Journal of Agri-Food and Applied Sciences
Available online at jaas.blue-ap.org
©2014 JAAS Journal. Vol. 2(2), pp. 39-44, 28 February, 2014
E-ISSN: 2311-6730

Characterization of some Sudanese Edible Forest Fruits

Nawal A Abdel-Rahman*, Innam Awad I and ELrakha Elshafe'a BB

Food Research Centre, P. O. Box 213, Khartoum North, Sudan

Corresponding Author: Nawal A Abdel-Rahman

Received: 25 January, 2014 *Accepted: 15 February, 2014* *Published: 28 February, 2014*

ABSTRACT

Non-wood forest products (NWFPs) have received high attention since they have important usages throughout the world during the last few years, and Forest fruits are one of which. The objectives of this work were directed towards the study of characterization of *Hyphaene thebaica* L (Doum), *Randia geipaeflora* (Kirkir), *Naucleae latifolia* (Karmadoda) and *Grewia tenax* (Godeim) forest fruits. These fruits were subjected to physico-chemical analyses. The physical properties included colour, dimensions, weight and percentages of edible part, seeds and peels, as well as figures and colours. However, the edible portions were analyzed for moisture, crude protein, fats, crude fibre, ash, carbohydrates and energy value, in addition, to sugars, ascorbic acid, ß-carotene and pectin. The fruits showed that they have good quantities of C. protein, C. fibre and ash. As well as, they contain high percentages of carbohydrates and excellent quantities of ascorbic acid of 156.25, 153.9, 76.33 and 63.64 mg/100g for *Randia geipaeflora*, *Naucleae latifolia*, *Grewia tenax* and *Hyphaene thebaica* L, respectively. The *Naucleae latifolia* and *Randia geipaeflora* contain adequate amounts of ß-carotene of 178.45 and 115.61 IU vitamin A/100 g, respectively. On the other hand, high values of energy were obtained by these fruit, which ranged from 310 to 372 Kcal/100g.

Keywords: *famines, forest fruits, indigenous, non-wood forest products.*

INTRODUCTION

Over thousands of years millions all over the world relied on forests as a resource for their livelihood, and remained food forests (Powell wt , 2011; Vinceti, 2008), insects and wildlife as important components in the diet of rural areas (FAO, 2013). Forests and trees out-side forests contribute to the livelihoods of more than 1.6 billion people (FAO, 2010). Trees and shrubs are providing a multitude of useful products especially in semi-arid areas (Jens, 2002). With a new understanding of the value of indigenous fruit trees in providing food security and meeting nutritional needs, these plants will receive attention, because they are found naturally and traditionally managed in Africa forests and wooded lands (Ofori, 2014). As well as, it is good sources of nutrients, protein and fibre than common fruits and vegetables for rural population (Johns and Sthapit, 2004; Leakey, 1999). Numerous wild fruits have a high vitamins and minerals, *Grewa tenax* is a good source of iron for children under 8 years old (Kehlenbeck, 2013). *Tamarindus indica* L. and *Adansonia digitata* L. are important sources of energy because they contain high sugar percent (FAO, 2013).

Sudan is considered one of the largest countries in Africa with an area which includes different ecological zones from the desert in the North to the tropical rainforest in the South (Ngambi, 2013). The savanna areas are vast, and occupy at least 37% of the entire land in Sudan, and which are habitats for numerous plant species (El-Amin, 1990). The fruits of forest plants species played an important role in the diet of people in the savanna belt of Sudan especially during food shortages and famines (Kordufan and Darfur; 1983/84). During this time, the forest fruits were the main ingredients given as a gesture of hospitality and generosity (Abdel Muti, 2002). However, the information on their physical properties and chemical composition is still limited. It is high time to conduct research for the proper assessment and maximum utilization of edible forest fruits and possible use of fresh products as table and processed items; emphasizing the populating, nutritional and

economic value (Abdel-Rahman, 2011). This study was therefore undertaken to study the characterization of few indigenous fruits which included *Randia geipaeflora*, *Naucleae latifolia*, *Grewia tenax* and *Hyphaene thebaica* L.

MATERIALS AND METHODS

Edible forest fruits, Doum (Figure 1), Kirkir (Figure 2), Karmadoda (Figure 3) and Godeim (Figure 4) were obtained from ElObaid Research Station, Sudan. Ripe fruits of the four types were used fresh.

Fruits were peeled, and then doum and kirkir fruits were crushed, whereas karmadoda fruits were cut into small pieces and the seeds were removed from godeim.

Physical properties

The physical properties studied included colour, dimensions (length, width and thickness), weight and percentages of edible part, seeds and peels. The diameters of fruits were recorded using vernier calipers (model: E H B Stainless, Hardened, Germany). In addition, the whole fruits, edible part, peel and stones of fruits were weighed by a top loading balance (model: D0001 – H R 120, A & D Company, Limited E C).

Physico-chemical analyses:

All chemicals and reagents, used in this study, were of analytical grade.

The moisture, crude protein, fats and ash were determined according to methods described in the AOAC (2000), while the crude fibre was determined according to AOAC (1990). Available carbohydrates were calculated by subtracting the sum of fat, protein, fibre and ash as a percentage from 100 as described by West et al. (1988). The caloric values of the different samples were calculated according to IMNA (2002). The total and reducing sugars were evaluated by HPLC according to Bagdanov and Baumann (1988), quantities of ascorbic acid (vitamin C) were calculated according to Ranganna (2001). The method used to evaluate beta-carotene was a modification of the HPLC method described by Dietz et al. (1988). Quantitative determination of total pectin was estimated according to the AOAC (2000).

Statistical analysis

Replicates of each sample were analyzed using Statistical Analysis System (SAS). The randomized complete design (RCD) was adopted for this study. The analysis of variance (ANOVA) and least significant difference (LSD at 5 %) were used to separate the means according to Mead and Curnow (1983).

Figure 1. Doum fruits
The source: This study

Figure 2. Kirkir fruits

The source: This study

Figure 3. Karmadoda fruits.
The source: This study

Figure 4. Godeim fruits
The source: This study

RESULTS AND DISCUSSION

Physical properties

The physical properties of forest fruits were studied for three sizes of fruits: small, medium and large. Results of physical properties (Tables 1, 2, 3 and 4) were in agreement with results reported by Vogt, (1995) and El-Amin, (1990). However red colour of kirkir was reported by Abdel Muti, (2002). The weight of godeim fruit was obtained from 100 seeds, and which weighed 14.0 g. 52.20 % of this weight is edible part and peels together, consequently 47.80 % is seeds.

Physico-chemical composition

Physico-chemical composition of forest fruits are showed in Table 5. The moisture content of the forest fruits was in the range from 5.47 % (doum) to 60.52% (karmadoda), the first value was higher than the findings of FA0, (2006) for African doum of 4.00 %. While, the second value was not coping with the result (70.1 %) reported by Kuria, (2005). The differences in moisture content are influenced by cultivation and post-harvest conditions (Bates, 2001).

The protein content obtained ranged from 3.80 to 7.71% for doum and kirkir, respectively. The value obtained for doum was similar to the value of African doum (3.80 %). Layman, (2003) mentioned that the minimum recommendation target of dietary protein of approximately 70 g/day for adults. Moreover, the plants are inexpensive source of protein; therefore kirkir could be exploited for protein supplementation. The changes in protein contents however, indicate variations in metabolic activity during the different development stages (Wills, 1981).

Kirkir gave the highest fat content (2.35 %), and doum fruit gave the lowest value (0.95 %). Abdel Muti (2002) reported 1.20 % for kirkir and Nwosu et al, (2008) recorded the same value for doum.

Values of crude fibre content varied from 7.30 (godeim) to 18.89 % (kirkir), but most values were in the range from 16.03 to 18.89 %. These results were between the range of 2.30 – 45.30 % obtained by Saka et al. (1994) for some fruits of wild trees from Malawi.

The result of ash contents of the forest fruits ranged between 2.48 % for karmadoda to 7.17 % for doum. The last result is exactly coincides to 7.17 % and higher than 2.03 % recorded by Abdel Rahman, (2007) for two Sudanese varieties of mango called Baladi and Abu-Samaka. This increase in ash content gives a sign to increase of minerals content of doum fruit.

Carbohydrate content of fruit ranged from 67.42 to 84.49 % for kirkir and godeim, respectively. This level is superior than the range of 3.00 - 25.00 % mentioned by Bates et al, (2001) for some common fruits.

The forest fruits recorded high percentages of crude protein, fat, crude fibre and carbohydrate. Consequently, this designate that the fruits constitute significant source of energy. The energy values obtained were 309.90, 327.28, 338.49 and 371.98 Kcal for doum, kirkir, karmadoda and godeim, respectively.

The highest total sugars (83.04 %) were recorded for godeim and the lowest (29.59 %) for kirkir, whereas the maximum level of reducing sugars was 77.05 % (godeim) and lowest was 4.67 % (doum). The values of total sugars in this study were higher than 15.21, 12.30 and 9.82 % for apple, pineapple and orange, respectively obtained by Fasoyiro et al, (2005). These differences could be attributed to the difference between species and varieties. Abdel Muti, (1991) reported that "Godeim have a very high level of sugars in the form of D-glucose and D-fructose which are readily available nutritionally".

Ascorbic acid content of the investigated plants varied between 31.74 – 389.82 mg/100g. Rathore, (2009) gave a vitamin C content of 30.00 mg /100g for orange. Moreover, the values are within the range of Baobab (*Tabaldi*) of 150 – 499 mg/100g recorded by Manfredini, (2002).

Doum fruit contains low level of ß-carotene; 27.49 IU vitamin A/100 g; while karmadoda and godeim contains high level of 178.45 IU vitamin A/100 g. These results are within the range from 0 to 4162.5 IU vitamin A/100g for pumpkins (Cucurbitaceae) reported by Adebooye, (2007).

The studies of ß-carotene during storage and processing of vegetables showed no definite trend of nutrient retention, but fluctuate among samples. The decrease in ß-carotene during thermal processing was negligible particularly at the temperature and time of preparation of sample (Howard et al., 1999). According to Karel et al, (2003) the D value which is the time needed to reduce the concentration of vitamin A by 90 % at 121 °C was reported 12.4 days.

The pectin content of forest fruits were 0.27 % (kirkir) - 1.02 % (karmadoda and godeim). The value of doum fruit is within the range from 0.28 to 0.48% stated by Zyren et al, (2006) for 10 kinds of fruits. Whereas, the higher values were cope with level reported by Ibrahim et al, (2000) to Halawy date cultivar.

The data appear to designate that all samples are important sources of nurture crude protein, crude fibre and ash (mineral); in addition, to carbohydrates and energy values. Karmadoda is excellent source of vitamin C, kirkir and karmadoda are best source of ß-carotene. These forest fruits require more investigation in the area of nutritive value, as the determination of abundant elements and amino acids profile.

Table 1. The physical properties of forest fruits

Parameter	Doum	Kirkir	Karmadoda	Godeim
Figure	Not symmetric	Bally	Bally	Not symmetric
Skin colour	Brown to red	Bright yellow- brown	Crimson	Orange
Edible part colour	Bright yellow	Bright yellow-yellow	Red – brown	Bright orange
Taste	Sweetly	Acidic	Acidic sweet	Very sweet
Seeds count	Single	2 - 5	Numerous	2 - 4

Table 2. Physical properties of different sizes of doum fruit

Parameter	Fruit size			$Lsd_{0.05}$	$SE\pm$
	Small	medium	Large		
Length (cm)	5.01 ± 0.03^{c}	5.73 ± 0.01^{b}	8.29 ± 0.05^{a}	0.06318	0.01826
Width (cm)	4.62 ± 0.08^{c}	5.67 ± 0.03^{b}	6.43 ± 0.06^{a}	0.1264	0.03651
Thickness (cm)	5.12 ± 0.07^{c}	5.35 ± 0.02^{b}	6.15 ± 0.06^{a}	0.1094	0.03162
Weight (g)	100.22 ± 0.2^{c}	113.31 ± 2.07^{b}	137.22 ± 0.5^{a}	2.474	0.7151
Edible part (%)	30.87 ± 0.38^{b}	32.53 ± 0.89^{a}	22.37 ± 0.12^{c}	1.127	0.3256
Seeds (%)	63.12 ± 0.60^{a}	56.82 ± 0.16^{c}	61.65 ± 0.60^{b}	0.9929	0.2869
Peels (%)	6.27 ± 0.11^{c}	10.97 ± 0.10^{b}	15.65 ± 0.68^{a}	0.8041	0.2324

***** Means±SD bearing different superscript letters within rows are significantly different (P≤0.05)

Table 3. Physical properties of different sizes of kirkir fruit

Parameter	Fruit size			$Lsd_{0.05}$	± SE
	Small	Medium	Large		
Length (cm)	1.05±0.17[c]	1.58±0.02[b]	2.03±0.05[a]	0.2095	0.06055
Width (cm)	0.92±0.02[c]	2.08±0.03[b]	2.22±0.07[a]	0.08935	0.02582
Thickness (cm)	0.90±0.10[c]	2.03±0.03[b]	2.23±0.03[a]	0.1264	0.03651
Weight (g)	4.09±0.01[c]	6.78±0.03[b]	9.46±0.02[a]	0.0006318	0.0001826
Edible part (%)	13.99±0.04[c]	30.83±0.07[b]	35.59±0.50[a]	0.5825	0.1683
Seeds (%)	64.87±0.76[a]	49.80±0.05[c]	53.07±1.00[b]	1.453	0.4199
Peels (%)	20.83±0.30[a]	19.49±0.13[b]	11.43±0.42[c]	0.6093	0.1761
Count of seeds	2.00±0.00[c]	4.00±0.00[b]	5.00±0.00[a]	0.0006318	0.0001826

* Means±SD bearing different superscript letters within rows are significantly different (P≤0.05)

Table 4. Physical properties of different sizes of karmadoda fruit

Parameter	Fruit size			$Lsd_{0.05}$	± SE
	Small	Medium	Large		
Length (cm)	1.62±0.03[c]	2.78±0.04[b]	3.78±0.21[a]	0.2527	0.07303
Width (cm)	1.62±0.02[c]	2.81±0.14[b]	4.52±0.11[a]	0.2095	0.06055
Thickness (cm)	1.65±0.05[c]	2.73±0.04[b]	3.70±0.17[a]	0.2095	0.06055
Weight (g)	20.38±0.65[c]	29.76±0.22[b]	43.47±0.10[a]	0.8017	0.2317
Edible part and seeds (%)	94.42±1.90[a]	94.04±0.10[a]	92.47±0.01[a]	2.192	0.6335
Peels (%)	5.95±0.89[b]	6.00±0.14[b]	7.55±0.04[a]	1.042	0.3011

* Means±SD bearing different superscript letters within rows are significantly different (P≤0.05)

Table 5. Physico-chemical composition of forest fruits (on dry weight basis)

Component (%)	Doum	Kirkir	Karmadoda	Godeim
Moisture	5.47	7.92	60.52	16.63
Crude protein	3.80	7.71	6.85	5.35
Fat	0.95	2.35	1.05	0.38
Crude fibre	18.36	18.89	16.03	7.30
Ash	7.17	3.63	2.48	2.48
Carbohydrates	69.72	67.42	73.59	84.49
Energy value (Kcal)	309.90	327.28	338.49	371.98
Total sugars (%)	50.00	29.59	79.86	83.04
Reducing sugars (%)	4.67	17.25	77.05	77.05
Vitamin C (mg/100g)	31.74	156.25	389.82	76.33
ß-carotene (IU Vitamin A/ 100 g)	27.49	115.61	178.45	178.45
Pectin (%)	0.38	0.27	1.02	1.02

REFERENCES

Abdel Muti OMS. 2002. Nutritive Value of Wild Plants of the Sudan. Arab Journal for Food and Nutrition. 3(3): 6-67.

Abdel Muti OMS. 1991. Biochemical and Nutritional Evaluation of Famine Foods of the Sudan. Ph. D. Thesis. University of Khartoum. Sudan.

Abdel-Rahman NA. 2011. A study of some Sudanese Edible Forest Fruits and Their Nectars. P h. D. Thesis. Sudan Academy of sciences. Khartoum, Sudan.

Abdel Rahman NA, El-Mubarak A and Mohamed BE. 2007. Characterization of Pectic Substances of Two Mango (Mangifera indica L.) Cultivars. Journal of Food Science and Technology (Sudan). 2:32-45.

Adebooye OC. 2007. Activity and Components of Antioxidants in the Fruit Pulp of Snake Tomato (Trichosanthes cucumerina L.). Electronic Journal of Environment, Agricultural and Food Chemistry. 6(3):1912-1920.

AOAC. 2000. Association of Official Analytical Chemist. Official Methods of Analysis. Assoc. of Analytical Chemist. 17th. Gaithersburg, DW. Washington. DC. USA.

AOAC. 1990. Association of Official Analytical Chemist. Official Methods of Analysis Assoc. of Analytical Chemist. Vol. II. Gaithersburg, DW.

Bagdanov S and Baumann SE. 1988. Bestimmung von Honigzucker mit HPLC. Mill. Gebiele Lebensm. Hyg. 79:198-206.

Bates RB, Morris JR and Gandall PG. 2001. Priciples and Practices of Small and Medium-Scale Fruit Juice Processing: Fruit Morphology and Composition. Chapter III. Agriculture and Consumer Protection. FAO. Rome. Italy.

Dietz JM, Kantha SS and Erdman JW. 1988. Reversed Phase HPLC Analysis of a- and b-carotene From Selected Raw Cooked Vegetables. Journal of Plant Foods for Human Nutrition. 33:333-341.

El-Amin MH. 1990. Trees and Shrubs of the Sudan. 1st published, pp: 106, 400, 451. Ithaca Press. England.

FAO. 2013. International Conference on the role of forests in the Food Security and Nutrition. Forestry Department. FAO. May 13 to 15. Rome. Italy.

FAO. 2010. Global Forest Resources Assessment 2010: Progress Towards Sustainable Forest Management. Rome, FAO. (Available at: www.fao.org/docrep/013/i1757e/i1757e.pdf

FAO. 2006. Composition and Characteristics of Selected Palm Products. FAO Corporate Document Repository. Forestry Department. Tropical Palm. FAO. Rome. Italy.

Fasoyiro SB Babalola SO and Owosibo T. 2005. Chemical Composition and Sensory Quality of Fruit-Flavoured Roselle (Hibiscus sabdariffa) Drinks. World Journal of Agricultural Sciences. 1(2):161-164.

Howard LA, Wong AD, Perry AK and Klein BP. 1999. ß-carotene and Ascorbic Acid Retention in Fresh and Processing Vegetables. Journal of Food Science. 64(5):929-936.

Ibrahim AF, Attalla AM, El-Kobbia AM and Mostafa LY. 2000. Physico-chemical Characteristics of Fruits and Pits of some Date Palm Cultivars as Affected by Cultivars and Seasons. pp. 167-176. Available at: http://www.pubhort.org/datepalm

IMNA. 2002. Institute of Medicine of the National Academies. The National Academies Press. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Washington, DC. USA.

Jens G, El-Siddig K and Ebert G. 2002. The Potential of Under-utilized Fruit Trees in Central Sudan. Conference on International Agricultural Research for Development. Deutscher Tropentag. October 9-11. Witzenhausen.

Johns T and Sthapit BR. 2004. Biocultural Diversity in the Sustainability of Developing Country Food System. Food and Nutrition Bulletin. 25)2):143-155.

Karel M, Fennema OR and Lund D. 2003. Principles of Food Science. Part II: Physical Principles of Food Preservation. 2ed edition. Publisher Marcel Dekker, INC. pp 50, 54. New York, USA.

Kehlenbeck K, Asaah E and Jammadass R. 2013. Diversity of Indigenous Fruit Trees and Their Contribution to Nutrition and Livelihoods in Sub-Saharan Africa: Examples from Kenya and Cameroon. In J. Fanzo, D. Hunter et al. eds. Diversifying food and diets: using agricultural biodiversity to improve nutrition and health issues in agricultural biodiversity. London, Earthscan, pp. 257–269.

Kuria SG, Wanyoike MM, Gachuiri CK and Wahome RG. 2005. Nutritive value of Important Range Forage Species for Camels in Marsabit District, Kenya. Tropical and Subtropical Agroecosystems. 5:15-24.

Layman DK. 2003. The Role of Leucine in Weight Loss Diets and Glucose Homeostasis. Journal of Nutriton. 133(1): 261-267.

Leakey RRB. 1999. Potential for Novel Food Products From agrofoeretry Trees. Food Chemistry. 64:1-14.

Manfredini S, Vertuani S, Braccioli E and Buzzoni V. 2002. Antioxidant Capacity of Adonsonia digitata Fruit Pulp and Leaves. Acta Phytotherapeutica 2. pp. 2-7. Publisher Nicol, B. M.

Mead B and Gurnow RW. 1983. Statistical Methods in Agricultural Experimental Biology, London, New York, Chapman and Hall.

Ngambi JW Alabi O and Norris D. 2013. Role of of Goats in Food Security, Poverty Alleviation and Prosperity with Special Reference to Sub- Saharn Africa: A review. Indian Journal of Animal Research. 47(1):1-9.

Nwosu FO, Dosumu OO and Okocha JOC. 2008. The Potential of Terminalia catappa (Almond) and Hyphaene thebaica (Doum palm) fruits as raw materials for Livestock Feed. African Journal of Biotechnology. 7(24):4576-4580.

Ofori DA, Gyau A, Dawson IK, Asaah E, Tchoundjeu Z and Jamnadass R. 2014. Developing more productive African agroforestry systems and improving food and nutritional security through tree domestication. 6:123-127.

Powell B, Hall J and Johns T. 2011. Forest Cover, Use and Dieatry Intake in East Usambara Mountains, Tanzania. International Forestry Review. 13(3):305-317.

Ranganna S. 2001. Manual of Analysis of Fruit and vegetable Products. pp 7-15. Tata McGrawm – Hill Publishing Company Limited. New Delhi.

Rathore M. 2009. Nutrient Content of Important Fruit Trees from Arid Zone of Rajasthan. Journal of Horticulture and Forestry. 1(7):103-108.

Saka JDK, Msonthi JD and Magherube JA. 1994. The Nutritional Value of Edible Fruits of Indigenous Wild Trees of Malawi. Forest Ecology and Management. 64(2-3):245-248.

Vogt K. 1995. A Field Worker's Guide to the Identification, Propagation and Uses of: Common Trees and Shrubs of Dryland Sudan. pp. 100, 101, 125. Publisher SOS Sahel International (UK). London. Printed by: Antony Rowe Ltd. Chippenham.

Vinceti B, Eyzaguirre P andohns T. 2008. The Nutritional Role of Forest Plant Food for Rural Cmmunities. In C. J. P. Colfer, ed. Human Health and Forests: A global Overview of Issue, Practice and Policy. London: Earthscan (Chapter 4).

West CE, Repping F and Temalilwa CR. 1988. Handbook on the composition food commonly eaten in East Africa. Published by Wangeningen, The Netherlands.

Wills RHH, Lee TH, Graham D, McGlasson WB and Hall EG. 1981. Post-harvest: An Introduction to the Physiology and Handling of Fruits and Vegetables. AVI Publishing. Co. Westport. Connecticut.

Zyren J, Elkins ER, Dudek JA and Hagen RE. 2006. Fiber Contents of Selected Raw and Processed Vegetable, Fruits and Juices as Served. Journal of Food Science. 48(2):600-603.