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Nutritional Composition of *Grewia* Species (*Grewia tenax* (Forsk.) Fiori, *G. flavescens* Juss and *G. Villosa* Willd) Fruits

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Abstract: Analysis of the nutritional composition of fruits of three species of *Grewia* (G. *tenax, G. flavescens* and *G. villosa*) were carried out. The proximate composition as well as the content of amino acids, mineral elements (K, Ca, Mn, Fe, Cu and Zn), tannin and pectic substances was determined. The results, which referred to (%) dry weight, showed that *G. tenax, G. flavescence* and *G. villosa* contained 13, 15 and 14% moisture; 20.5, 42.8 and 25.5% crude fibre; 5.2, 3.4 and 4.0% ash and 66, 75 and 84% carbohydrates, respectively. *G. tenax* had the highest value of reducing sugar (13.8 %) and starch content (44.4%). The three species contained low amount of protein and fats, which ranged from 6.7% (*G. villosa*) to 8.7% (*G. flavescens*) and 1.30% (*G. flavescens*) to 1.7% (*G. tenax)* respectively. They all had similar distribution of amino acids but in varying amounts. The essential amino acids detected in *G. tenax* fulfil the requirements of the FAO/WHO 'standard protein'. The predominant mineral in the three species was potassium, which ranged from 817 mg/100 g (*G. tenax*) to 966 mg/100 g (*G. villosa*). The three *Grewia* spp contained remarkably high amounts of iron with values ranged from 20.8 mg/100 g (*G. tenax*) to 29.6 mg/100 g (*G. villosa*). This finding supports the traditional use of *Grewia spp* in the treatment of anaemia. Tannin content was low and ranged from 1.13% (*G. flavescens*) to 2.46% (*G. villosa*). Pectic substances content was higher in *G. tenax* (13.02%) and *G. villosa* (11.72%) than in *G. flavescens* (6.26%). The results of this study provide evidence that these local traditional fruits could be important contributors to improving the nutritional content of rural and urban people.

Key words: Amino acids, *G. tenax* (Forsk.) Fiori, *G. villosa* Willd, *Grewia flavescens* Juss, mineral, pectic substances, proximate, tannin

INTRODUCTION

It has been well documented that during times of natural and man-made disasters, populations suffering from severe food shortages can become heavily reliant on wild food plants for survival (Leborgne *et al*., 2002). While every measure is being taken to boost food production by conventional agriculture, a lot of interest is currently being focused on the possibilities of exploiting the vast numbers of less familiar plant resources existing in the wild (Rao, 1994; Felger, 1979). Many such plants have been identified, but the lack of data on their chemical composition has limited the prospects for their utilization (Vijayakumari *et al*., 1994; Viano *et al*., 1995). Most reports on some lesser known and unconventional crops indicate that they could be good sources of nutrients, and many have the potential of broadening the present narrow food base of the human species (Janick, 1990).

Grewia tenax (Forsk.) Fiori, *G. flavescens* Juss 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 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 (FAO/WHO, 1988). *G. tenax* fruit was reported to contain large amounts of iron (Maydell, 1990) and as such is used for treatment of anaemia and malaria (Sulieman and Eldoma, 1994).

However, limited research has been carried out on exploitation and utilization of *Grewia* species fruits as a potential food source. Furthermore, their good taste is acceptable to the human palate. The main target of this work was to study the nutritional potential of these three species.

MATERIALS AND METHODS

Plant materials: This study was conducted on October 2008. Fruits of *G. villosa* and *G. flavescens* were collected

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from Kordofan (Western Sudan) and those of *G. tenax* were collected from the campus of University of Khartoum. All species were authenticated at the Herbarium of Botany Department, University of Khartoum where voucher specimens were deposited.

Preparation of powders: Fruits were washed with water to remove dirt and foreign materials and dried at shade. Finally, fruits were ground, sieved through mesh screen and stored in a refrigerator at 5ºC.

Proximate analysis: Moisture, ash, crude fibre, crude protein and fat were analysed by the methods described in AOAC (1990). Moisture was determined by drying a representative 2 g sample in an oven with air circulation at 100-105ºC for 3 h. Ash content was determined by the incineration of a sample (4 g) in a muffle furnace at 600ºC for 6 h until the ash turned white. For crude fibre, a moisture free and ether extracted sample was first digested with dilute H_2SO_4 and then with dilute KOH solution. Crude protein was estimated by the Kjeldahl method. Total protein was calculated by multiplying the evaluated nitrogen by 6.25. Fat was determined by petroleum ether extraction in a Soxhlet apparatus. A representative 3 g of sample was extracted for 6 h. Carbohydrate content was estimated by subtracting the sum of the weights of protein, fibre, ether extract and ash from the total dry matter and reported as nitrogen-free extractives (NFE by difference) (FAO/WHO/UNU (1981). All determinations were in triplicates.

Amino acids analysis: Amino acid composition of samples was measured as hydrolysate using amino acid analyzer (Sykam-S7130) based on high performance liquid chromatography technique. Sample hydrolysis was prepared following the method of Moore and Stein (1963). 200 mg of sample were taken into a hydrolysis tube. 5 ml 6 N HCL were added to the sample. The tube was tightly closed and incubated at 110ºC for 24 h. After incubation period, the solution was filtered and 200 µl of the filtrate were evaporated to dryness at 140 ºC for an hour. The hydrolysate was diluted with 1 ml of buffer (citrate buffer pH 2.2). Aliquot of 150 µl of sample hydrolysate was injected in cation separation column at 130ºC. Ninhydrin solution and an eluent buffer (the buffer system composed of solvent A of pH 3.45 and solvent B of pH 10.85) were delivered simultaneously into a high temperature reactor coil (16 m length) at a flow rate of 0.7 ml/min. The buffer/ninhydrin mixture was heated at 130ºC for 2 min to accelerate chemical reaction of amino acid with ninhydrin. The products of the reaction mixture were detected at wavelength of 570 nm on a dual channel photometer. The amino acids were identified by their retention time and wavelength ratio calculated from the areas of standards obtained from the integrator and expressed as percentages.

Table 1: Proximate composition, reducing sugar and starch values of *Grewia* spp (Expressed as (%) on DW basis)

	*G. tenax**	*G. flavescence**	*G. villosa**
Moisture	13±0.17	15±0.19	14±0.13
Fibre	20.5±0.11	42.8±0.14	25.5±0.08
Ash	5.2±0.09	3.4±0.10	4.0±0.12
Protein	7.7±0.12	8.7±0.10	6.7±0.06
Lipids	1.7±0.39	1.3±0.17	1.5±0.13
Carbohydrate	66±1.41	75±1.1	84±1.80
Reducing sugar	13.8±0.12	10±0.40	10.4±0.22
Starch	44.4±0.09	38.6±0.60	22.8±0.13

*: The data are mean values ± (SD) of three replicates

Mineral analysis: The mineral elements were determined on 0.3 g powder by the methods of Funtua (2004) using Energy Dispersive X-ray Fluorescence (EDXRF) transmission emission spectrometer carrying an annuar 25 mCi 109Cd isotopic excitation source that emits Ag-K X-ray (22.1 keV) and a Mo X-ray tube (50KV, 5mA) with thick foil of pure Mo used as target material for absorption correction. The system had a Canberra Si (Li) detector with a resolution of 170 eV at 5.9 keV line and was coupled to a computer controlled ADC- Card (Trump 8K). Measurements were carried out in duplicate.

RESULTS AND DISCUSSION

Proximate analysis: Data on proximate composition of *Grewia tenax*, *G. flavescens* and *G. villosa* fruits were given in Table 1. Moisture content ranged from 13% (*G. tenax*) to 15% (*G. flavescens*) on dry weight basis. These data were low when compared with the result obtained by Murray *et al.* (2001) for *G. villosa* (24%) and *G. bicolour* (26%) fruits. The three species contained low amount of protein, which ranged from 6.7% (*G. villosa*) to 8.7% (*G. flavescens*). However, these values were comparable to that obtained by Murray *et al.* (2001) for *G. villosa* (7.1%) and higher than the results obtained by Yadav (1999) and Morton (1987) for *G. asiatica* fruits (1.57 and 1.58% respectively). *G. flavescens* contained the highest value of crude fibre (42.8%) and *G. tenax* the lowest content (20.5%). The crude fibre content of all the studied *Grewia species* fruits was high when compared with the results of Yadav (1999) and Morton (1987) for *G. asiatica* fruits (5.53 and 1.77% respectively). The highest value of ash content was found for *G. tenax* (5.2%) followed by *G. villosa* (4%) and *G. flavescens* (3.4%) respectively. These values were comparable with that obtained by Murray *et al.* (2001) for *G. villosa* (4.8%) and higher than the result obtained by Yadav (1999) (1.1%) for *G. asiatica* fruits. The level of carbohydrate for the three species was high and ranged from a low of 66% (*G. tenax*) to a high 84% (*G. villosa*). These data may have nutritional interest. The reducing sugar and starch content were also given in Table 1. *G. flavescens* and *G. villosa* have similar reducing sugar content of values of 10 and 10.4% respectively, while *G. tenax* has higher value

Table 2: Amino acids composition of *Grewia species* (g/100g)

Amino acid	*G. tenax*	*G. flavescence*	*G. villosa*	Human requirement FAO/WHO (1991) Preschool child	School child	Adult
Histidine	2.0	0.89	0.89	1.9	1.9	1.6
Isoleucine	8.84	4.38	4.43	2.8	1.3	4.2
Leucine	11.09	5.69	4.37	6.6	4.4	1.9
Lysine	1.68	0.99	0.49	5.8	4.4	1.6
Methionine	1.89	1.18	0.82	-	-	-
Cystine	0.76	0.64	0.53	-	-	-
Met + Cys	2.65	1.82	1.35	2.5	2.2	1.7
Tyrosine	1.08	0.76	0.42	-	-	-
Phenylalanine	5.58	2.73	2.03	-	-	-
Tyr + Phe	6.66	3.49	2.45	6.3	2.2	1.9
Threonine	3.39	1.4	0.88	3.4	2.8	0.9
Valine	12.8	7.22	6.82	3.5	2.5	1.3
Serine	3.76	0.989	1.32			
Glutamic acid	7.01	3.09	2.38			
Aspartic acid	17.73	26.85	9.1			
Glycine	1.09	0.61	0.98			

(13.8%). Also, *G. tenax* has highest value of starch content (44.4%), followed by *G. flavescens* (38.6%) and *G. villosa* (22.8%). Simple sugar content of *G. villosa* fruits were found to be 62% as reported by Murray *et al.* (2001). Moreover, it was found that *G. asiatica* fruits had low values of total sugar content (10.27 and 21.1%) as reported by Yadav (1999) and Morton (1987) respectively. Among the three studied species the fat level were consistently low; 1.3% for *G. flavescens*, 1.5% for *G. villosa* and 1.7% for *G. tenax*. These values were similar to the results obtained by Yadav (1999) (1.82% for *G. asiatica*) and Murray *et al.* (2001) (< 2% for *G. villosa*) and higher than that of Morton (1987) (<0.1%) for *G. asiatica* fruits.

Amino acids content: Results of the composition of amino acids were shown in Table 2. Fourteen amino acids were present in the fruits of three species. *G. tenax* revealed the highest value for all the amino acids detected except for aspartic acid which was higher in *G. flavescens*. In fact, it was noted that aspartic acid was the predominant amino acid. The amount of essential amino acids was compared to the F.A.O. reference pattern. With the exception of lysine (for preschool child), the essential amino acids of *G. tenax* fulfil the requirements of the FAO/WHO 'standard protein'. The limiting amino acids in *G. flavescens* were histidine, lysine and threonine where as, sulfur-containing amino acids (cystine and methionine) were deficient for preschool and school children. The limiting amino acids in *G. villosa* were histidine, lysine and methionine and cystine in addition to threonine for preschool and school children.

Minerals content: Mineral element contents were shown in Table 3. Among the macroelements determined; potassium showed higher content than calcium. Potassium content was high in *G. villosa* (966 mg/100 g) followed by *G. flavescens* (877 mg/100 g) and *G. tenax*

Table 3: Minerals composition of *Grewia* spp (mg/100g dry weight)

Element	*G. tenax**	*G. flavecence**	*G. villosa**
K	817±0.02	877±0.03	966±0.06
Ca	790±0.15	269±0.11	536±0.01
Mn	5.1±0.08	0.1±0.07	0.1±0.11
Fe	20.8±0.01	26.9±0.13	29.6±0.05
Cu	1.5±0.07	1.1±0.05	1.2±0.04
Zn	1.9±0.03	1.1±0.01	2.5±0.01

*: The data are mean values ± (SD) of duplicates

(817 mg/100 g). Calcium content ranged from a low of 269 mg/100 g (*G. flavescens*) to a high of 790 mg/100 g (*G. tenax*). The three *Grewia* spp analysed in this study contained remarkably high amounts of iron with values ranged from a low of 20.8 mg/100 g (*G. tenax*) to a high of 29.6 mg/100 g (*G. villosa*). This finding supports the traditional use of *Grewia* spp in the treatment of anaemia. A study of the effect of aqueous extract of *G. tenax* fruit (AEGTF) on iron absorption by averted gut sac was carried out by Khemiss *et al.* (2006). They reported that addition of AEGTF at different concentrations favours significantly iron absorption. The maximum iron absorption was carried out in presence of AEGTF at 10 $mg.ml^{-1}$ and 5 min of incubation time in stomach, duodenum and jejunum. The three species showed low amount of copper and zinc and with the exception of *G. tenax,* manganese. *G. tenax* contained adequate manganese when compared with the recommended dietary allowance. Some cereal powders in the baking industry are very deficient in some elements. Fortification of these powders with Grewia fruits might improve their dietary properties.

Tannin and pectic substances: Tannin content was low and ranged from 1.13% (*G. flavescens*) to 2.46% (*G. villosa*) (Table 4). Tannin decrease feed intake, growth rate, feed efficiency and protein digestibility. Therefore, foods that have high tannin contents are harmful for health (Chung *et al.*, 1998). Pectic substances

Table 4: Tannin, and pectic substances values of *Grewia* spp (Expressed as (%) on DW basis)

Substance	*G. tenax**	*G. flavescence**	*G. villosa**
Tannin	1.13±0.01	2.18±0.07	2.46±0.11
Pectic substances	6.26±0.14	13.02±0.11	11.72±0.14

*: The data are mean values ± (SD) of three replicates

were found at high levels in *G. tenax* (13.02%) and *G. villosa* (11.72%) but with low value in *G. flavescens* (6.26%). Previous research has shown that pectin can suppress colonic tumor incidence in rats (Heitman *et.al.*, 1992) and inhibit cancer cell metastasis in mice and rats (Platt and Raz, 1992; Nangia-Makker *et al.*, 2002).

CONCLUSION

The results of this study potentially indicate that the fruits of the studied *Grewia* spp. are rich in nutrients and they could be important contributors to improving the nutritional content of rural and urban people in Sudan. Furthermore, these species can be considered as a serious source of iron supplements. Further investigation into possible toxic and antinutrient factors, digestibility, is still required before recommendations are made.

Abbreviations:
AOAC: Association of Official Analytical Chemists.
FAO: Food and Agricultural Organization
DW: Dried weight

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