ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3 July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2017; **17(3):** 12215-12226 **DOI: 10.18697/ajfand.79.15590**

PROXIMATE NUTRIENT COMPOSITION OF SOME WILD EDIBLE MEDICINAL PLANTS FROM UGANDA

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ABSTRACT

There are high levels of malnutrition especially among children in Africa. In Uganda, this is compounded by widespread food insecurity. There are various wild edible plant species in Uganda. However, little research has been carried out to document and validate the claims associated with their use. A study was, therefore, carried out to analyse the nutritional contents of six commonly used wild edible medicinal plant species from Nebbi district in Northwestern Uganda. These plants were *Erythrococca bongensis*, *Grewia trichocarpa*, *Leptadenia hastata*, *Nymphaea lotus*, *Oxygonum sinuatum* and *Talinum portulacifolium.* The plants were selected mainly because of their use as both food and medicine. All the selected plant species have documented medicinal uses among the local communities in Nebbi district where they are used. However, many of them are often neglected and underutilized, despite their potential therapeutic and nutritional benefits. The vitamin C, β-carotene, macronutrient, calcium, iron, magnesium, phosphorous and sodium compositions of the selected edible parts of the plant species were analysed. With the exception of *Grewia trichocarpa* fruits and *Nymphaea lotus* seeds, the leaves of *Talinum portulacifolium* had higher Fe (4.54±0.07 mg/100g), P (0.31±0.01 mg/100g), Mg (0.3±0.3 mg/100g), β-carotene (0.275±0.00 µg/100g) and crude ash (22.13±0.19%) contents than the rest of the plant species. The leaves of *Leptadenia hastata* had higher levels of vitamin C (17.93±2.01 mg/100g) than the leaves of other plant species. All the plant species analysed were richer in iron than the common cabbage *Brassica oleracea var capitata.* There were significant differences in the nutritional contents of the plant species analysed ($p<0.05$). However, the nutrient values of the plant extracts were generally much lower, providing a small percentage of Recommended Dietary Allowance or Recommended Nutrient Intakes (RNI) values. The vitamin C, β-carotene and other nutrient contents of most of the plant species analysed were generally comparable or even higher than those of the common cabbage in some instances. Consumption and conservation of these plant species should be encouraged by local authorities because they not only supplement the local staples with the much needed nutrients, but they could also have medicinal properties.

Key words: Wild, edible, Medicinal plants, Nutrient, Food-security, food, underutilized, Uganda

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INTRODUCTION

The number of undernourished people in the world remains unacceptably high, with an estimated 925 million reported to be undernourished in 2010 [1]. The majority of the undernourished people live in rural areas in the developing world [2]. There are high levels of malnutrition, especially among children in Africa [3]. In Uganda, this is compounded by widespread food insecurity [4]. Malnutrition was reported to be more pronounced and widespread in northern Uganda, with food insecurity affecting a third of the households in the West Nile district of Nebbi [4]. The food on which the majority of Ugandans feed lacks essential micronutrients, despite the fact that Uganda is endowed with a rich diversity of indigenous food plants and herbs [5].

Globally, people are dependent on a handful of widely cultivated plant species for food security [6]. Thirty species of plants are known to provide about 90% of the world's nutritional needs [7]. There is, thus, an overreliance of humans on a narrow food base [8]. Wild food plants are known to provide a comparable or greater dietary, nutritional and medicinal diversity than cultivated ones [6]. They are also locally available, sometimes when other crops are not in season or are inexpensive and can play a critical role in the survival of individuals and entire communities during periods of food scarcity [3].

The number of non-cultivated edible plant species in Uganda has been reported to be far higher than those cultivated [7]. The therapeutic and nutritive potentials of such plant species to manage various lifestyle-related diseases has led to an increase in their consumption [9]. Many of these wild plant species contain a variety of secondary compounds such as flavonoids, alkaloids, coumarins among others, to which the therapeutic effects of such plants have been attributed [10].

The widespread empirical use of wild plants demands accurate and reliable information on their potential benefits and prospective products [11]. Unfortunately, due to limited research, the knowledge on wild plant species currently lags behind that of cultivated species [5]. This is despite their widespread consumption especially in rural areas in Uganda [8].

Wild food species are declining in many agricultural landscapes due to unsustainable harvests, commercialization and deforestation [3]. Most of these underutilized crops are well adapted to marginal environments and are often neglected by researchers and policy makers, because they are considered food for the poor [12]. There is a general lack of public awareness in Uganda of the value of wild plants, including those used as food and the need to use them sustainably [13]. Families in Nebbi have only one harvest or agricultural season per year, growing mainly cassava, maize and sesame. This places a serious burden on the nutritional status and health of the local people [4]. The objective of this study was, therefore, to investigate the nutritional content of six important wild nutraceutical plant species from Nebbi district. The plant species were selected for analysis as a follow up to previous studies [12,14], basing on their frequencies of use as food and medicine, conservation status, market value and availability of information on the plant from literature. The plant species selected were:

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Erythrococca bongensis, *Grewia trichocarpa*, *Leptadenia hastata*, *Nymphaea lotus*, *Oxygonum sinuatum* and *Talinum portulacifolium.* All the plant species analysed have previously been shown to have medicinal properties in addition to being used as food [12,14]. Therefore, studying their nutritional profiles will help in generating information that is lacking about their possible nutritional benefits.

MATERIALS AND METHODS

Study area

Nebbi district is located in the northwestern part of Uganda, in the equatorial forest belt extending from Democratic Republic of Congo (DRC) [15]. It occupies a total area of 3,288 km^2 and lies between 2^o 44' N; 31^o 24' E at an altitudinal range of 945–1, 219 m above sea level [15]. Nebbi has an average annual rainfall of 1,500 mm and high temperatures of the modified equatorial climatic type [15].

Collection of plant material

Plant materials were harvested from their natural habitats in the wild during organised field visits in randomly selected villages of Kaal, Padoch South, Nyakaduli and Pacer South in Panyango Sub County, Nebbi district. The collection process was carried out with herbalist representatives from each village as the key informants. Voucher specimens of each of the plant species were collected in triplicates for identification in accordance with standard plant collection procedures [16]. The plants were taken to the Makerere University Herbarium for identification. An average of 20-30 plant specimens of each plant species was collected for nutritional analyses from the field following standard procedures [17]. Only the edible parts of the plants were collected for analysis. The plant materials collected were transported fresh to the Nutritional Laboratory, at the Department of Food Technology and Human Nutrition, Makerere University for analysis. All the plant species harvested were dried and analysed for dry weight. This is due to the fact that these edible plant species double as medicine, and are traditionally processed by drying or prepared fresh during their processing, with the exception of *G. tricocarpa* which is eaten fresh only and *N. lotus* which is only eaten dry. For consistency, however, dry weights of all the plant species were used.

Preparation of plant samples for analysis

The plant materials from the edible plant parts were rinsed with distilled water to remove soil debris and other potential contaminants that may contribute to inaccurate results. After that, they were dried in an oven using the air oven method No. 14.003 [18]. All laboratory analyses were carried out in triplicates.

Nutrient analysis

The moisture content was determined using the air oven method [19]. The crude ash content was determined by standard methods [19]. The crude fat content was determined using the Soxhlet method (AOAC, 1984) [19], using Soxtec equipment (Tector, Soxtech system HT 1043 extraction unit, Tecator, USA). The dietary fibre was determined using Acid Detergent Fibre (ADF) solution following standard procedures [20]. The β-carotene content was determined using standard methods [21]. Vitamin C was determined by the titration method [20].

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Calcium (Ca), Iron (Fe), Magnesium (Mg), Sodium (Na) and Phosphorus (P)

Nutrient element concentrations of Ca, Fe, P, Na, Mg and were determined from standard procedures [22], using an Atomic Absorption Spectrophotometer (Perkin-Elmer 2380, USA).

Data analysis

Variations in the mean micronutrient and macronutrient contents of the selected nutri-medicinal plants were analysed using one-way ANOVA [23], using GENSTAT software, 12th edition 2009, version 12.2.0.3717, VSN international. Tukey's HSD *post hoc* test was used to determine how the means of the micronutrient and macronutrient contents of the plant species differed from one another.

RESULTS

Proximate analysis

Table 1 presents the macronutrient composition of the six plant species selected for analysis. Analyses were done on dry weight basis.

Moisture content: There was no significant difference in the moisture content of all the parts of the plant species analysed.

Crude ash: The leaves of *Talinum portulacifolium* had higher ash content (22.13±0.19 %) than the leaves of the rest of the plant species analysed. There were significant differences in their mean ash contents ($p<0.05$).

Dietary fibre: All the plant species whose leaves were analysed had significant differences in their dietary fibre content ($p<0.05$) except for *E. bongensis* (24.32 ±0.30g) and *L. hastata* (24.06 ±2.10 g).

Crude fat: Leaves of *L. hastata* had the highest amount of crude fat (2.7±0.1%) in comparison with the leaves of the other plants analysed. There was a significant difference ($p<0.05$) in the crude fat content of the leaves of *E. bongensis* (2.4 ±0.10g/100g), *L. hastata* (2.7 ±0.10 g/100g) and *T. portulacifolium* **(**1.6±0.10g/100g) at LSD value of 0.313.

β-carotene: The leaves of *T. portulacifolium* had the highest β-carotene content of 0.275 ±1.7 µg /100mg. There was a significant difference in the β-carotene content of the leaves of *E. bongensis* (0.096±0.00 mg), *T. portulacifolium* (0.275 µg/100mg) and *O. sinuatum* (0.115 µg /100mg).

Vitamin C: *L. hastata* had the highest vitamin C content (17.93 mg/100g) while *E. bongensis* had the lowest Vitamin C content (8.26 mg/100g).

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Mineral analysis

Table 2 presents the micronutrient composition of the six plant species selected for analysis.

Iron: Leaves of *T. portulacifolium* had the highest iron content (4.54 mg/100g) followed by the leaves of *O. sinuatum* (3.55 mg/100g). The iron contents of all the plant species analysed were significantly different ($p<0.05$) from each other.

Phosphorus: Leaves of *T. portulacifolium* (0.31±0.01 mg/100g) and *E. bongensis* (0.30 mg/100g) had the highest phosphorus content.

Calcium: Leaves of *O. sinuatum* had the highest Calcium content (1.15 mg/100g). There was a significant difference ($p<0.05$) in the Calcium content of *E. bongensis N. lotus* and *O. sinuatum.*

Magnesium: The leaves of *T. portulacifolium* had the highest levels of Magnesium (0.3 ±0.03mg/100g) followed by *L. hastata* (0.1±0.01mg/100g). The rest of the plant species had only trace amounts (< 0.06 µg/g) [24] of Magnesium. The Magnesium content of *L. hastata* (0.1 mg/100g) *and T. portulacifolium* (0.3 mg/100g) were significantly different ($p<0.05$).

Sodium: There were only trace amounts of sodium in all the plant species analysed (Table 2).

DISCUSSION

The moisture content of the samples of the plants was generally high. The moisture contents of these plants were found to be within the same ranges as that of the common cabbage *Brassica oleracea var capitata* L. from a study by Agea *et al*. [25] in Uganda.

The leaves of *Talinum portulacifolium* had the highest ash content (22.13g/100g). There is a significant difference in the mean ash contents of all the plant species analysed ($p<0.05$). The high ash content of *T. portulacifolium* indicates a high mineral content of the plant. In comparison, an analysis by Agea *et al.* [25] found the common cabbage to have lower ash content value (0.67 g/100g) a value lower than all the plant species analysed in this study [25].

The dietary fibre content of *L. hastata* (24.06/100g) in this study was found to be much higher than those in a study conducted in Nigeria [26]. This could be attributed to differences in edaphic and other environmental conditions in the different study areas. Dietary fibre, which includes the non-digestible carbohydrates, lignin including non-starch polysaccharides plays an important role in normal bowel function according to the European Food Safety Authority (EFSA) [27]. The EFSA also recommended dietary fibre intakes of 25 g per day to be adequate for normal laxation in adults. Many of the nutraceutical plants analysed can be a good source of dietary fibre.

Leaves of *L. hastata* were found to have higher lipid values of (6.66 g/100g) than those studied in Nigeria [26]. Although the fat content was generally low, the wild nutraceutical plants had higher fat values than the common cabbage (0.12 g/100g) [25].

The Recommended Daily Allowance (RDA) for β-carotene, a precursor for Vitamin A, which is essential for the normal functioning of the visual system, is between 2400-4200 µg for children, 4800 µg for women and 6000 µg for men [28]. *T. portulacifolium* (275 µg/ 100 fresh weight), which had the highest β-carotene in this study can only supply between 6.55-11.46% of the RDA of children, 5.73% of the RDA of women and 4.58% of the RDA for men. However, it is important to note that the plant species analysed are also used as medicine and are not routinely consumed as a source of food. Even when they are consumed, they are seldom eaten fresh. Therefore, much as their contribution to RDA's or the Recommended Nutrient Intakes (RNI) may seem minimal at glance, they still play a therapeutic role in different diseases as discussed in Anywar *et al.* [12, 14].

Vitamin C has a potentially protective role as an antioxidant and has enzymatic functions as an electron donor [28]. However, the vitamin C amounts in the plant species analysed were generally low, contributing about 0.04 % of the RNI for vitamin C for adults between 19-65 years of 40 mg/day [28]. Recommended Nutrient Intakes have been defined as the daily intake, which meets the nutrient requirements of almost all (97.5%) apparently healthy individuals in an age and sex specific population group [28].

Iron functions as a carrier of oxygen to the tissues from the lungs by red blood cell haemoglobin [28]. The RNI for adult males and females 18 years of age and above ranges between 9.1-27.4 mg/day and 19.6-58.8mg/day, depending on the percentage of dietary iron bioavailable [28].

The RNI for phosphorus for the life stage group of 19-30 years is 700mg/day for both males and females [29]. Phosphorus is a major component of bones and teeth. It also helps in maintaining a normal pH in the body and is involved in metabolic processes [29]. The Phosphorus contents of all the plant species were generally much lower (<0.05%) than the RNI values for Phosphorus.

The calcium content of *L. hastata* in this study (0.71 mg/100g) was higher than the value of 0.12±0.08 mg/100g reported by other researchers after using the same method for drying the plant [26]. Calcium plays an essential role in blood clotting, muscle contraction, nerve transmission and bone and tooth formation [28]. The calcium values of these plants fall below the Dietary Reference Intakes (DRI) for calcium of 1000 mg/day for females, 19 years to menopause and males 19-65 years of ages [28].

Apart from *T. portulacifolium* and *L. hastata* (0.1mg/100g), the rest of the plant species had only trace amounts of magnesium. Magnesium functions as a co-factor of many enzymes involved in energy transformation, protein synthesis and RNA and DNA synthesis among others [28]. However, quantities reported were much lower than the RNI of 220 and 260 mg/kg for female and male adults, respectively, of 19-65 years of

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age [28]. The rest of the plant species had only trace amounts of magnesium. A higher magnesium content 1.27 mg/100g for *L. hastata* was, however, reported in Nigeria [26].

Despite the fact that all the plant species analysed had trace amounts of sodium, the leaves of *L. hastata* analysed in Nigeria contained higher sodium levels (1.29 mg/100g) from the same method for analysis [26].

Some of the variations in nutrient profiles of the plant species can be attributed to the fact that the phytochemical and micronutrient profiles of plant species are known to vary with species, agro-climate, edaphic factors, genetic conditions, farming practices, age of plants at harvest, stage of ripeness and plant moisture content among others [30].

CONCLUSION

This study confirms that the different plant species analysed contained varying amounts of the different nutrients tested for. Of key significance were the leaves of *T. portulacifolium* and *L. hastata. T. portulacifolium* had significantly higher ($p<0.05$) Fe, P, Mg, β-carotene, vitamin C and crude ash contents than the rest of the plant species whose leaves were analysed. *L. hastata* is one of the only two plant species in this study that had both Mg and Na, albeit in trace amounts. The vitamin C, β-carotene, macro and micro nutrient contents of most of the plant species analysed were generally comparable or even higher than those of some vegetables like the common cabbage. Consumption of these plant species should be encouraged by local authorities to supplement local staple diets with the much needed nutrients

ACKNOWLEDGEMENTS

We are very grateful to Carnegie Corporation of New York, through the RISE-AFNET Programme and SIDA Phase III who provided financial support towards the successful completion of this work. Our funders had no role in choosing the research topic or study design, collection and interpretation of the data. We thank all the respondents for their valuable contribution towards this research. We also acknowledge the invaluable support and input of our research assistants Mr. Walter Okello Onenarach and Mr. Henry Opio, all the key informants and local authorities who ensured that this study was carried out smoothly.

AUTHORS' CONTRIBUTIONS

This work was carried out in close collaboration among all authors. All the authors were involved in the work and preparation of the final manuscript. Author AG wrote the original concept and designed the study. Authors Hanningtom Oryem-Origa & Kamatenesi-Mugisha Mauda were involved in supervising and guiding the progression of the study. They also proof read, and advised on protocol and data analysis. All the authors have read and approved the final manuscript.

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Table 1: Macronutrient content of selected wild edible medicinal plants in Nebbi district (g/100g dry weights)

Plant Species & [Part used]	MC %	CA %	DF %	CF
1. *Erythrococca bongensis* Pax [L]	89.89±5.28 [a]	12.02±0.23 [d]	24.3±0.30 [c]	2.4±0.1 [c]
2. *Grewia trichocarpa* Hochst. ex A. Rich. [Fr]	92.30±0.11 [a]	6.32±0.12 [b]	57.8±1.70 [f]	1.6±0.1 [b]
3. *Leptadenia hastata* Vatke [L]	89.17±1.85 [a]	9.96±0.55 [c]	24.06±2.10 [c]	2.7±0.1 [d]
4. *Nymphaea lotus* L. [Sd]	89.88±0.67 [a]	1.78±0.06 [a]	7.88±0.10 [a]	1.3±0.1 [a]
5. *Oxygonum sinuatum* (Hochst. & Steud ex Meisn.) Dammer [L]	89.32±2.17 [a]	11.91±0.31[d]	28.6±0.70 [d]	1.4±0.2 [ab]
6. *Talinum portulacifolium* (Forssk.) Asch. ex Schweinf. [L]	91.45± 0.46 [a]	22.13±0.19 [e]	18.3±1.50 [b]	1.6±0.1 [e]
LSD	4.395	0.518	3.174	0.313

Values are means of three (3) individual measurements ± standard deviation. Means in each column followed by different superscript letters are significantly different (Tukey's HSD, p<0.05), LSD =Least Significant difference

Key *Fr=Fruits, L=Leaves, Sd=Seed, MC=Moisture Content, CA=Crude Ash, DF=Dietary Fibre, CF= Crude Fat*

Table 2: Vitamin C, β-carotene & Mineral content of selected wild edible medicinal plants in (mg/100g dry weights)

Plant species & [Part used]	Mg	Na	Fe	P	Ca	β-carotene (μg)	Vit C
1. *Erythrococca bongensis* Pax (L]	T	T	2.58±0.10[d]	0.30±0.02[d]	0.87±0.01[b]	0.096±0.00 [c]	8.26±1.63 [a]
2. *Grewia trichocarpa* Hochst. ex A. Rich. [Fr]	T	T	0.46±0.02[a]	0.19±0.00[b]	0.69±0.03[a]	0.06±0.01 [b]	15.16±3.78 [c]
3. *Leptadenia hastate* Vatke (L]	0.1±0.1[b]	T	1.54±0.13[c]	0.22±0.02[c]	0.71±0.02 [a]	0.067±0.00 [b]	17.93±1.56 [d]
4. *Nymphaea lotus* L. [Sd]	T	T	1.36±0.14[b]	0.15±0.01[a]	0.98±0.07[c]	0.035±0.01 [a]	10.01±1.70 [ab]
5. *Oxygonum sinuatum* (Hochst. & Steud ex Meisn.) Dammer [L]	T	T	3.55±0.08[e]	0.16±0.01[a]	1.15±0.05[d]	0.115±0.00 [d]	10.83±0.96 [b]
6. *Talinum portulacifolium* (Forssk.) Asch. ex Schweinf. [L]	0.3±0.3[c]	T	4.54±0.07[f]	0.31± 0.01[d]	0.74±0.02[a]	0.275±0.00 [e]	10.96±2.01 [b]
LSD	0.035		0.1735	0.02336	0.064	0.01594	2.023

Values are means of three (3) individual measurements ± standard deviation. Means in each column followed by different letters are significantly different (Tukey's, p<0.05), LSD =Least Significant difference, T= Trace < 0.06 µg/g [24]

Key: *L=Leaves, PU=Part used, Fr=Fruit, Sd=Seeds, P=Phosphorus, Ca=Calcium, Na=Sodium, Mg=Magnesium, Fe=Iron, Vit=Vitamin*

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