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Chemical Compositions, Antioxidant, and Nutritional Properties of the Food Products of Guddaim (Grewia tenax)

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ABSTRACT

The present study aimed to evaluate the nutritional and antioxidant value of jam, juice and syrup of Guddaim seed. The proximate chemical composition, moisture, protein, fat, ash, crude fiber, acidity, carbohydrate, reducing sugar, total sugar, non-reducing sugar, total soluble solids, ascorbic acid were determined in Guddaim seed. The highest moisture was in syrup (51.52%) and the lowest was in the seeds (7.45%), the highest crude protein content was recorded in seeds (7.99%) and the lowest was in the syrup (0.95). The highest fat content was recorded in seeds (1.30%), and the lowest was in syrup 0.24%. The highest total carbohydrates content was in jam (84.60%), and the lowest was in syrup (46.98%). The highest vitamin C content was in seeds (16.28 mg \100g). On the other hand, the highest phenolic acids profile was recorded in seeds of Guddaim. The highest total phenol was recorded in seeds (3.25 mg GAT\g). Similarly, the highest antioxidants were recorded in seeds (4.59). Lutein and β-carotene were high in seeds, jam and juice. The results of this study showed that Guddaim fruit contained many important nutrients useful for human health.

Key words: *Guddaim, Seed, Juice, Jam, Syrup, Antioxidant.*

INTRODUCTION

Grewia tenax is a medicinal tree spread in Africa and Southeast Asia. It belongs to the family of *Tileacea*. The fruit known locally in Sudan as “guddaim” as a rich source of carbohydrates, proteins, vitamins, minerals, and constitutes which are important contributors to improving the nutritional contents of rural and urban people in Sudan [1]. Guddaim fruits are small round, orange sweetened berries that may be consumed either fresh or dried. In fact, *Grewia tenax*is is a plant that has been used in popular medicine in various ways in different countries. The good taste of Guddaim fruit makes it palatable for human. Guddaim fruit can be added to yogurt to produce high quality food with a different flavor [2].

The root is used in treating jaundice, pulmonary infections and asthma. The leaf is used in protecting against trachoma [3]. Seed decoction and fruit juice are used for their tonic and anti-anemic properties. Grewia tenax (Forsk.) Fiori, G. flavescensJuss and G. villosa Willd fruits, when ripe, are either eaten fresh or left to dry for consumption at a later date. In Sudan, a drink is prepared by soaking the fruits over-night, and then they are hand pressed, sieved and sweetened. A light porridge is prepared by the addition of flour or custard to Grewia drink and is served during the fasting month of Ramadan and is also fed to lactating mothers to improve their health and lactating abilities. Moreover, the fruits are made into a fermented drink in Sudan and Southern Africa [3]. Guddaim fruit has been reported to contain large amounts of iron [4] and so it has been used for treatment of anemia and malaria [5].

The fruit pulp represents only 40-50% of the whole fruit, and contains crude fiber, ash, fat, carbohydrates, iron, potassium, sulfur, phosphorus, magnesium, calcium and sodium, and a good source of amino acids (aspartic acid, threonine, serine, glutamic acid, proline glycine, alanine, valine, cysteine, methionine, isoleucine, leucine, tyrosine, phenylalanine, lysine, histidine and arginine) [6, 7].

The aim of the current work was to study the nutritional and antioxidant properties of juice, jam and syrup of Sudanese Guddaim.

MATERIALS AND METHODS

Collection of fruits

Guddaim fruits were bought from West Darfour State, Sudan, in July 2016. The fruits were sorted to remove low quality ones, and stored in plastic bags at room temperature until use.

Preparation of guddaim fruits juice

The guddaim fruits were put in a large bowl and washed with tap water, followed by distilled water to get rid of any impurities or dust on their surface. The fruits were sorted to isolate broken or scratched ones. Guddaim fruits juice was obtained by soaking the fruits (extraction ratio was 1 Guddaim :4 fruits : water) for about four hours, and then the fruits were pressed till exhaustion, and stirred, and the whole mass was filtered through a filter cloth and pressed to remove cell wall, fiber and seeds. A yield of 75% deep orange juice which tasted good and fruity was obtained. For pasteurizing the juice, the fruit juice was blanched by sufficient quantity of water, so, it could be kept in the refrigerator for a long time without losing quality.

Preparation of Guddaim fruit syrup

The guddaim fruit syrup was prepared according to Hallabo et al. [8].

Preparation of guddaim fruits jam

Guddaim jam was prepared according to Saeed and Elmubark's [9] method.

Chemical composition

Moisture, protein, fat, ash and crude fiber content of guddaim seed were determined according to AOAC [10], whereas acidity, carbohydrate, reducing sugar and total sugar were determined according to [11], non-reducing sugar was calculated as the difference between total and reducing sugar. Total soluble solids (TSS) were determined using Atago type refractometer.

Color measurements

The color was measured using a spectrocolorimeter with the CIE color scale (Hunter, Lab scan XE). This instrument was standardized against the white tile of Hunter Lab color standard (LX No.16379): X= 77.26, Y= 81.94 and Z= 88.14. The L*, a* and b* values were reported.

Determination of ascorbic acid content :

Ascorbic acid content was determined using the 2, 6-dichlorophenol-indophenol titration method described in AOAC [10]. L ascorbic acid was used to prepare a standard solution (1 mg/ml). The ascorbic acid concentration was calculated by comparison with the standard.

Determination of total phenolic content :

The total phenolic content was determined according to the Folin- Ciocalteu procedure [12].

Determination of radical DPPH scavenging activity

Free radical scavenging capacity of extracts was determined using the stable DPPH* according to [13]. Percent inhibition of the DPPH free radical was calculated by the following equation:

Inhibition (%) = $100 \times [(A_{control}-A_{sample}) /A_{control}]$

Where: A control is the absorbance of the control reaction (containing all reagents except the test compound) and A sample is the absorbance with the test compound.

The standard curve was prepared using Trolox. The results were expressed as mM Trolox equivalents (TE)/g sample). Additional dilution was needed if the measured DPPH value was over the linear range of the standard.

Determination of radical ABTS scavenging activity

The stock solutions of ABTS* reagent was prepared according to [13]. The results were expressed as mM Trolox equivalents (TE)/g sample). Additional dilution was needed if the measured ABTS* value was over the linear range of the standard.

Ferric reducing activity power (FRAP) assay

The FRAP assay was done according to [13].

Determination of phenolic acids profile

Phenolic acid was extracted according to [14]. HPLC analysis was carried out according to [15].

Carotenoid composition :

Carotenoids were extracted according to the method of [14].

Sensory evaluation of syrup and jam

It was done by a trained twenty-member panel consisting of students and female staff members of the Home Economics faculty. The tests were performed under fluorescent lighting in a sensory evaluation laboratory. Water was provided to rinse the mouth between the evaluations. The judges evaluated the samples for appearance, color, flavor, texture and overall acceptability. Each sensory attribute was rated on a 7- point hedonic scale (1 disliked extremely, 3 neither liked nor disliked, 7 extremely liked) [16].

Determination of minerals

Minerals: Mineral contents of all the produced products (Na, K, Fe, Zn, Cu and Ca) were carried out in the Central Laboratory, Faculty of Agriculture, Kafrel Sheikh University, using atomic absorption (NC.9423-400-30042) England method by techniques described by A.O.A.C. [10].

Statistical Analysis

Data generated were subjected to SAS version 9.2. One-factor complete randomized design (CRD) was assessed, and then the means were separated according to Duncans' Multiple Range test.

RESULTS AND DISCUSSION

The proximate chemical composition of syrup, jam and seeds of Guddaim fruits has been presented in table (1). Moisture was higher in syrup (51.52) compared with syrup and seeds. From table (1), protein, fat, crude fiber and ash content in seeds were higher than syrup and jam. They were 7.99, 1.30, 22.08 and 3.32; respectively. Fat content was lower when compared with the results obtained by [17] which was 10.7mg/g, and [7] who reported 1.7% for guddaim seed, and [18] who reported 10.7% . Total carbohydrates, total sugar, reducing sugar and non-reducing sugar were high in jam compared with syrup and seeds. Vitamin C was the highest level in seeds (16.28 mg/100g). The fruit pulp represented only 40-50% of the whole fruit, and contained 10-15% moisture, 20% crude fiber, 5.2% ash, 0.4% fat, 66% carbohydrates, 13.8% reducing sugar and 44.4% starch [6, 7]. Total carbohydrates including total sugar, sucrose, glucose and fructose were high in jam compared with syrup and seeds. The results obtained by [17], reported 15.4, 2.0, 5.7, and 7.6 mg/g ; respectively.

Minerals content of syrup, jam and seeds of Guddaim fruits included Mg, K, Na, Ca, Fe and Zn (mg/100g) which has been represented in table (2). Minerals like zinc, manganese and iron play an important role in body regulatory functions, it could be noticed that seeds' content of minerals was higher than jam and syrup, the values were: 114.00, 60.00 ,360.00, 571.40, 8.45 ,6.21 and 0.89 (mg/100g) in Na, P, Ca ,k, Mg, Fe and Zn; respectively. From these results, Guddaim fruits were found to contain many important minerals which can be used in cereal and cereal products 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 enzymes, (ii) regulating the liquid compartment pH which permits the achievement of metabolic reaction, and (iii) controlling the osmotic equilibrate between cells and their environment [19].

Hunter color parameters of syrup, jam and seed of Guddaim fruits have been shown in table (3).

Total color difference ΔE, which is a combination of parameters L*, a* and b* values, is a colorimetric parameter extensively used to characterize the variation of colors depending on processing conditions [20]. Color attribute of a product is of primary importance to consumers as a product quality criterion, since consumers associate it with freshness, therefore, it is critical for the acceptance of a particular product among others [21]**.** Producers strive to prevent products with defective colorations from reaching the market [22, 23] because when they do not do that, their prices are significantly affected [24] or the products are rejected by the consumer [25, 26]. When an object is visually being assessed; three physical factors must be present. There must be a source of light, the object, and a light receptor mechanism. The colorimeter generates a composite three parameter L*a*b* number. It has been extensively used in many industries throughout the world which is sometimes referred to as the CIELAB color difference metric. From table (3) it could be noticed that L*, a* and b* were the highest in seeds of Guddaim fruits which were 39.24, 24.63 and 32.63; respectively.

The CIE L*a*b* uniform color space, the color coordinates were as follows: L*—the lightness coordinate; a*—the red/green coordinate, with +a* indicating red, and -a* indicating green; and b*—the yellow/blue coordinate, with +b* indicating yellow, and -b* indicating blue. The L*, a*, and b*coordinate axis defined the three-dimensional CIE color space. Thus, if the L*, a*, and b* coordinates were known, then the color could not only described, but also be located in a quadrant [27].

Physicochemical properties of syrup, jam and seed of Guddaim fruits have been shown in table (4). Total soluble solids were higher in jam (84.00). Titratable acidity (as % citric acid) was higher in syrup (0.83) compared with jam and seeds.

Phenolic acids profile of syrup, jam and seed in of guddaim fruits have been shown in table (5). From this table, it could be noticed that seeds contain the highest level in all phenolic acids including: gallic acid, catachine, syrngic acid, vanillic acid, coumarin, cinnamic acid, chyrsin, caffeic acid, ferulic acid, sinapic acid and kaempferol1 with amount of 2.88, 18.06,19.17, 15.19 ,24.70,5.61, 4.91, 19.87 ,16.84, 4.28 ,9.89(µg/g), respectively, whereas jam contained the highest content of protocatechuic acid and rutin with amount of 20.79 and 11.57(µg/g); respectively.

An antioxidant was defined as 'any substance, when present at low concentrations compared with those of the oxidizable substrates, significantly delays or inhibits oxidation of that substrate, but later it was defined as "any substance that delays, prevents or removes the oxidative damage to a target molecule" or it was defined as a molecule that inhibits the oxidation of other molecules [28]. Natural antioxidants have been known to exhibit a wide range of biological effects including antibacterial, antiviral, anticancer, anti-inflammatory, anti allergic, antithrombic and vasodilatory activities. Antioxidant activity gives rise to anticarcinogenicity, antimmunogenicity and antiaging activities [29-31].

Total phenol compounds and antioxidant activity of syrup, jam and seed of Guddaim fruits have been presented in table (6). Total phenol (mg GAE/g) and antioxidant activity (DPPH, ABTS and FRAP) were the highest in seeds which were 3.25, 4.439,4.108 and 4.595; respectively.

Plant-derived compounds have been identified to prevent and treat of cancer, such as resveratrol, lycopene and astaxanthin, and phenolic acids [32, 33]. Studies have suggested that antioxidants from fruits and their residues can reduce the risk of cancer and related mortality; and consuming foods rich in polyphenols may lead to a lower incidence of cancers. Besides, the antioxidants' potential and functional properties of nutrients from various natural sources have been investigated, mainly to replace the use of synthetic antioxidants in food products that can be a health hazard [34]. Guddaim possesses the highest reducing potential as well as antioxidant capacity. Antioxidant values obtained in this study were similar with the earlier studies [35-37].

Guddaim seed also possesses the maximum amount of phenolic content in aqueous extract, therefore, only aqueous extract was considered for the antioxidant evaluation, as from the literature, the highest antioxidant activity may be attributed to the presence of high phenolic content and flavonoids in the species. From present findings, Table (5) shows the total phenolic content and total flavonoids of various plant extracts in which total phenolic was the highest in the aqueous extract of Guddaim (10.67 µg/ml), and flavonoids were found to be maximum (32.7 µg/ml) in hydroalcoholic extract of the same species, as compared to the other two species. The findings related to antioxidants, phenolic constituents and flavonoids revealed that this species can be used for therapeutic usage at a very lower cost, and with minimum side effects in comparison to other commercial drugs available in the market [38]. The standard values of phenolic acids standards have been shown in figure (5), whereas the phenolic compounds of the seed have been shown in figure (6).

Carotenoids of syrup jam and seeds of Guddaim fruits have been shown in table (7). Lutein and β-carotene content were higher in seeds 33.50 and 26.00 (µg/g), while in syrup, they were lower: 30.32 and 24.46 µg/g, respectively. The standard values of carotenoids and lutein have been shown in figure (1), and. Lutein and β-carotene contents of seeds have been presented in figure (2), while figure (3) shows the carotenoids content of syrup, and that of jam was shown in figure (4), Grewia spp was reported to have antioxidant, anti-microbial activities against different fungi, gram-positive and gram-negative bacteria, in addition to other pharmacological activities. Among the important metabolites in the genus, Grewia flavonoids and β-carboline alkaloids are the most important. Biological activities of β- carboline alkaloids include antioxidant activities, and the inhibition of platelets aggregation. Many studies have suggested that flavonoid exhibits biological activities, including antiallergenic, antiviral, anti-inflammatory, and vasodilating actions. These pharmacological effects are generally linked to the antioxidant properties of these molecules.

Sensory evaluation of syrup and jam samples of guddaim fruits seeds have been shown in Table (8). It included color, taste, texture and general acceptability. Syrup and jam recorded high scores in all the sensory evaluations.

CONCLUSION

The approximate chemical composition indicated that Guddaim fruit contained higher amounts of crude protein, crude fiber and carbohydrates. Its nutritional value lied in its good content of iron, ascorbic acid, D-fructose sugar and calcium. The sensory evaluation revealed that the Guddaim- flavored syrup and jam were good and acceptable. Guddaim fruit also showed higher antioxidant activity.

Conflict of Interests :

Authors declared no conflict of interest.

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Table 1: Chemical composition of syrup, jam and seed of guddaim fruits.

Component	syrup	Jam	Seeds	$Lsd_{0.05}$	SE±
Moisture content (%)	51.52^{a}±4.38	12.73^{b}±2.09	7.45^{c}±1.22	3.526^{*}	1.524
Crude protein (%)	0.95^{c}±0.07	1.60^{b}±0.18	7.99^{a}±1.34	0.461^{*}	0.013
Fat content (%)	0.24^{b}±0.03	0.55^{b}±0.07	1.30^{a}±0.16	0.519^{*}	0.017
Crude fibre (%)	11.33^{c}±2.41	12.32^{b}±2.49	22.08^{a}±3.07	0.877^{**}	0.026
Ash content (%)	0.31^{b}±0.04	0.52^{b}±0.05	3.32^{a}±0.25	0.301^{*}	0.008
Total carbohydrates (%)	46.98^{c}±3.76	84.60^{a}±5.09	57.86^{b}±4.01	4.153^{**}	1.211
Total sugars (%)	28.37^{b}±3.54	39.25^{a}±2.61	11.17^{c}±2.44	6.528^{**}	1.967
Reducing sugars (%)	2.87^{b}±0.16	10.16^{a}±2.33	2.28^{b}±0.35	1.462^{*}	0.086
Non-reducing sugars (%)	25.50^{b}±1.41	29.09^{a}±3.67	8.89^{c}±2.17	2.528^{**}	1.173
Vitamin C (mg/100g)	2.05^{c}±0.13	3.13^{b}±2.51	16.28^{a}±2.66	0.491^{**}	0.015

Values are mean ±SD. Mean(s) bearing different superscript(s) in a row are significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT).

Table 2: Minerals content of syrup, jam and seed of guddaim fruits.

Mineral (mg/100g)	syrup	Jam	Seeds	Lsd0.05	SE±
Sodium-Na	47.00^{c}±3.52	89.00^{b}±5.52	114.00^{a}±8.65	13.524^{**}	7.846
Phosphorous-P	12.82^{c}±1.07	13.60^{b}±1.17	60.00^{a}±5.27	0.846^{**}	0.109
Calcium-Ca	30.00^{c}±3.26	49.00^{b}±3.88	360.00^{a}±14.08	14.870^{*}	7.901
Potassium-k	55.60^{c}±4.91	122.20^{b}±8.04	571.40^{a}±15.76	21.621^{*}	8.650
Magnesium-Mg	5.97^{b}±0.35	6.09^{b}±0.31	8.45^{a}±0.67	0.409^{*}	0.033
Iron-Fe	0.25^{b}±0.01	0.58^{b}±0.05	6.21^{a}±0.36	1.764^{*}	0.214
Zinc-Zn	0.53^{a}±0.04	0.78^{a}±0.06	0.89^{a}±0.10	0.064^{s}	0.153

Values are mean ±SD. Mean(s) bearing different superscript(s) in a row are significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT).

Table 3: Hunter Color parameters of syrup, jam and seed of guddaim fruits.

Sample	L^{*}	A^{*}	b^{*}
Syrup	10.70^{b} ±2.41	7.29^{c}±0.61	13.44^{b}±2.57
Jam	5.19^{c}±0.48	8.49^{b}±2.37	7.78^{c}±0.65
Seeds	39.24^{a}±5.66	24.63^{a}±3.80	32.63^{a}±4.02
$Lsd_{0.05}$	2.547^{**}	0.528^{**}	4.761^{**}
SE±	1.481	0.093	0.984

Values are mean ±SD. Mean(s) bearing different superscript(s) in a column are significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT).

Table 4: Physicochemical properties of juice, jam and seed of guddaim fruits.

Sample	Total soluble solids (%)	Titratable acidity (as % citric acid)
syrup	45.80^{b}±3.21	0.83a±0.07
Jam	84.00^{a}±5.17	0.22a±0.01
Seeds	-	0.52a±0.04
$Lsd_{0.05}$	16.824**	0.749n.s
SE±	7.462	0.153

Values are mean ±SD. Mean(s) bearing different superscript(s) in a column are significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT).

Table 5: Phenolic acids profile of syrup, jam and seed of guddaim fruits.

Compound	SYRU (µg/ml)	Jam (µg/g)	Seeds (µg/g)	Lsd0.05	SE±
Gallic acid	1.58c±0.16	8.00b±1.52	12.88a±2.35	3.526**	0.526
Protochatchuic acid	2.42c±0.14	20.79a±3.57	18.06b±4.51	7.214**	0.479
Catachine	3.10b±0.09	0.00c±0.00	19.17a±6.08	1.057**	0.038
Syrngic acid	0.00c±0.0	3.89b±1.05	15.19a±2.43	2.525**	0.446
Vanillic acid	0.00b±0.00	0.00b±0.00	24.70a±6.37	9.586**	2.514
Coumarin	0.00c±0.00	1.70b±0.09	5.61a±1.28	0.744*	0.011
Cinnamic acid	0.11b±0.02	0.64b±0.0	4.91a±1.15	0.812*	0.024
Chyrsin	0.00b±0.00	0.00b±0.00	19.87a±6.33	5.469**	1.637
Caffeic acid	1.54c±0.06	4.46b±0.17	11.98a±2.46	1.451**	0.045
Ferulic acid	2.05b±0.06	2.17b±0.11	16.84a±6.49	0.524*	0.009
Sinapic acid	2.43b±0.8	0.98c±0.14	4.28a±1.18	0.413*	0.005
Rutin	7.93b±1.57	11.57a±2.02	3.98c±0.23	1.072**	0.035
Kaempferol	1.08b±0.05	1.17b±0.08	9.89a±0.0	0.839*	0.026

Values are mean ±SD.Mean(s) bearing different superscript(s) in a row are significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT).

Table 6: Total phenol compounds and antioxidants activity of Syrup, jam and seed of Guddaim fruits.

Sample	Total phenol (mg GAE/g)	Antioxidants activity		
		DPPH (mg TE/g)	ABTS (mg TE/g)	FRAP (mg TE/g)
Syrup	0.558c±0.06	0.537c±0.04	0.512c±0.03	0.662c±0.08
Jam	1.197b±0.15	1.058b±0.10	1.194b±0.13	1.398b±0.17
Seeds	3.255a±0.24	4.439a±0.27	4.108a±0.22	4.595a±0.28
Lsd0.05	0.639*	0.421*	0.587*	0.631*
SE±	0.217	0.095	0.164	0.252

Values are mean ±SD. Mean(s) bearing different superscript(s) in a column are significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT).
Where: GAE ≡ Gallic acid equivalent and TE ≡ Trolox equivalent

Table 7: Carotenoids of syrup, jam and seeds of guddaim fruits.

Sample	Lutein (µg/g)	β-carotene (µg/g)
Syrup	30.32c±0.25	24.46b±0.13
Jam	31.30b±0.27	25.67a±0.18
Seeds	33.50a±0.31	26.00a±0.19
Lsd0.05	0.972*	0.361*
SE±	0.358	0.054

Values are mean ±SD. Mean(s) bearing different superscript(s) in a column are significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT).\

Table 8: Sensory evaluation of syrup and jam samples of guddaim fruits.

Quality attribute	syrup	Jam	Lsd0.05	SE±
	Scores			
Colour	9.46a±0.66	9.62a±0.51	0.173n.s	0.0827
Taste	9.31a±0.85	9.15a±0.80	0.169n.s	0.0531
Texture	9.08a±0.86	9.15a±0.69	0.085n.s	0.0196
General acceptability	9.54a±0.52	9.54a±0.52	0.003n.s	0.0042

Values are mean ± SD. Mean(s) bearing different superscript(s) in a row are significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT).
Sensory evaluation of syrup and jam samples of guddaim fruits are shown in Table (8) include color, taste, texture and general acceptability, syrup and jam recorded high scores in all sensory evaluation.

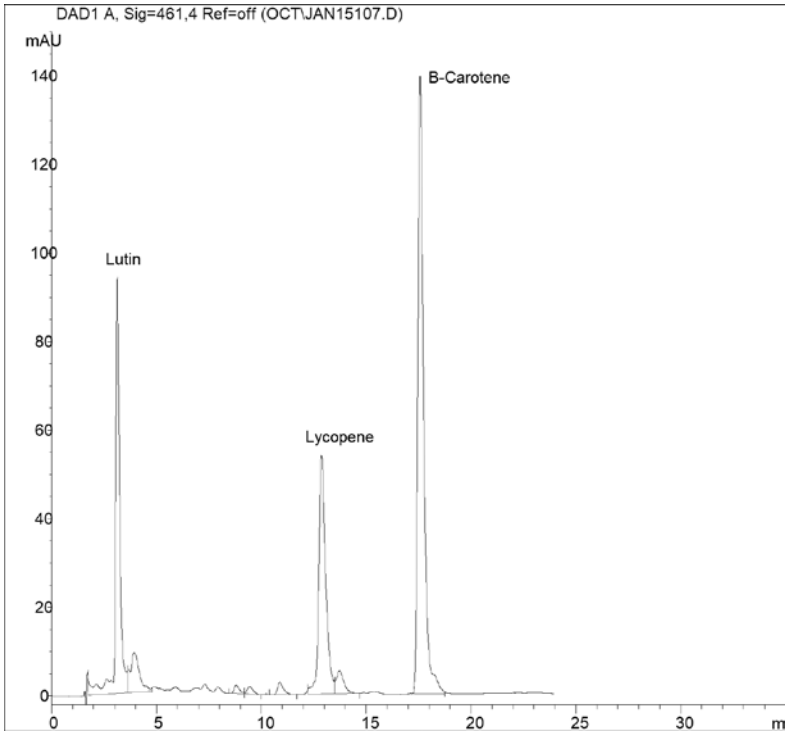

Figure 1: Profile of cratinoids standard**.**

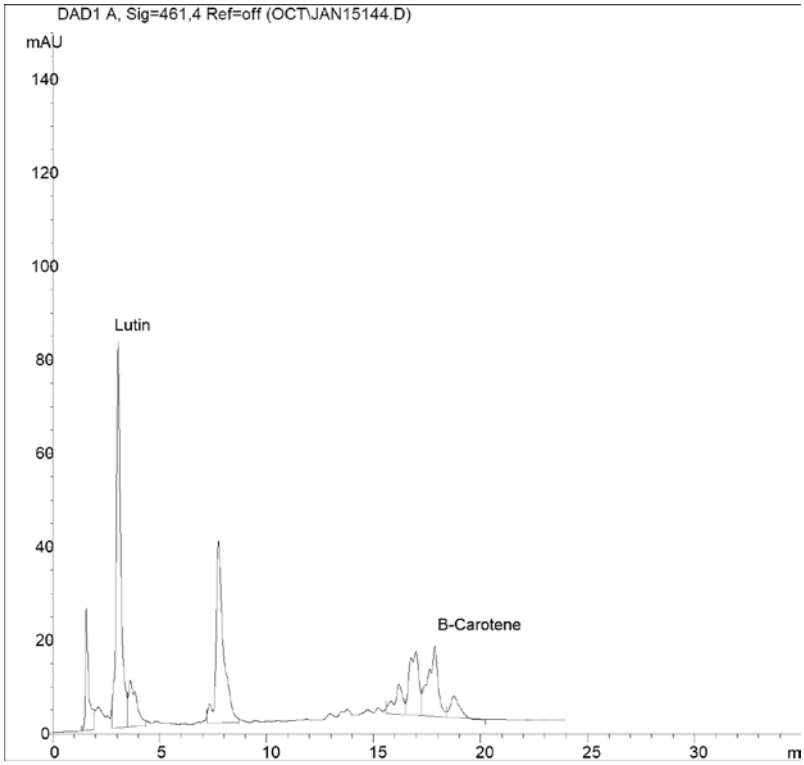

Figure 2: Profile of carotenoids of seeds.

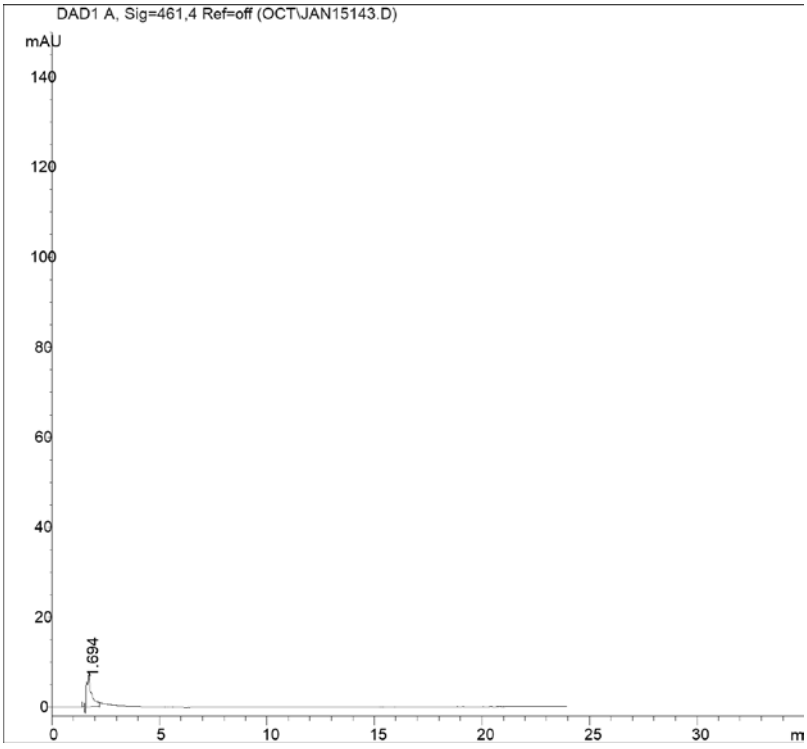

Figure 3: Profile of carotenoids of syrup.

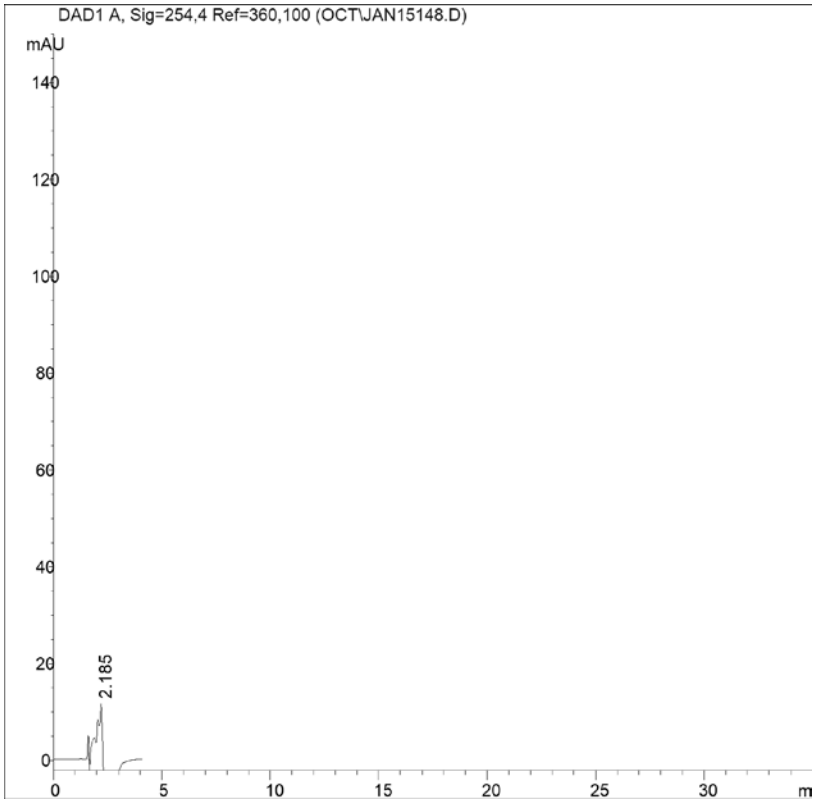

Figure 4: Profile of carotenoids of jam.

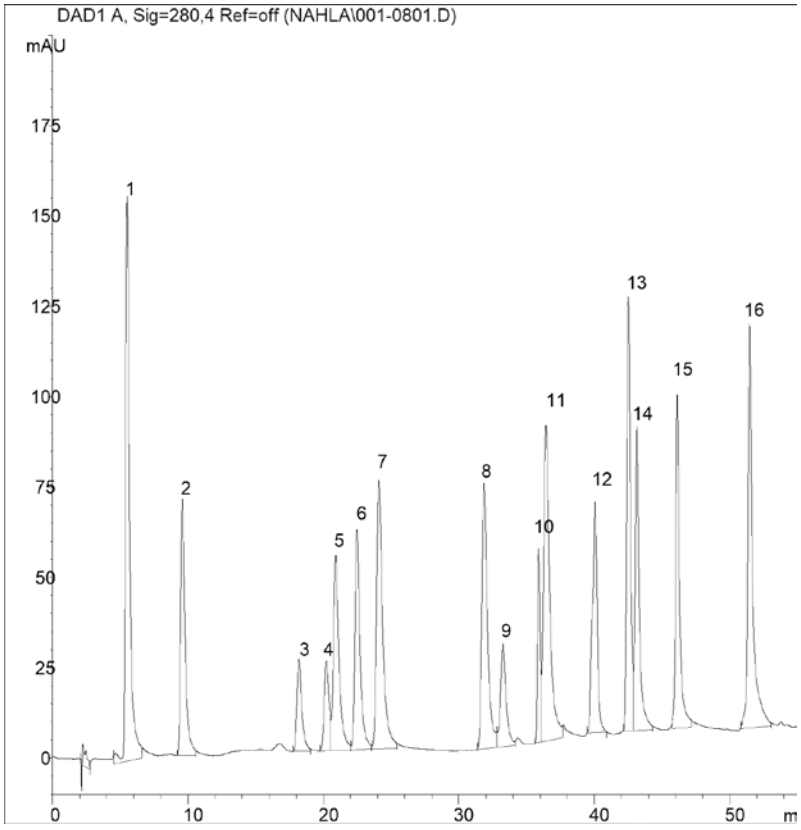

Figure 5: Profile of phenolic acid standards.

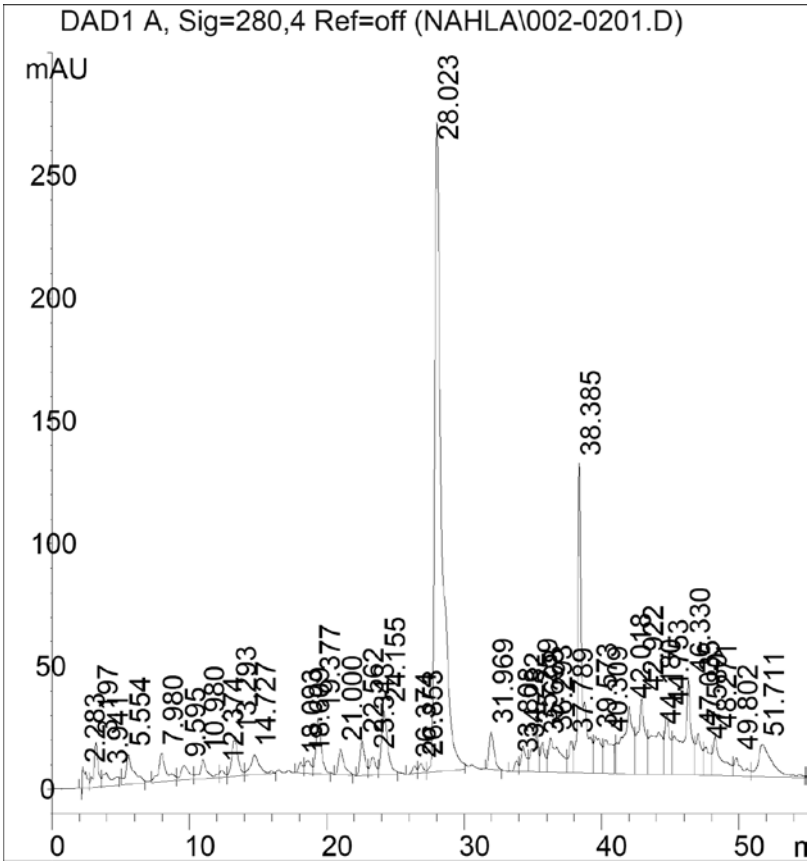

Figure 6: Phenolic compounds of seed**.**

Phenolic acid standards

Where : 1= gallic acid, 2= protocatechuic acid, 3= catechin, 4= chlorogenic acid, 5= caffeic acid, 6=syrngic acid, 7= vanillic acid, 8= ferulic acid, 9= sinapic acid, 10=Rutin, 11=coumarin, 12= rosmarinic acid, 13= cinnamic acid, 14=Quercetin, 15= Kaempferol 16= chyrsin**.**