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Original Research Article

Physicochemical, Nutritional, and Functional Characteristics of Seeds, Peel and Pulp of *Grewia tenax* (Forssk) Fiori Fruits

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Abstract

Purpose: *To determine the physicochemical, nutritional, and functional characteristics of the seeds, peel, and pulp of Grewia tenax (Forssk.) Fiori fruits.*
Methods: *The whole fruit was flooded with ionized water for 6 h, and the seeds manually separated from the peel and pulp. The mineral content was determined by atomic absorption spectroscopy while the amino acids were separated and quantified by injecting 50 µL into an amino acid analyzer (Hitachi 835-50). Gas chromatography–mass spectrometry (GC/MS) was used to separate and determine the volatile compounds, whereas color was measured with a digital colorimeter.*
Results: *Protein, fat and ash contents were higher in the seeds than in the peel and pulp. Carbohydrate content was higher in the pulp (87.09 %) than in the seeds and peel (59.56 and 70.74 %), respectively. The peel, seeds, and pulp had Na concentration of 19.3, 5.8 and 11.5 mg/100 g, respectively; and for potassium (K), 502.5, 400 and 300 mg/100 g, respectively. The pulp contained the following essential amino acids: histidine, thereonine, valine, isoleucine and lysine at levels of 4.3, 6.4, 9.7, 9.5, and 6.4 g/100 g, respectively. The pulp had the highest water absorption capacity (WAC, 3.3 ml/g), whereas oil absorption capacity was 3.6 ml/g in the peel. Foaming capacity (FC) was 8.6 % in the seed. The bulk density (BD) of seeds, peel, and pulp were 0.5, 0.6, and 0.9 g/mL, respectively. The concentration of the volatile components of seeds, peel, and pulp of the fruits was 42.1, 97.9, and 71.4 %, respectively.*
Conclusion: *Grewia tenax fruits are a good source of nutritional components and essential nutrients, including minerals and amino acids, and have functional properties, which, if properly utilized, can improve human nutrition and health.*

Keywords: *Grewia tenax, Physicochemical, Amino acids, Nutrition, Functional properties, Minerals, Volatile compounds*

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INTRODUCTION

Grewia tenax (Forssk.) Fiori is a small-leaved white cross berry that belongs to the Tiliacea family. This fruit-producing deciduous shrub or small tree is prevalent in African and Southeast Asian countries, with the fruits known locally as guddaim in Sudan. The tree has a wide distribution in the savannah plantation area in the north and middle of Sudan [1]. *Grewia tenax* has been used in folk medicine in several ways in different countries. The roots have been used to treat jaundice, lungwort infections, and asthma. There is commercial potential in using the fruits in beverages, yogurt, ice cream, and baby food. The fruits are used by rural villagers as an iron supplement for anemic children. A thin porridge called nesha is prepared by boiling millet flour and the pulp of *Grewia tenax* fruits and then adding custard to the mixture [2]. This porridge is given to pregnant and lactating women to improve their health and their ability to produce milk for their children [3].

Some studies have shown that *Grewia tenax* fruits have been used as a traditional treatment for irritations and skin infections in both human beings and animals in Sudan. *Grewia tenax* fruits, which can be eaten ripe or stored for later use, consist of large quantities of carbohydrates in a liquefied form as well as a large quantity of calcium. Different parts of several species in the genus *Grewia* are used as folk medicine in various areas of the world.

The main objective of this study was to determine the nutritional value, amino acid content, color, levels of micronutrients and minerals, and functional properties (e.g., water and oil absorption capacities (WAC and OAC, respectively), bulk density (BD), foaming capacity (FC), and foam stability) of the different parts of *Grewia tenax* fruits.

EXPERIMENTAL

Plant material

Grewia tenax fruit was collected in September 2014 from a local market in Wad Medani City, Gezira State, Sudan and then placed in plastic bags and brought to Jiangnan University, Wuxi city, People’s Republic of China. The samples were sorted to remove low-quality fruits and then stored in plastic bags at room temperature until use.

Sample preparation

The fruits were first washed with distilled water in a large bowl to eliminate any impurities or dust on their surface; they were then sorted to identify and remove broken or scratched fruits. The fruits were flooded with ionized water for 6 h and divided into seeds, peel, and pulp. The seeds were manually separated from the peel and pulp, and the seeds and peel were then sun dried for 4 days. Drying was completed in an oven for 24 h at 40 °C. Dried samples were ground into a powder using a blender (25000 rpm, type WK – 1000A. Qing Zhou Jing Cheng Machinery Co., LTD, Shandong, China) and then passed through a 60-mesh sieve to produce a fine powder. The powder was sealed in plastic bags and stored in a refrigerator at 4 °C, and the pulp was collected in plastic bags and stored at -20 °C in a refrigerator until use. Analytical reagents and HPLC-grade solvents were obtained from Sinopharm Chemical Reagent Co. Ltd., Shanghai, China.

Chemical composition

The moisture, fat, fiber, and ash contents were determined using standard AOAC International methods 925.09, 932.06, 985.2912, and 923.03, respectively [4]. The ash content was estimated by weighing 2 g of the sample in a porcelain crucible and burning at 600 ^{o}C for 6 h in an ashing muffle furnace until a white ash was obtained. For crude fiber, 2 g of moisture-free sample was weighed, extracted by ether, and digested with dilute H_2SO_4 and then with KOH solution. Fat was determined by petroleum ether in a soxhlet apparatus (SZC-101 Fat Meter, Xian Jian Instruments Co., Ltd, Shanghai, China) for 5 h. Crude protein was determined using a nitrogen analyzer (DK-3400, FOSS, Hillerød, Denmark), and calculated by multiplying the evaluated total nitrogen by a standard factor of 6.25. The total carbohydrate content was calculated as the difference (i.e., the sum of the moisture, fat, protein, and ash contents was subtracted from 100).

Mineral determination

Minerals in the sample were determined by the dry-ashing method [5].One gram of sample was acid-digested with an 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 distilled water and filtered through a Whatman No. 42 filter paper as reported by [6]. The calcium content was estimated by a titrimetric method. The iron content was estimated using a UV-visible spectrophotometer (model UV-160A, Shimadzu, Shanghai, China) at 480 nm [18], with the blue color that developed measured by the same spectrophotometer at 650 nm. Other minerals were determined by atomic absorption spectroscopy using an instrument (AA 6701F, Shimadzu) equipped with hollow cathode lamps.

Amino acid composition

Amino acids were determined according to the modified AOAC method 982.30 a [4]. One gram of dried sample was hydrolyzed with 8 ml of 6 M HCl at 110 °C for 24 h under a vacuum. After cooling, the hydrolyzed sample was washed with distilled water, filtered through a Whatman No 40 filter paper, and centrifuged at 10,000 rpm for 10 min. The supernatant was collected and vacuum dried at 60 °C using a rotary evaporator; the dried residue was dissolved in 0.02 M HCl. A 50-µL sub-sample was injected into an amino acid analyzer (Model 835-50, Hitachi, Tokyo, Japan) equipped with a 162.6 × 150-mm ion exchange column coated with resin 2619 at 53 °C.

Gas chromatography–mass spectrometry (GC/MS)

GC/MS was used with a SPAM fiber to separate the volatile compounds on a CP-Sil-8CB (Varian, Walnut Creek, CA, USA), fused silica capillary column (30 m length, 0.25 mm, i.d., and 0.25 µm film thickness) in a gas chromatograph (model 3800, Varian, Palo Alto, CA, USA). The split injector was maintained at 220 ºC, and the flame ionization detector (FID) was maintained at 250 ºC; volatile compounds were separated with a capillary column DB WAX (30 × 0.25 µm, J & W Scientific, Folsom, CA, USA). The separation was performed as follows: the oven temperature was set at 40 ºC, held for 3 min, ramped to 100 ºC at a rate of 6 ºC/min, and then ramped to 230 ºC at 10 ºC/min. The constant column flow was 0.9 ml/min. Mass spectra were obtained in the Electron Impact (EI+) mode with an energy voltage of 70 eV. The mass range was 33 to 450 m/z. The identification of volatile compounds was conducted by matching the compounds with the mass spectra of standard compounds found in the wily 130 K and National Institute of Standards and Technology (NIST) 98 libraries of MS spectra based on their retention indices.

Evaluation of physical characteristics

Color parameters

A Hunter Lab digital colorimeter (TC-PIIG system, Beijing Optical Instrument Co. Ltd., Beijing, China) was used to measure the color of selected *Grewia tenax* fruit samples, and the color scale L*a*b* values were recorded. A plastic bag containing the same quantity of samples was placed at the light port (50 mm in diameter). The values were read directly by the hunter lab digital colorimeter. We investigated the following parameters using a modified version of the method of [7]: lightness (L*), coordinate red/green (a*), and coordinate yellow/blue (b*).

Bulk density (BD)

The BD of the samples was determined according to a modified version of a method previously suggested by [8]. Samples were gently placed in a 15-mL graduated cylinder. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level after filling the 15-mL mark. The BD was calculated as the weight of sample per unit volume of sample (g/mL).

Determination of functional properties

Water and oil absorption (WAC and OAC) capacities

The WAC and OAC of samples were determined. Samples (1 g) were dispersed in 10 ml of distilled water and placed in pre-weighed centrifuge tubes. The dispersions were stirred occasionally, held for 5 min, and then subjected to centrifugation for 20 min at 500 rpm. Supernatant was poured in the graduated cylinder for the determination of oil absorption capacity, and the same method was used for WAC [9].

Foaming capacity (FC)

FC was investigated according to a slightly modified version of the method described by [10]. Two grams of each sample were mixed with 100 mL of distilled water. This experiment was performed at room temperature. The solution was whipped with a high-speed homogenizer for 5 min. Foaming capacity was expressed as foam expansion immediately after whipping. The solution was then poured into a 250-mL graduated cylinder. The total sample volume was taken at 30 s for FC and calculated as in Eq. 1.

$$FC (\%) = \{(V_a – V_b) / V_b\} 100 \qquad (1)$$

where Va and Vb are the volumes before and after whipping, respectively.

Statistical analysis

The data were analyzed in terms of means ± standard deviations (± SD) (n = 3), and statistical analysis was performed using IBM SPSS Statistics for Windows version 19.0 (SPSS Inc., Chicago, IL, USA). A one-way analysis of variance (ANOVA) was used to determine significant differences between means, and Duncan's test was used to perform multiple comparisons between means. The significance level was defined as $p < 0.05$.

RESULTS

Chemical composition analysis

The chemical composition of *Grewia tenax* fruit (seeds, peel, and pulp) is shown in Table 1.

Table 1: Chemical composition of seeds, peel, and pulp of *Grewia tenax* fruits (%)

Content	Composition (%)		
	Seed	Peel	Pulp*
Moisture	5.11±0.06^c	6.23±0.08^b	86.52±0.02^a
Crude fiber	13.42±0.80^b	15.33±0.04^a	8.13±0.60^c
Ash	4.0±0.05^a	4.0±0.02^a	1.0±0.03^b
Crude protein	7.21±0.33^a	2.12±0.03^c	3.58±0.12^b
Crude fats	10.7±0.09^a	1.7±0.01^b	0.2±0.01^c
Carbohydrate	59.56±1.78^c	70.74±0.18^b	87.09±0.76^a

*Values are means ± SDs; values in the same row with different superscript letters differed significantly (p ≤0.05) using Duncan's least significant test. *on a dry-weight basis*

Table 2: Mineral content of seeds, peel, and pulp of *Grewia tenax* fruits (expressed as mg/100g)

Mineral content	Seeds	Peel	Pulp
Copper (Cu)	1.35±0.01a	0.78±0.003b	0.27±0.001c
Chromium (Cr)	0.02±0.002a	0.02±0.001a	0.01±0.003b
Lead (Pb)	0.01±0.005b	0.01±0.001a	0.015±0.002a
Manganese (Mn)	1.70±0.04a	0.62±0.03b	0.28±0.03c
Potassium (K)	400±0.11b	502.5±0.09a	300±0.11c
Sodium (Na)	5.82±0.03c	19.32±0.02a	11.57±0.13b
Iron (Fe)	3.65±0.07b	3.25±0.05b	4.00±0.11a

Values are means ± SDs; values in the same row with different superscript letters differed significantly (p ≤0.05) using Duncan's least significant test

Based on dry weights, the moisture distribution of *Grewia tenax* fruits was as follows: seeds, 5.11 %; peel, 6.23 %; and pulp, 86.52 %. The crude protein content of seeds, peel, and pulp were 7.21, 2.12, and 3.58 % respectively. The seeds contained more fats (10.7 %) than did the peel and pulp (1.7 and 0.2 %, respectively). The carbohydrate content was 59.56 % for seeds, 70.74 % for peel, and 87.09 % for pulp.

Mineral composition

The mineral contents of the seeds, peel, and pulp of *Grewia tenax* fruits are shown in Table 2. The highest values of K and Na were found in the peel, and these differed significantly ($p \le 0.05$) compared with the values for the seeds and pulp. The levels of Cu and Mn in the seeds differed significantly ($p \le 0.05$) compared with those of the peel and pulp, whereas Cr and Fe were present at low levels in all samples.

Amino acid composition

The concentration of amino acids in the samples is shown in Table 3. A total of 18 amino acids were present in the different parts of *Grewia tenax* fruits. The pulp contained the essential amino acids, histidine, thereonine, valine, isoleucine, and lysine at concentrations of 4.29, 6.43, 9.70, 9.54, and 6.46 g/100g, respectively.

Volatile compounds

The volatile components of the seeds, peel, and pulp of *Grewia tenax* fruits are summarized in Table 4. More than 82 volatile compounds were identified in the pulp, whereas 43 and 33 components were found in the peel and seeds, respectively. These components were found in different percentages in various parts of the fruits. The most common volatile component was 5, 9-undecadien-2-ol, 6, 10-dimethyl, with a content ranging from 1.01 % in the pulp to 22.18 % in the peel, whereas it was not present in the seeds. The ethanol content was 16.68, 3.08 and 2.97 % in the pulp, peel, and seeds, respectively. Total concentrations of the volatile components of seeds, peel, and pulp of *Grewia tenax* fruits were 42.1, 97.9 and 71.4 %, respectively.

Color

The results obtained for color measurements by hunter color values (L*, a*, b*) for different samples are presented in Table 5. The lightness (L*) values of seeds and peel ($p > 0.05$) were 68.38 and 68.81, respectively, whereas pulp had a lower value, 45.84. In terms of the red–green coordinate, the redness (a*) value for pulp was high, 21.42, whereas those for peel and seeds were 10.49 and 5.06, respectively ($p > 0.05$).

Table 3: Amino acid concentrations in the seeds, peel, and pulp of *Grewia tenax* fruits (g/100g) and the Daily Recommended Allowance (DRA) for children and adults according to the Food and Agriculture Organization of the United Nations / World Health Organization / United Nations University (FAO/WHO/UNU)

Essential Amino Acids (EAA)	IAA g/100g			FAO/WHO/UNU[a]	
	Seeds	Peel	Pulp	Child	Adult
Histidine	2.03	8.56	4.29	1.90	1.60
Thereonine	2.72	1.56	6.43	3.40	0.90
Arginine	9.12	4.15	3.59	-	-
Valine	4.90	2.23	9.70	3.50	1.30
Methionine	1.72	9.32	1.40	2.70[b]	1.70[b]
Phenylalanine	4.66	2.05	1.06	6.30[c]	1.90[c]
Isoleucine	3.41	1.92	9.54	2.80	1.30
Leucine	6.04	2.66	1.20	6.60	1.90
Lysine	1.23	1.89	6.46	5.80	1.60
Total	35.83	34.34	43.67	33	12.2
Non-essential amino acids					
Tyrosine	1.29	1.01	4.93		
Cysteine	4.19	1.22	4.87		
Aspartic acid	8.57	5.41	2.63		
Glutamic acid	1.90	4.56	2.18		
Serine	3.20	1.67	6.46		
Glycine	4.95	2.90	1.01		
Arginine	9.12	4.15	3.59		
Proline	4.54	1.76	1.00		
Alanine	3.81	2.15	1.10		
Total	41.57	24.83	27.77		
	Proportion of different of amino acids[d]				
Large hydrophobic	25.27	19.34	24		
Polar	11.4	5.46	22.69		
Charged	22.85	24.57	19.15		

[a]FAO/WHO/UNU: Daily health requirements for children and adults from observed intakes (FAO, 2007).[b]Requirements for methionine + cysteine. [c]Requirements for phenylalanine + tyrosine. IAA: Indispensable amino acid of Grewia tenax fruits. [d]Large hydrophobic (valine, leucine, isoleucine, methionine, proline, and phenylalanine), polar (serine, thereonine, tyrosine, and cysteine), and charged amino acids (lysine, arginine, histidine, aspartic acid, and glutamic acid)

In terms of the yellow–blue coordinates, the yellowness (b*) values were 28.71, 28.60, and 19.55 for pulp, peel, and seed samples, respectively ($p < 0.05$).

Bulk density (BD)

The BD values of *Grewia tenax* (seeds, peel, and pulp) samples, which are shown in Figure 1, were 0.55, 0.56, and 0.94 g/ml, respectively ($p < 0.05$).

Water and oil absorption capacities (WAC and OAC)

Variations in the WAC and OAC among the different samples are presented in Figure 1. The results indicate that pulp had the highest WAC (3.3 ml/g), followed by the peel (2.5 ml/g), whereas the lowest result was observed for seeds (1.2 ml/g). The OAC of different samples ranged from 1.16 to 3.6 ml/g.

Foaming capacity (FC)

The FC results indicate that seeds had the highest value (8.62 %), followed by pulp (6.51 %), and then peel (5.5 %).

DISCUSSION

The moisture content of seeds was lower than that reported [2] previously (7.30 %) for *Grewia tenax* fruits. Moisture is an important parameter in the storage of flours, with levels greater than 12 % allowing for microbial growth [8]. Table 1 shows that the fiber content of *Grewia tenax* pulp was lower than that for its peel and seeds. The ash content of pulp was lower than that of peel and seeds. The protein content of seeds was similar to that reported previously (7.50 %) [2]. The carbohydrate content was higher in the pulp than in the peel and seeds. The levels of potassium were higher than those of the other minerals in all samples (peel, seeds, and pulp).

Table 4: Volatile compounds and the chromatographic profile of seeds, peel, and pulp of (*Grewia tenax)* fruit

No.	Constituent	RT*			Relative peak area %		
		Seeds	***Peel***	***Pulp***	***Seeds***	***Peel***	***Pulp***
1.	Acetic acid, ethyl ester	3.46	-	3.45	1.71	-	0.87
2.	Ethanol	4.24	4.25	4.27	2.97	3.08	16.68
3.	Propane, 2-(ethenyloxy)-	-	5.18	-	-	1.01	-
4.	2-Pentanone	-	5.18	4.96	-	-	1.03
5.	Benzeneacetic acid, 2-tetradecyl ester	6.26	-	-	1.02	-	-
6.	2-Butenal	-	6.27	-	-	0.98	-
7.	Hexanal	7.28	7.28	7.26	-	6.35	1.39
8.	2-Propanol, 1-methoxy-	-	8.46	9.01	-	4.40	-
9.	1-Butanol	-	8.95	9.42	-	3.87	10.7
10.	Heptanal, 2-methyl-	-	-	9.65	-	-	1.33
11.	1-Butanol, 3-methyl-	10.49	10.50	10.76	0.53	0.52	2.33
12.	Furan, 2-pentyl-	11.03	11.03	-	0.59	0.50	-
13.	Heptadecane	11.35	11.35	-	1.01	0.74	-
14.	1-Pentanol	11.53	11.53	11.71	5.42	0.97	1.25
15.	Octanal	12.40	12.40	12.20	-	0.81	0.68
16.	2-Butanone, 3-hydroxy-	-	12.24	12.52	-	0.96	-
17.	2-Penten-1-ol, (Z)-	-	13.17	13.25	-	2.16	1.29
18.	6-Methyl-5-hepten-2-one	13.51	13.51	13.44	0.58	1.27	0.71
19.	1-Hexanol	13.90	13.90	13.94	7.24	1.79	4.68
20.	Tridecane, 3-methyl-	14.16	14.16	-	0.88	0.61	-
21.	Pentadecane	14.59	14.81	-	-	3.23	-
22.	Nonanal	14.68	14.69	14.56	9.45	15.73	5.86
23.	1-Octen-3-ol	15.71	15.71	15.69	4.00	0.65	0.50
24.	Decanal	16.51	16.51	16.43	2.80	4.72	1.09
25.	Benzaldehyde	16.87	-	16.85	-	-	0.59
26.	1-Octanol	-	17.40	17.39		0.69	1.77
27.	2,3-Butanediol, [S-(R*,R*)]-	17.63	17.63	17.64	-	0.59	0.63
28.	Butyrolactone	18.39	-	18.41	1.06	-	-
29.	Silanediol, dimethyl-	-	-	18.55	-	-	2.12
30.	1-Nonanol	18.79	18.79	18.77	1.24	1.16	2.41
31.	2,5-Heptadien-1-ol, (Z,E)-	-	19.15	19.14	-	0.78	1.42
32.	2-Furanmethanol, 5-methyl-	-	-	19.54	-	-	1.43
33.	5,9-Undecadien-2-one, 6,10-dimethyl-,(E)	-	21.15	21.12	-	1.81	2.04
34.	Benzyl alcohol	-	21.38	21.38	-	-	1.99
35.	Phenol, 2,6-bis(1,1-dimethylethyl)-4-met	21.76	-	21.73	0.69	-	-
36.	Phenylethyl Alcohol	-	21.78	21.78	-	0.85	3.04
37.	5,9-Undecadien-2-ol, 6,10-dimethyl-	-	22.18	22.18	-	22.18	1.01
38.	2(4H)-Bezofuranone, 5,6,7,7a tetrahydro	-	26.18	26.18	-	1.17	1.64
39.	1,2-Benzenedicarboxylic acid, bis(meth)	27.97	27.98	27.97	0.91	14.36	0.92
	Total				42.1	97.9	71.4

** RT = retention time per minutes; "-" means the content <0.5 %*

Table 5: Color parameters of different parts of (*Grewia tenax*) fruits: seeds, peel, and pulp

Parameter	Sample		
	Seeds	***Peel***	***Pulp***
L*	68.38±0.05[a]	68.51±0.39[a]	45.84±0.03[b]
a*	5.06±0.04[c]	10.49±0.10[b]	21.42±0.06[a]
b*	19.55±0.19[b]	28.60±0.05[a]	28.71±0.03[a]

Values are means (± SDs), n =3. Mean values in the same row with different letters differed significantly (p <0.05). L*a*b* is an international standard for color measurements L* is the lightness component, which ranges from 0 to 100, and the parameters a* (from green to red) and b* (from blue to yellow) are the two chromatic components, which range from 120 to 120

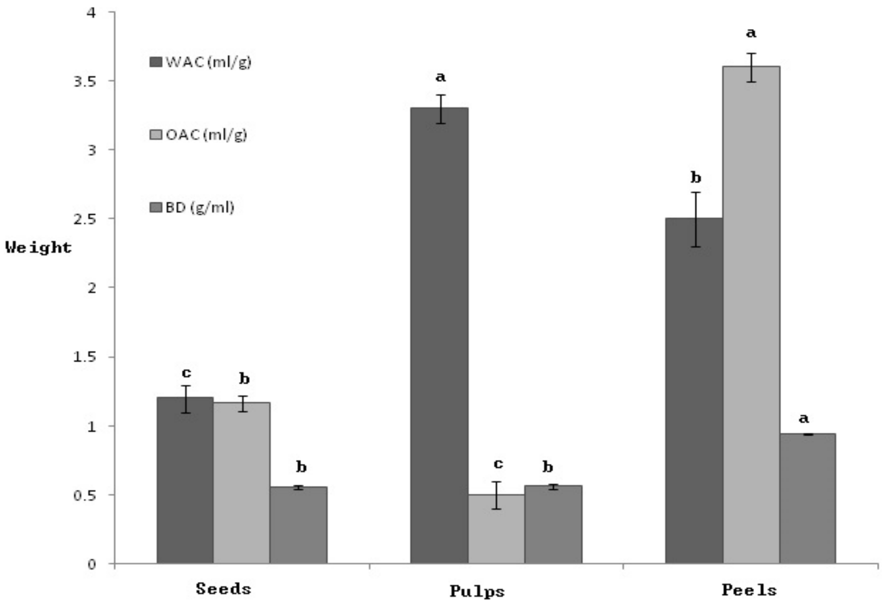

Figure 1: Water absorption capacity (WAC), oil absorption capacity (OAC), and bulk density (BD) of different parts of *Grewia tenax* fruits: seeds, pulp, and peel. Means ± SD (n = 3). Mean values with different letters differed significantly (p <0.05)

The results show that *Grewia tenax* contains many important minerals that can be used in cereal and cereal products, especially flour for baked good, to improve their nutritional properties. Mineral elements are considered to be essential substances for the healthy functioning of an organism [14,15].

The quantities of essential amino acids was compared with those found by a previous report [12] in terms of the daily amounts currently recommended for an adult human (standard protein). The peel and pulp contained higher levels of some amino acids than the requirements for adult humans issued by the Food and Agriculture Organization of the United Nations/World Health Organization/United Nations University (FAO/WHO/UNU), which indicates that they could be used in some medical applications as a good source of amino acids. Different parts of *Grewia tenax* fruits contained higher amounts of charged amino acids than of large hydrophobic and polar amino acids.

A small subset of these compounds can be sensed by animals and humans, with the volatile profiles being the defining elements of the distinct flavors of individual foods. The volatiles responsible for flavor are derived from an array of nutrients, including amino acids, fatty acids, and carotenoids. The predominance of volatiles derived from essential nutrients and health-promoting compounds suggests that these volatiles provide important information about the nutritional composition of foods. However, *Grewia tenax* fruits can be considered to be a good source of volatile compounds and can be used as an additive to many foods or beverages to provide a better taste and flavor.

Color is one of the most important quality parameters in food products, and color changes caused by dietary fibers limit their potential application in food [16]. The high L* values of seeds, peel, and pulp, together with their high water absorption capacity (WAC) values, indicate a likely improvement in the lightness of food products to which they are added. BD is a reflection of the load that a sample can carry if it is allowed to rest directly on another, and the BD of flour can be used to determine its packaging requirements [8].

The WAC of pulp was higher than those of the other samples, which suggests that it could be useful in the industrial production of food and food products. The OAC values of the different samples are presented in Figure 1. The OAC is of great importance from an industrial perspective, because it reflects the emulsifying capacity.

FC is one of the most important quality parameters in food products and food. In this study, the seeds of *Grewia tenax* had the highest FC.

CONCLUSION

The findings of this study indicate that the chemical composition, functional properties, and volatile compounds of the seeds, peel, and pulp of *Grewia tenax* differed significantly. It was found that the pulp had highest levels of essential amino acids (EAA), which is the most important quality parameter in food products. Furthermore, the use of *Grewia tenax* fruits to meet human nutritional 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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