controlling the osmotic equilibrate between cells and their environmental [10,23].

Table 2. Mineral contents of guddaim fruits powder (Expressed as mg/100g on (DW basis)

Minerals	Contents
Copper (Cu)	0.708±0.02
Chromium (Cr)	0.063±0.01
Zink (Zn)	2.107±0.05
Manganese (Mn)	1.034±0.17
Potassium (K)	856.25±1.76
Sodium (Na)	22.135±0.16
Magnesium (Mg)	135.625±0.53
Iron (Fe)	8.222±1.05

Values are means ±standard deviation of triplicates.

3.4. Amino acids composition

Indeed, the amino acid is classified nutritionally into two classes i.e. essential and nonessential that is distinguished between those that the body can

manufacture and those that have come from the diet [20]. The results of the amino acids content of guddaim fruits are shown in Table 3. Eleven amino acids were considered as essential. The ten amino acids listed below were essential for humans: arginine, valine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, and tryptophan. Of the ten listed above, two amino acids, namely arginine and histidine, can be partly synthesized by adult humans and hence are considered as semi-essential amino acids [20]. The amount of essential amino acids was compared to the [16], In terms of the recommended daily amounts currently in use for essential amino acids in adult human's requirement (standard protein) mg/kg body Weight per day. A Guddaim fruit has essential amino acids, threonine, valine, phenylalanine and leucine (1.99, 2.91, 2.77, 3.62 g/100 g), respectively, these values were higher than the levels suggested by FAO/WHO/UNU pattern for adult human's requirement and lower than that child requirement FAO [16]. Amino acids such as Histidine, methionine, isoleucine and lysine were lower than FAO/WHO/UNU adult human requirement limits reference pattern FAO. Classifications of amino acids in different groups according to chemical properties are shown in Table 3. guddaim fruits contained high amount of charged amino acids more than a large hydrophobic and polar amino acids.

Table 3. Amino acids composition of guddaim fruits powder (g/100g) and Daily Recommended Allowance (DRA) FAO/WHO/UNU for human child and adult

Essential Amino Acids (EAA)	IAA g/100 g	FAO/WHO/UNU[a]	
		child	Adult
Histidine	1.21	1.90	1.60
Thereonine	1.99	3.40	0.90
Arginine	4.03	-	-
Valine	2.91	3.50	1.30
Methionine	1.18	2.70[b]	1.70[b]
Phenylalanine	2.77	6.30[c]	1.90[c]
Isoleucine	2.10	2.80	1.30
Leucine	3.62	6.60	1.90
Lysine	2.55	5.80	1.60
Total	44.72	33	12.2
Non-essential amino acid			
Tyrosine	1.01		
Cysteine	8.50		
Aspartic acid	9.07		
Glutamic acid	9.60		
Serine	2.40		
Glycine	3.36		
Arginine	4.03		
Proline	3.58		
Alanine	2.80		
Total	44.35		
Ratio of amino acid with different characteristics [d]			
large hydrophobic	16.6		
polar	13.9		
charged	26.46		

Lists of FAO/WHO/UNU: Daily requirements for human child and adult (FAO, 2007).bRequirements for methionine + cysteine. cRequirements for phenylalanine + tyrosine.IAA: Indispensable amino acid of guddaim powder. d large hydrophobic, polar and charged amino acids: (Valine, leucine, isoleucine, methionine, proline and phenylalanine), (Serine, thereonine, tyrosine and cysteine), (Lysine, arginine, histidine, aspartic acid and glutamic acid), respectively.

3.5. Vitamins and Sugars

As is well known, vitamins were divided into two main groups: the fat-soluble vitamins and water-soluble vitamins. Among water-soluble vitamins, the B group including B1, B2, B6 and B9 are the most important. They play important different specific and vital functions in metabolism, and their lack or excess produce specific diseases [21]. Vitamin C is an essential component of the diet for humans, and an adequate intake is important not only for the prevention of scurvy but also to limit the risk of developing chronic diseases such as heart disease and cancer [8]. Vitamins content of guddaim fruit was given in Figure 1. L-Ascorbic acid (C), Thiamine (B_1), Riboflavin (B_2), Pyridoxine (B_6) and folic acid (B_9), were 0.415, 0.185, 0.205, 3.15, 0.765 mg/100g,respectively. Vitamin (B_6) was higher than the other vitamins. Vitamin (C) was higher than (B_1) and (B_2).

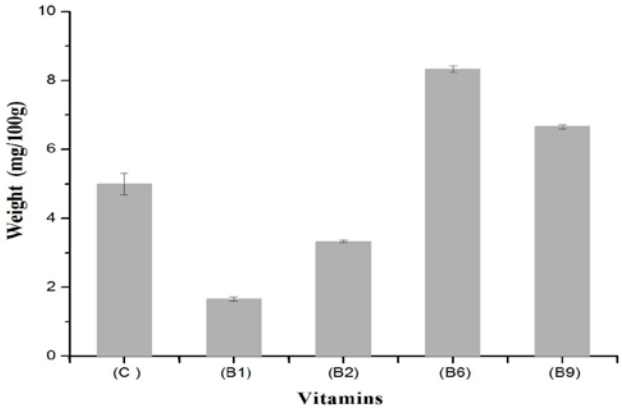

Figure 1. Vitamins content (mg/100 g) of guddaim (*Grewia tenax*) fruits powder. The pyridoxine (B_6) is higher than others vitamins

As shown also in Figure 2, the results showed high content of glucose 115.734 mg/g, fructose 91.902 mg/g and low content of sucrose 1.553 mg/g indeed, the guddaim fruit was earlier reported to contain a high level of total sugars (66.59%) hence a good source of carbohydrate (Table 1).

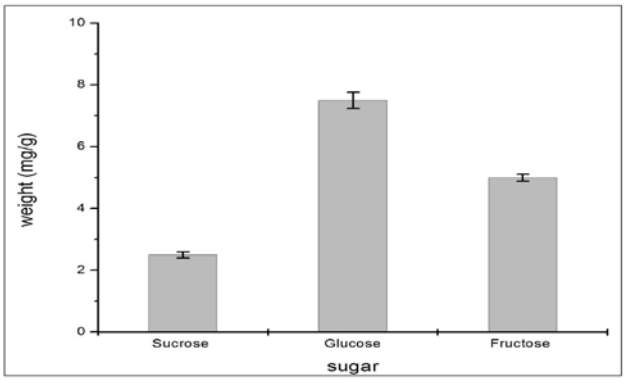

Figure 2. Sugars profile of guddaim (Grewia tenax) fruits powder (mg/g). The glucose extract presented higher among than other sugars

3.6. Volatile Compounds

Sixty- three volatile compounds of guddaim fruit are shown in Table 4. The peak area percentage was used to indicate the relative concentration of each compound. Twenty- three compounds are unknown and forty were found. The main compounds identified based on the relative amount were; acetic acid 61.04%; hydrazine – methyl 4.78%; 2,3-Butanediol 4.06%; hexanoic acid 3.48%; 1,3-Butanediol 2.41% Fig 3. Plants produce many volatile metabolites. A small subset of these compounds is

sensed by animals and humans, and the volatile profiles are defining elements of the distinct flavors of individual foods. Flavor volatiles are derived from an array of nutrients, including amino acids, fatty acids, and carotenoids [19]. However guddaim fruits can be considered as a good source of volatile compounds, which can be used as an addition to the many food or beverages where it gives them better taste and good flavor.

Table 4. Headspace volatile components of guddaim fruits powder, retention time and peak area percent (%) and retention time (minuets)

NO	Components	Rt* (min)	Percent relative peak area
1	Hydrazine, Methyl-	3.467	4.783
2	2,4 Pentadienal	6.146	1.076
3	Propene 3,3,3-D3	7.337	0.508
4	1-Butanol, 3-methyl-	9.252	0.149
5	1-Pentanol	10.28	0.422
6	2-Penten-1-ol, (Z)-	11.879	0.327
7	Pentafluoropropionic acid, hexyl ester	12.64	0.826
8	3,7,7-Trimethyl-Cyclohepta-1,3,5-Triene	12.814	0.186
9	Nonanal	13.457	0.601
10	Hydroxylamine, O-decyl-	13.545	0.735
11	Benzene, 1-ethyl-2,3-dimethyl-	13.986	0.169
12	6-Hydroxy-Hexan-2-One	14.135	0.362
13	Benzene, 1-ethyl-3,5-dimethyl-	14.187	0.39
14	Pentadecane	14.281	0.522
15	Acetic acid	14.41	61.04
16	2-Furancarboxaldehyde	14.718	1.042
17	Unknown	14.819	0.316
18	Unknown	14.871	0.161
19	Unknown	14.914	0.288
20	Unknown	15.155	0.508
21	2-Decenal, (E)-	15.268	0.218
22	Unknown	15.305	0.139
23	Hydroxylamine, O-decyl-	15.379	1.79
24	Unknown	15.608	0.021
25	Unknown	15.723	0.102
26	Propanoic acid	15.968	0.471
27	1,3-Butanediol	16.085	2.416
28	meso-2,3-Butanediol	16.183	0.01
29	2-Undecanol	16.346	0.093
30	2-Butanone, 3-hydroxy-	16.421	0.149
31	Unknown	16.509	0.176
32	2,3-Butanediol	16.634	4.063
33	2-Hexanol	16.848	0.768
34	Methoxyacetic acid, 3-tridecyl ester	16.901	0.351
35	Undec-3-en-2-ol	16.99	0.241
36	2(3H)-Furanone, dihydro-5-methyl-	17.066	0.149
37	Butanoic acid	17.279	1.821
38	Propanoic acid, 2-oxo-	17.397	0.088
39	Unknown	17.528	0.093
40	Unknown	17.593	0.162
41	2-Furanmethanol	17.738	1.391
42	Butanoic acid, 3-methyl-	17.845	0.58
43	5-Hexen-2-one	17.99	0.061
44	2-Pyrrolidinone, 1-methyl-	18.104	1.326
45	2-Furanmethanol, 5-methyl-	18.529	0.332
46	Butanoic acid	18.698	0.337
47	N-Methyl-9-aza-tricyclo[6.2.2.0 (2,7)] dod	18.777	0.13
48	Unknown	19.008	0.044
49	Hexanoic acid	19.956	3.484
50	Unknown	20.115	0.274
51	Unknown	20.357	0.098
52	Benzeneethanol	20.757	0.349
53	Heptanoic acid	21.121	0.318
54	Ethanone, 1-(1H-pyrrol-2-yl)-	21.383	0.061
55	2-Furanmethanol, tetrahydro-	21.997	0.762
56	Octanoic acid	22.214	0.35
57	1,2,3-Propanetriol, diacetate	22.376	0.14
58	Unknown	22.482	0.082
59	Cyclopropylcarbinol	22.627	0.107
60	Ethanol, 2-phenoxy-	23.096	0.694
61	Nonanoic acid	23.243	0.28
62	2(4H)-Benzofuranone, 5,6,7,7a-tetrahydro	25.108	0.811
63	1,6-Anhydro-.beta.-d-talopyranose	27.305	0.254

Major volatile (>2.0%) bolded; *RT: Retention time.

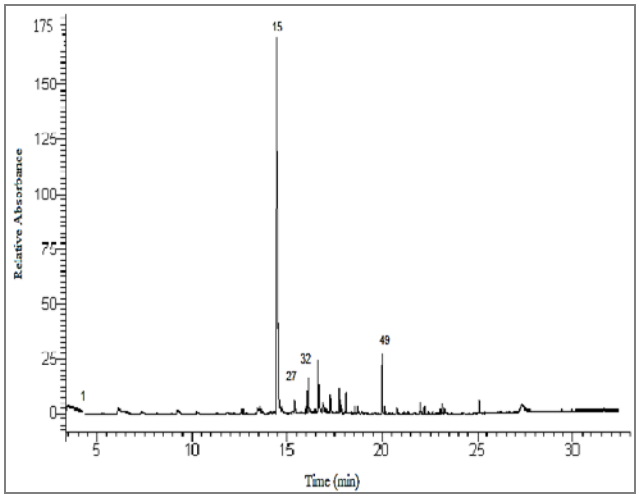

Figure 3. Chromatograms of volatile compounds in guddaim fruits. The Acetic acid extract presented as richest profile with a larger peak

4. Conclusion

The results of this current study on guddaim fruits have revealed that guddaim fruits contain essential nutrients such as minerals, amino acids, sugars, vitamins and volatile compounds which if properly utilized can improve human nutrition and health. Furthermore, the volatile compounds identified in guddaim fruits can be used by food industries to improve flavor and taste of food products. It can be concluded that utilization of guddaim fruits in human nutrition needs to be extensively promoted to ensure both good health and nutrition especially to poor and low resource communities in developing countries.

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