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Nutritional Value of Two Underutilized Wild Plant Leaves Consumed as Food in Northern Angola: *Mondia whitei* and *Pyrenacantha klaineana*

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MM, LN and KNN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MM, PMK and FMB managed the analyses of the study. Authors TL and FLL managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Background/Aims: Traditional edible plants are good sources of minerals, fibers, proteins and others useful phytochemicals for human nutrition and health. *Mondia whitei* and *Pyrenacantha klaineana* leaves are underutilized, wild edible plants considered as food and spice in habitants in some part of Northern Angola. The aim of this study was to investigate the nutritional value and mineral contents of *M. whitei and P. klaineana leaves*.

Materials and Methods: The leaves were harvested from a forest. The samples were analyzed for proximate and mineral contents using the standard methods. The results were analyzed statistically using mean and standard deviation.

Results: The proximate composition of *M. whitei* raw and cooked leaves showed that the samples had ranged of ash, 9.53 - 12.93%, fiber 13.16 - 15.11%, protein 16.48 - 19.24%, fat 2.95 - 4.94%, carbohydrates 51.59 - 54.48% and energy (kcal) 310.39 - 326.10 in 100 g respectively. The proximate composition of *P. klaineana* raw and cooked leaves showed that the samples had range of ash, 4.13 - 6.74%, fiber 40.45 - 43.56%, protein 14.93 - 18.80%, fat 1.13 - 3.78%, carbohydrates 29.74 - 36.58% and energy (kcal) 217.77 - 227.88 in 100 g respectively. The mineral contents of the *P. klaineana* raw leaves, K 2459.20 mg, Ca 2126.33 mg, P 239.90 mg, Se 77.86 mg are richer than *M. whitei* raw leaves, K 1149.83 mg, Ca 844.87 mg, P 175.89 mg, etc. Conversely, the leaves of *M. whitei* are richer in Se 87.80 mg and Cu 3.14 mg/ 100 g than the *P. klaineana* (Se 77.86 and Cu 2.84 mg/100 g).

Conclusion: The wild edible leaves are rich in nutritional value and mineral composition such as fiber, protein, Ca, Fe, K, Mn, Mg, P, Se etc. The consumption of *M. whitei* and *P. klaineana* leaves should be vulgarized to nutrition, diversity diet and food security.

Keywords: Mondia whitei; Pyrenacantha klaineana; Northern Angola; nutritional value; wild plants.

1. INTRODUCTION

The increase in world demography, the depletion of natural resources and the necessity to feed the population call for more food supplies. It is imperious that local leaders and scientists engage in exploring new food resources within their ecosystems. The humankind has evolved using plants abundantly, as natural and organic resources for several purposes, and animals do so, equally. Henceforth, research on new plants that have such potential for the purposes, such as food, fodder crops, as well as medicinal, energy and industrial uses should be undertaken. It is a matter of survival, amid the progress in processed food, pharmaceutical products and genetically modified crops and plants. Wild food plants used such as traditional foods have maintained their importance in human history [1]. According to Turner et al. [2], many people around the world rely on wild plants – which include roots, shoots, leafy greens, etc. - to meet their daily minimum necessary nutritional requirements. Wild food plants and locally produced foods are valuable and important nutrient contributors in the diet for humans, both in rural and urban areas. However, it should be stressed that they are most important in the rural areas where nutrition is likely based on natural organic food [3]. Nowadays, vegetables are essential foods as far as nutrition and health are concerned [4]. Compared to the other plants, which are mainly grown for food, wild plants possess superior nutritional values. Previous researches have reported on the richness of these referred species in proteins, vitamins, minerals, carbohydrates, fibers, and secondary metabolites such as phenolic compounds [5]. More wild vegetables and edible plants are good sources for minerals and other useful phytochemicals for human health, thus they play a great role in supplying the mineral requirements of local rural populations [1].

Ertan et al. [6] emphasized that, minerals with critical significance in human nutrition and health are essential nutrients for normal physiological functions of the body. As for dietary fibers, they play an important role in decreasing the risks of many disorders such as constipation, diabetes, cardiovascular diseases, diverticulosis and obesity [7].

The consumption of wild food plants contributes in health protective functions. For instance, vegetables provide vital nutrients for healthiness and maintenance of the human body [8], and the dietary intake of fruits and other edible plant parts rich in health protective and diseases preventive phytochemical, contributes to same kind of disease prevention and good health. In general, they have been shown to provide protection against a wide variety of cancer and a number of chronic and degenerative diseases such as neoplasm, cardiovascular diseases, cataracts, diabetes, aging process, etc. [9]. Beside the dietary and nutritional benefits, wild-growing plants also constitute a source of income through sales as food or medicinal plants, i.e. phytotherapy (herbal medicine) [10]. In short, wild edible plants and herbs play an essential role in food security, human nutrition and health and economic welfare of rural communities; thus, a huge contribution to world's development [11].

In Northern Angola-Africa, a great number of wild edible plants species are consumed by local communities as vegetables, shoots, fruits, seeds, barks, spices, roots, tubers, wine palms, etc. [12, 13,14,15]; but, some of the wild edible plants are underutilized with among them the green edible leaves of *Mondia whitei* and *Pyrenacantha klaineana*.

The neglect or underutilization of wild edible plants as food by consumers would have arisen as consequence of the introduction of exotic vegetables into the markets [16], and also a lack of popularization and non-provision of objective information about their nutrients contents and therapeutic properties [17]. Industrial revolution, changes in lifestyle, less contact with nature (e.g. society urbanization), large-scale cultivation of a limited number of crops (such as wheat, maize and rice), are also among other reasons to consider for such a decline in wild edible products consumption [18]. *Mondia whitei* (Hook.f.) Skeels is an African plant which belongs to the Apocynaceae family [19]. The plant is a perennial climber, characterized by latex and woody roots, which are aromatic when old. It grows in the savannah and forest, and encountered in the Angolan Uíge province savannah land. *M. whitei* is endemic to South, Central, East and West Africa [20]. It is one of the few wild green leafy vegetables used by Bakongos' ethnic groups in Northern Angolan region. This plant has many local names in Kikongo language such as Kimbiolongwa, Nlondo or Nlondo nlondo. The *M. whitei* leaves are eaten cooked as a soup mixed with palm oil, onion, tomatoes, peanut butter, [21] "mwamba nguba in kikongo language", fish, meats, caterpillars, etc. In the Northern Angola region, the fleshy bark of the Mondia whitei root is eaten raw, or occasionally after drying to freshen the mouth, as an aphrodisiac and appetizer.

Pyrenacantha klaineana Pierre ex Excell & Mendonça belongs to the Icacinaceae family. This plant is a forest liana, reaching the treetops, with an unpleasant smell; it grows wild in the savannah and forest [22]. This plant has many local names in *Kikongo* language such as *Ndulu nsi, Mbizi a nsaki* or *Mbizi ya nsaki*. Juice of the *P. klaineana* leaves is used as a spice and a sodium bicarbonate substitute to flavour cassava leaves. Said, this juice is added before or during the cooking of the cassava leaves in order to tenderize them and enhance the taste or flavour.

The study of wild food plants is important to identify the potential nutrients sources, which could be utilized as alternative food [23]. The wild flora of Northern Angola abounds in numerous plants with multiple uses for human and his habitat. These plants are used for food, human and animal health, handicrafts, furniture, house construction and others [13]. Among wild edible plants available in various natural habitats in the Northern region of Angola, it has been observed that no nutritional composition of either *M. whitei* leaves or *P. klaineana* is available in the literature. Thus, there is a need for a research aimed at assessing and providing their respective nutritional information and some other properties such as medicinal or nutraceutical, as well. This study has investigated the nutritional and mineral contents of *M. whitei* and *P. klaineana* leaves, two of the underutilized wild edible leaves of Northern Angola.

Besides, we have evaluated the functional properties of these plants to better understand their importance in human's nutrition. The results and parameters could then provide fundamental bases for the nutritive exploitation, reducing food insecurity, and malnutrition problems and also increasing dietary diversity within local communities and beyond.

2. MATERIALS AND METHODS

2.1 Plant Material and Harvesting Method

The plant material consist of the wild edible leaves of *M. whitei* (Fig. 1a) and *P. klaineana* (Fig. 1b) that were collected in the Northern region of Angola, respectively at Ambuila municipality (S 07°29.778' ; E 014°38.440') and Mbanza Kongo municipality (S 05°52.122' ; E 014°04.998'). The collection was completed in beginning of May 2018 and the plants samples were identified by comparison with reference specimens available at the Department of

Biology, Faculty of Science (University of Kinshasa, Democratic Republic of the Congo) where voucher specimens with assigned sample number ANG-01/MM/2018 and ANG-02/MM/2018 were deposited in the Laboratory of Ethno-biology and Medical Phytochemistry (Laboratoire E-PHYMED). In Northern Angola, the leaves of *M. whitei* and *P. klaineana* are widely exploited by the rural population who live near forest areas. The gathering of these leaves is done by hands. The technique consists of gathering only the large leaves from the stem and leaving the smaller ones on the plant. In addition, the leaves samples were collected from three plants of the same species.

Mondia whitei (Hook.f.) Skeels is a large liana belonging to Apocynaceae family with the following characteristics: leaves herbaceous, petiole 2-7 cm long, glabrous to puberulent, lamina ovate, broadly ovate, elliptic, broadly elliptic or sub-orbicular; Inflorescences 10-20 flowered, glabrous to puberulent, flower odour most unpleasant. *Pyrenacantha klaineana* Pierre ex Exell & Mendonca is a plant species of Icacinaceae. This plant is a forest liana reaching to the tree tops; with flowers and fruits on stem in the understory [22].

2.2 Cooking Method

The temperature and cooking time adopted in this study correspond to those practiced in traditional cuisine in northern Angola. The cooking of meals is done by boiling it at a temperature of 100 °C for an average time of 30 minutes.

2.3 Proximate Composition Analysis

2.3.1 Moisture

The determination of moisture (expressed in g/ 100 g of sample) was performed per the weight loss method [24].

2.3.2 Estimation of ash

The total ash was determined by incinerating a known amount of the sample in an electric muffle furnace until obtaining a white ash. Briefly, 5 g of each sample was weighed in a silica crucible and heated in muffle furnace for about 5-6 hours at 500 °C. It was cooled in a desiccator and weighed. It was heated again in the furnace for half an hour, cooled and weighed. This was repeated consequently till the weight became constant (ash became white or grayish white). Weight of ash gave the ash content [24].

Fig. 1a and 1b. Show the plant material respectively, *Mondia whitei* and *Pyrenacantha klaineana*

2.3.3 Estimation of total fats

Total lipids (expressed as g/100 g of sample) were measured by Soxhlet method which consists in extracting under heat the lipids contained in the sample by means of an appropriated apolar organic solvent (n-hexane) [24].

2.3.4 Estimation of total carbohydrates

The total carbohydrates were obtained by subtracting from 100, the sum of the contents of the other constituents of the analyzed sample (moisture, protein, ash and crude fiber) [24].

2.3.5 Estimation of fibers

Crude fibers the raw materials or cellulosic fibers were measured following Kurschner method based on attack under reflux condenser of sample powder by mixing acetic and nitric acids [24].

2.3.6 Estimation of total proteins

Determining the crude proteins or total crude nitrogen content was performed according to Kjeldahl method [24].

2.3.7 Estimation of energy value

The quantity of heat energy provided by 100 g of material sample (in kcal) was calculated using the method modified by the Congolese Control Office found in the food codex book by applying Atwater coefficients for proteins, lipids and carbohydrates (ie by multiplying the values obtained for proteins, fats and total carbohydrates by 4, 9 and 4 respectively and adding up the values) [24].

2.4 Mineral Content Determination

The mineral contents were determined by Inductively Coupled Argon Plasma Optical Emission Spectrometry (ICP-OES) [Optima 8300 Perkin Elmer, USA] as previously reported by Ngbolua et *al.* [25]. Briefly, the sample (0.3 g) was dissolved in 5 mL of distilled water placed in PM60 Teflon bombs (Analytikjena 40 Bar) and heated at 60 °C and 10 mL of nitric acid (HNO_3 65%) (Merck) was then added.

The resulting mixture was incubated at room temperature for 30 minutes to allow the oxidation to occur and later the bombs were covered first with caps and then stripped with HNO_3/H_2O (v/v, 1:1). The bombs were placed in the high frequency microwave mineralizer (Analytikjena AG Top wave: 2.5 Ghz, Germany) controlled by microcomputer by choosing the vegetable leaves mode as a digestion mode at 180 °C, 50 bars for an hour. At the end of mixing, the digester was stopped by letting the bombs rest for 3 hours until completely cooled.

The cooled analyte was thus carefully transferred by filtration on Whatman filter paper, bombs to 50 mL volumetric flasks previously stripped. The calibration of the ICP-OES was performed using the working standard prepared from the commercially available standard multi-element solution 3 at two points (1 mg/L and 2.5 mg/L, Perkin Elmer, USA). The most appropriate wavelength, gaseous argon flow, plasma stabilization and other ICP-OES instrument parameters for minerals were selected and measurements were made in the linear range of the working standards used for calibration. The operating conditions were: Power of Rf (1500 Watt); Plasma gas flow (Ar): 8 L /min; Nebulizer (0.70 L /min); Auxiliary gas flow (Ar): 0.2 L / min; Viewing size (5-22 mm); Copy and playback time: 1-5s (maximum 45 s); Flow time: 1s (maximum 10 s); View: Radial.

2.5 Statistical Analysis

All assays were carried out in triplicate and the values were obtained by calculating the average of three experiments and data are presented as Mean ± SD (Standard Deviation). Data were subjected to analysis of variance (ANOVA) and significant differences were determined by the Tukey test at $p \leq 0.05$ probability threshold level, using Sisvar 5.7 software.

3. RESULTS AND DISCUSSION

Wild food plants contain fascinating dietary components for human population. In this study, chemical composition of two wild underutilized edible plants growing in Northern Angola was analyzed. These are two plants species, namely *M. whitei* and *P. klaineana*, mostly used for food purposes such as vegetables in the region.

3.1 Proximate Composition

Ash, fibers, proteins, fats, carbohydrates and energy content are presented in the Table 1. Statistical analysis showed a significant difference ($P < 0.05$) in the ash, fibers, proteins, fats, carbohydrates and energy of *M. whitei* and *P. klaineana* leaves. The proximate composition comprising the major nutritional value indicators and the energetic value of *M. whitei* and *P. klaineana* leaves are presented in Table 1.

The ash content that reflects the total mineral content reveals a greater richness of *M. whitei* leaves than *P. klaineana*. *Mondia whitei* leaves is richer in ash than *P. klaineana* both in raw and boiled leaves (12.93 ± 0.20% and 9.53 ± 0.07%) and (6.74 ± 0.09 and 4.13 ± 0.13%), respectively (Table 1). Ash is an indication of minerals concentration in food. Food with high ash is said to possess high mineral constituents. The results of the study show that boiling resulted in higher ash losses, -26.30 and -38.72% in the *M. whitei* and *P. klaineana* leaves, respectively. This corroborates those of Nafir-Zenati et al. [26] obtained on the cooking of spinach. Finally, the significant decrease in ash content during boiling would result from diffusion of minerals into the boiling water. Similar results have been reported for others foods such as*, Solanum macrocarpum*, *Amaranthus hybridus*, and *Ocimum gratissimum* [27]

The amount of fibers could be of immense importance in the human digestive process in controlling for example constipation and accelerating the feces. *P. klaineana* is richer in dietary fiber than *M. whitei* in both raw and boiled leaves, (40.45 ± 0.36 et 43.56 ± 0.49 %) and (13.16 ± 0.31 15.11 ± 0.12%), respectively. In addition, the results of this study show that cooking in water results in an increase on dietary fiber, +7.69 and +14.82%, respectively, on the leaves of *P. klaineana* and *M. whitei*. The increase of dietary fibers content may be attributed to their solubility after cooking. Furthermore, this amount of fibers could have immense importance in the digestive process of humans in controlling constipation [28].

Proteins are an important source of amino acids that is required for body development and maintenance [29]. The chemical composition of these two species shows a good level of proteins (Table 1). *M. whitei* is richer in proteins than *P. klaineana* in both raw and boiled leaves, (16.48 ± 0.23; 19.24 ± 0.96%) and (14.93 ± 0.36; 18.80 ± 0.49%), respectively. In addition, it is that cooking in water results in a significant increase in proteins, +16.75 and +25.92%, respectively, in the *M. whitei* and *P. klaineana* leaves. It is worth to indicate that the proteins content which increases in cooked *M. whitei* leaves could be attributed to solubilization of components in agreement with Pujola et al. [30] whose report for peas, lentils, beans and chickpeas showed that, the increase in protein content in cooked beans and lentils were attributed to solubilization of components and, consequently, as a concentration effect. *Mondia whitei* and *P. klaineana* leaves have higher protein contents than other species commonly consumed in the region such as: *G. africanum* (4.86 ± 0.16%) reported by Mbemba et al. [31]; *Manihot esculenta* (7.0%) by Moussa Ndong et al. [32]. The results of this study are encouraging, as these plants could be used by adults, children, pregnant women and lactating nursing mothers to make up for the deficit of proteins population in rural area.

M. whitei is richer in fats than *P. klaineana* in both raw and boiled leaves, (2.95 ± 0.06; 4.94 ± 0.93%) and (1.13 ± 0.11; 3.78 ± 0.21), respectively. In addition, the results show that cooking in water results in a significant increase ($P < 0.05$) in lipid, +67.46% in *M. whitei* and +234.51% in the *P. klaineana* leaves.This increase would be attributed to the concentration of dry matter in the food after cooking. Results of crude fat corroborate those of previous studies such as Vodouhe et al. [27], whose research work found that cooking in water increase contents on lipids leaves.

Carbohydrates are important sources of quick fuel for the brain which solely depends on it for good function alongside with many other organs of the body. *Pyrenacantha klaineana* is richer in carbohydrates than *M. whitei* in both raw and boiled leaves (54.47 ± 0.16; 51.59 ± 1.74%) and (36.58 ± 0.69; 29.74 ± 0.75%), respectively. The high carbohydrates content indicates a highly energy content in foods. The results of this study on the carbohydrates content are greater (superior) to those found by Mbemba et *al*. [31] for *G. africanum* (23.80 ±0.20%) and Moussa Ndong et al. [32] for *Manihot esculenta* (18.3%). According to Yisa et al. [33], the main function of carbohydrates in the body is to provide energy for daily activities in our lives.

M. whitei is richer in energy (kcal) than *P. klaineana* in both raw and boiled leaves, (326.10; 310.37 kcal) and (217.77; 227.88 kcal), respectively. The energy content (kcal) of the two edible wild leaves was observed to increase with the cooking. In addition, cooking the *M. whitei* and *P. klaineana* leaves resulted in an increase in proteins, carbohydrates and fats, resulting in an increase in energy. The amount of energy in the leaves of these two wild edible plants can be an adequate source of energy for rural populations in Northern Angola.

3.2 Mineral Compositions of *M. whitei* and *P. klaineana* Raw Leaves

The mineral contents (macro and micronutrients) of the two selected wild food underutilized in Northern Angola were statistically significant ($P<0.05$), and were found to be the rich sources of minerals (Tables 2 and 3).

The mineral elements are necessary for human biological processes, which regulate the osmotic pressure and protects against many disorders, such as cancer and cardiovascular diseases. In addition, they are ingredients of the skeleton and the enzyme systems [34].

Phosphorus concentration averagely ranged from 175.89 ± 0.17 mg/100 g in *M. whitei* to 239.90 ± 0.06 mg/100 g in *P. klaineana*. Phosphorus is the most abundant mineral in the body after Calcium. Phosphorus regulates various physiological functions including skeletal development, metabolization of mineral, transfer of energy through mitochondrial metabolism, cell signaling and aggregation of blood platelets [35]. It is a building material of bones and teeth together with calcium [36].

The phosphorus levels of some wild plants were found in the ranges of 27.6 to 431.0 mg/100 g [37]. According to Achaglinkame et *al*. [28], the role of phosphorus in the formation of strong bones and teeth, the maintenance of a regular heartbeat, muscle contraction, regulation of the storage and use of body energy, among other roles, cannot be undervalued. This is backed up by the fact that RDA requirement for Phosphorus in both adult males and non-pregnant females is 700 mg/day [38].

Potassium concentration averagely ranged from 1149.83 ± 0.09 mg/100 g DW in *M. whitei* to 2459.20 ± 0.31 mg/100 g DW in *P. klaineana*. Potassium is the mineral element, which presents the highest concentration in the leaves of *P. klaineana* than in those of *M. whitei*. Similar results were reported for K contents and that were obtained in the related studies for 542.88 to 1544.38 mg/100 g [39]. One of the highest macro-elements in many wild edible plants studied, such as *G. africanum* reported by Mbemba et *al*. [40] was determined as potassium. The highest macro element was also identified as K in this study. Potassium plays a very crucial role in the body by helping maintain body fluid and osmotic balance, as well as aiding in the regulation of nerve signals and muscle contractions [41]. According to Institute of Medicine cited by Umerah et *al*. [42], the Recommended Daily Allowance (RDA) for Potassium for both normal healthy males and non-pregnant females between the ages of 19 and 50 years is 4700 mg/day. The range of Potassium content reported in this study shows that the vegetables may be capable of providing about 24.46% (*M. whitei*) and 52.32% (*P. klaineana*) of RDA for healthy living.

Magnesium concentration averagely ranged from 219.90 ± 0.09 mg/100 g in *M. whitei* to 241.93 ± 0.18 mg/100 g in *P. klaineana*. Magnesium contents of various wild edible plants varied from 15.2 to 468.0 mg/100 g [37] The contents of Magnesium found in this study are higher than those reported by Mbemba et *al*. [40] for *G. africanum* (160 mg/100g DW). It established that Magnesium helps relax muscles along the respiratory pathway, enabling asthmatics to breathe with ease [43]. However, the consumption of the *M. whitei* and *P. klaineana* leaves may help prevent these health issues, following their high values. According to [44], Magnesium is a major constituent of bones and teeth alongside Calcium and Phosphorus; also, it is necessary for tissue respiration, the release of parathyroid hormone and for its action in the backbone, intestine, and kidney.

Table 1. The proximate composition (%) and energy value (kcal) of *M. whitei* and *P. klaineana* leaves

Parameters	*M. whitei*		Obs	*P. klaineana*		Obs
	Raw	Boiled		Raw	Boiled	
Ash (%)	12.93 ± 0.20^{a4}	9.53 ± 0.07^{a3}	Decrease	6.74 ± 0.09^{a2}	4.13 ± 0.13^{a1}	Decrease
Crude Fibers (%)	13.16 ± 0.31^{a1}	15.11 ± 0.12^{a2}	Increase	40.45 ± 0.36^{a3}	43.56 ± 0.49^{a4}	Increase
Crude proteins (%)	16.48 ± 0.23^{a2}	19.24 ± 0.96^{a4}	Increase	14.93 ± 0.36^{a1}	18.80 ± 0.49^{a3}	Increase
Fats (%)	2.95 ± 0.06^{a2}	4.94 ± 0.93^{a3}	Increase	1.13 ± 0.11^{a1}	3.78 ± 0.21^{a2a3}	Increase
Carbohydrates (%)	54.48 ± 0.16^{a4}	51.59 ± 1.74^{a3}	Decrease	36.58 ± 0.69^{a2}	29.74 ± 0.75^{a1}	Decrease
Energy (kcal/100 g)	310.39^{a1}	326.10^{a2}	Increase	217.77^{a2}	227.88^{a3}	Increase

Values are mean ± standard deviation. Values with different superscripts in the same row are significantly and statistically different (P < 0.05)

Table 2. Macro-elements present in the *M. whitei and P. klaineana* raw leaves (mg/100 g dry weight or DW)

Parameters	*P. klaineana*	*M. whitei*
Sodium (Na)	126.77 ± 0.24^{a2}	101.57 ± 0.15^{a1}
Potassium (K)	2459.20 ± 0.31^{a2}	1149.83 ± 0.09^{a1}
Calcium (Ca)	2126.33 ± 0.09^{a2}	844.87 ± 0.09^{a1}
Magnesium (Mg)	241.93 ± 0.18^{a2}	219.90 ± 0.09^{a1}
Phosphorus (P)	239.90 ± 0.06^{a2}	175.89 ± 0.17^{a1}

Values are means of three (3) individual measurements ± standard deviation. Means in each column followed by different superscript letters are significantly different (P < 0.05).

Table 3. Oligoelements contents in the *M. whitei* and *P. klaineana* raw leave (mg/100 g DW)

Parameters	*P. klaineana*	*M.whitei*
Copper (Cu)	2.84 ± 0.04^{a1}	3.14 ± 0.04^{a2}
Zinc (Zn)	3.47 ± 0.02^{a1}	1.42 ± 0.05^{a2}
Manganese (Mn)	6.14 ± 0.06^{a2}	5.11 ± 0.03^{a1}
Selenium (Se)	77.86 ± 0.11^{a1}	87.80 ± 0.12^{a2}
Cobalt (Co)	2.84 ± 0.12^{a2}	2.73 ± 0.05^{a1}
Aluminium (Al)	96.81 ± 0.17^{a2}	38.75 ± 0.09^{a1}
Iron (Fe)	21.69 ± 0.07^{a2}	14.21 ± 0.17^{a1}
Nickel (Ni)	7.76 ± 0.03^{a2}	6.32 ± 0.06^{a1}

Values are means of three (3) individual measurements ± standard deviation. Means in each column followed by different superscript letters are significantly different (P< 0.05).

The concentration of Calcium ranged from 844.87 ± 0.09 mg/100 g in M. whitei to 2126.33 ± 0.09 mg/100 g in *P. klaineana*. The contents of calcium found in this study on *M. whitei* and *P. klaineana* leaves are higher than those reported by Mbemba et *al*. [40] for the *G. africanum* (520 mg/100 g DW). According to Theobald [45], Calcium plays an important role in strong bone and teeth formation, the regulation of muscle contractions, and the transmission of nerve impulses in the body; thus, its presence in human diets is a necessity. Calcium also plays a crucial role in nerve impulse transmission and in the mechanism of neuromuscular system [35]. It plays an important role in blood clotting, muscles contraction, and neurological function and also helps in enzymatic metabolic processes [46]. Deficiency can cause rickets, bone pain and muscle weakness [47]. These wild underutilized food leaves can supplement the daily requirements of Ca which have been put by [48] at 260 mg/day.

A range of 101.57 ± 0.15 mg/100 g in *M. whitei* to 126.77 ± 0.24 mg/100 g in *P. klaineana* of Sodium was observed among the leaves and this was significant difference (P < 0.05) between two plant species. Sodium plays a vital role in the conduction of nerve impulses alongside potassium [49]. Compared with other major elements (K, P, Ca and Mg) examined in this study, the Sodium content of the plant was found to be relatively low (Table 2). However, the Sodium levels determined in the current study are compatible with findings of Roe et al. [50] on some common vegetables (0.5 to 30 mg/100 g) and findings of Kibar and Temel [51] on different wild plants (26.24 to 36.10 mg/100 g). Excess intake of Sodium has been implicated in inducing hypertension. Adequate intake for Sodium is 1.2 to 1.5 grams per day [52]. The RDA requirement for Sodium is 1500 mg and 2300 mg/day for normal healthy male adults and female non-pregnant adults aged 19-50 years respectively [53].

The content of Selenium present in the *M. whitei* leaves is higher than that of *P. klaineana*, 87.80 ± 0.12; 77.86 ± 0.11 mg/100 g DW respectively. According to Kieliszek and Błazejak, [54], Selenium is an element whose traces are essential for life. It participates in the protection of cells against excess H_2O_2, in the detoxification of heavy metals and in the regulation of the immune and reproductive system. It also ensures the proper functioning of the thyroid gland. Selenium induces the synthesis process of selenoproteins involved in the body's antioxidant defense mechanism.

Aluminum is highly concentrated in *P. klaineana* leaves than in *M. whitei* leaves, 96.81 ± 0.17 and 38.75 ± 0.09 mg/100 g DW respectively. The Cobalt present in the leaves of *P. klaineana* is higher than that of *M. whitei*, (2.84 ± 0.12 mg/100 g DW) and (2.73 ± 0.05 mg/100 g DW), respectively.

P. klaineana leaves are richer in Iron than *M. whetei*, 21.69 ± 0.07 and 14.21 ± 0.17 mg/100g DW, respectively. The contents of iron found in this study on *M. whitei* and *P. klaineana* leaves are higher than those reported by Mbemba et al. [40] for the *G. africanum* (20.38 mg/100 g DW).

Animals also require Fe to maintain the activities of many important enzymes and for vital haem proteins such as haemoglobin, myoglobin and cytochromes that are involved in oxygen transport and energy metabolism respectively. Like Cu, Fe is subject to strict homeostatic control, although unlike Cu, Fe deficiency is common in both industrialized and developing countries [55]. According to Elinge et *al.* [44], Iron performs several important functions in the body, such as the formation of blood and the transport of oxygen and carbon dioxide to tissues. In addition, Iron is very important for the transport of oxygen in the blood and the control of anemia and its side effects [43]. The Iron content of the *M. whitei* leaves and *P. klaineana* was higher than the FAO/WHO [48] Recommended Dietary Allowance for men (1.37 mg/day) and women (2.94 mg/day). The high level of Iron in these wild food plants could be a major reason for recommending consumption as an alicament as food or health for the control of diseases associated with Iron deficiency (anaemia). In addition, the studied wild underutilized food plants could be recommended in diets for reducing anemia, which affects over one million people worlwide [56].

The highest and lowest Copper contents were observed: *M. whitei* (3.14 ± 0.04 mg/100 g DW) and *P. klaineana* (2.84 ± 0.04 mg/100 g DW), respectively (Table 3). For adults, 0.9 mg of daily Cu intake can meet their daily requirement [57]. Copper (Cu) content in general, varies from 3 to 8 mg/kg for leafy vegetables [58]. The safe and adequate dietary intake of Cu is estimated to be between 1.2 and 3.0 mg per day [59]. Copper is an important trace element required for the activity of several key enzymes, such as cytochrome c oxidase, amino acid oxidase, superoxide dismutase and monoamine oxidase, and copper has been implicated in host cell defense mechanisms, red and white blood cell maturation, Fe transport, cholesterol and glucose transport, metabolism, myocardial contractility, bone strength and brain development [59].

The highest value of Zinc was determined in the *P. klaineana* (3.47 ± 0.02 % DW) and the lowest value was determined in *M. whitei* (1.42 ± 0.05 mg/100 g DW) (Table 3). In previous studies, the levels of Zinc in two different wild food plants were in the ranges of 2.28 to 12.1 mg/100 g DW. According to Bello et al. [43], Zinc is substantially linked to protein synthesis, catalytic activity of several enzymes, and rapid growth and development during early childhood, adolescence and wound healing. In addition, Zinc is a membrane stabilizer and stimulator of the immune response. Zinc deficiency leads to stunted growth and poor development of gonadal function [60].

Nickel is slightly higher in the leaves of *P. klaineana* than in those of *M. whitei*, 7.76 ± 0.03 and 6.32 ± 0.06 mg/100 g DM, respectively. According to Williams, [60], Nickel is a cofactor for an enzyme functioning in nitrogen metabolism.

Manganese content of *M. whitei* leaves was 5.11 ± 0.03 mg/100 g DW and was 6.14 ± 0.06 mg/100 g on *P. klaineana* leaves. The RDA for Manganese (1.8 mg/day) shows that *M. whitei* and *P. klaineana* are rich sources of manganese, which is a component of several metalloenzymes e.g., superoxidase dismutase [43].

4. CONCLUSION AND SUGGESTIONS

Wild edible plants are good sources for minerals, fiber and others useful chemical for human health. In this study, two wild edible leaves species underutilized and consumed in northern Angola were screened for their nutritional and mineral values. The result showed that *M. whitei* and *P. klaineana* leaves are poor sources of fat that make them good for obese people; they are good sources of fiber and can decrease the concentration of high cholesterol level in body. The mineral content showed that the wild edible leaves of *M. whitei* and *P. klaineana* are good sources of various minerals such as Sodium, Calcium, Iron, Calcium, Magnesium, Phosphorus, Potassium, and Selenium. According to their physiological importance, these macro and micronutrients will be of nutritional and health interests for rural populations that consume those leaves. The knowledge of the composition of these leaves seems to be a major nutritional argument to promote their consumption. However, variations in chemical nutrients may be attributed to species, plant genetic structure, topography and different agroclimatic conditions, soils, maturity organ and stage of plant development. There are many wild edible plants available in this part of the country, whose nutritional profile is yet to be documented. In addition, the wild edible leaves, which are mostly neglected, have a good potential in terms of food value and can serve as an easily accessible food resources. Finally, the phytochemical studies should be carried out to discover the toxic and medicinal properties of these plants.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Murat T, Tamer E, Nazim S, Fevzi O. Chemical composition of some edible wild plants grown in Eastern Anatolia. AJEONP. 2015;2(3):31-34.
2. Turner NJ, Łuczaj ŁJ, Migliorini P, Pieroni A, Dreon AL, Sacchetti LE, Paoletti MG. Edible and tended wild plants, traditional ecological knowledge and agroecology. Crit Rev Plant Sci. 2011; 30(1-2):198–225.
3. Nordeide MB, Hatloy A, Folling M, Lied E, Oshaug A. Nutrient composition and nutritional importance of green leaves and wild food resources in an agricultural district, Koutiala, in Southern Mali. Int J Food Sci Nutr. 1996; 47(6):455-468.
4. Özer MÖ, Aksoy M. Mineral composition and nutritional properties of *Trachystemon orientalis* (L.) G. Don populations in the Central Black Sea Region of Turkey. Acta Sci Pol Hort Cult. 2019; 18(4):157–167.
5. Korish M. Nutritional evaluation of wild plant Cissus rotundifolia. Ital J Food Sci. 2016; 28(1):43–49.
6. Ertan P, Yereli K, Kurt O, Balcıoglu IC, Onag A. Serological levels of zinc, copper and iron element among *Giadia lamblia* injected children in Turkey. Pediatr. Int. 2002; 44: 286–288.
7. Spiller GA. Dietary Fiber in Prevention and Treatment of Disease. In: Handbook of Dietary Fiber in Human Nutrition, Spiller GA (Ed.). CRC Press, Washington, DC. 2001; 363-431.
8. Fabbri ADT, Crosby GA. A review of the impact of preparation and cooking on the nutritional quality of vegetables and legumes. Int J. of Gast and Food Sci. 2016;3:2–11.
9. Prakash D, Upadhayay G, Singh BN, Singh HB. Antioxidant and free radical-scavenging activities of seeds and agrwastes of some varieties of soya bean (*Glycine max*). Food Chem. 2007; 104(2): 783-790.
10. Manduna I, Vibrans H. Consumption of Wild-Growing Vegetables in the Honde Valley, Zimbabwe. Eco Bot. 2018;72:436-449.
11. Saka J, Rapp I, Akinnifesi F, Ndolo V, Mhango J. Physicochemical and organoleptic characteristics of *Uapaca kirkiana*, *Strychnos cocculoides*, *Adansonia digitata* and *Mangiferia indica* fruit products. Int. J. Food Sci. Technol. 2007; 42: 836-841.
12. Mawunu M, Kola B, Afonso E, Makonzo Mbuta ZV, Luyindula N, Ngbolua KN. Contribution to the knowledge of no-timber forest products of Ambuila Municipality (Uíge, Angola): The wild edible plants]. Int J Innov Sci Res. 2016; 26,190-204.
13. Monizi M, Fernando J, Luyindula N, Ngbolua KN, Christoph N, Thea L, Lukoki LL, Heitor MT. Traditional Knowledge and Skills in Rural Bakongo Communities: A Case Study in the Uíge Province, Angola. Am J Env Sust Dev. 2018; 3(3):33-45.
14. Monizi M, André CD, Luyeye L, Ngbolua KN, Ndiku L. Ethnobotanical and socio-economics of *Dracaena camerooniana* Baker in Uíge Province, Northern Angola. J Agri Ecol Rese Int. 2019; 20(2):1-15.
15. Lautenschläger T, Monizi M, Pedro M, Mandombe JL, Bránquima MF, Christin H, Neinhuis C. First large-scale ethnobotanical survey in the province of Uíge, northern Angola. J Ethnobiol Ethnomed. 2018;14:51.
16. Remi K, Ludovic T, Pierre B, Hubert DB. Les légumes feuilles des pays tropicaux : Diversité richesse économique et valeur santé dans un contexte très fragile (Leafy vegetables from tropical countries : Diversity, economic wealth and health value in a very fragile context). Montpellier, France : CIRAD Déparement Flhor; 2005.
17. Islary A, Sarmah J, Basumatary S. proximate composition, mineral content, phytochemical analysis and in vitro antioxidant activities of a wild edible fruit (*Grewia sapida* Rosb. ex DC) found in Assam of North-east India. J. Inv.Biochem. 2016;5(1):21-31.

18. Łuczaj Ł, Pieroni A, Tardío J, Pardo-De-Santayana M, Sõukand R, Svanberg I, Kalle R. Wild food plant use in 21st century Europe: The disappearance of old traditions and the search for new cuisines involving wild edibles. Acta Soc Bot Pol. 2012; 81:359–370.
19. APG III. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. APG III. Bot J L Soc. 2009;161:105–121.
20. SANBI (South African National Biodiversity Institute). Whites ginger (*Mondia whitei*). Stoffel Petrus Bester National Herbarium, Pretoria, South Africa; 2007.
21. Latham P, Konda KA. Plantes utiles du Bas-Congo, République Démocratique du Congo. 2014; 380.
22. Available:http://www.plantoftheworldonline.org (Accessed on May 27, 2020).
23. Seal T, Chaudhuri K. Nutritional analysis of some selected wild edible plants consumed by the tribal people of Meghalaya state in India. Int J Food Sci Nutr. 2016;1(6):39-43.
24. AOAC. Official methods of analysis, 17th edn. Association of Official Analytical Chemists, Gaithersburg; 2000.
25. Ngbolua KN, Lengbiye ME, Mbembo-wa-Mbembo B, Ngiala BG, Mutwale KP, Ngombe KN, Messi M, Mbing NJ, Pegnyemb DE, Mpiana PT. Selenium Content, Anthelmintic, Antioxidant and Antibacterial Activities of *Artocarpus Heterophyllus* Lam. From Ubangi Ecoregion in Democratic Republic of the Congo. Am J Biomed Sci & Res. 2019; 6(2).
DOI : 10.34297/AJBSR.2019.06.001013
26. Nafir-Zenati S, Gallon G, Faver J-C. Effet de la cuisson sur la teneur en mineraux des epinards. ORSTOM Fonds Documentaire. No.36.445-ex1.1993.
27. Vodouhe S, Dovoedo A, Anihouvi VB, Tossou CV, Soumanou MM. Influence du mode de cuisson sur la valeur nutritionnelle de *Solanum macrocarpum*, *Amaranthus hybridus* et *Ocimum gratissimum*, trois légumes-feuilles traditionnels acclimatés au Bénin. Int. J. Biol. Chem. Sci. 2012;6(5):1926-1937.
28. Achaglinkame M, Aderibigbe R, Hensel O, Sturm B, Kudadam K J. Nutritional Characteristics of Four Underutilized Edible Wild Fruits of Dietary Interest in Ghana. Foods. 2019;8: 104.
29. Dreon DM, Vranizan KM, Krauss RM, Austin MA, Wood PD. The effects of polyunsaturated fat monounsaturated fat on plasma lipoprotein. J Am Med Ass. 1990;263:2462-2466.
30. Pujola M, Farreras A, & Casanas F. Protein and starch content of raw soaked and cooked beans (*Phaseolus vulgaris* L.). Food Chem. 2007; 102(4):1034-1041.
31. Mbemba F, MoutsamboteJM, Nzikou JM, Mvoula-Tsiery M, Itoua OSY, Nganga I, Mboungou Z, Silou Th. Physical Factures Nutritional Value of the Traditional Picking Vegetable, *Cuervea isangiensis* (De wild.) N. hallé in Congo-Brazzaville. Adv J Food Sci Tech. 2013; 5(1):72-76.
32. Moussa N, Salimata W, Nicole D, Amadou T G, Rokhaya D G. Nutritional value of *Moringa oléifera*, study of the bioavailability of iron, effect of enrichment of various traditional Senegalese dishes with the powder of the leaves. AJFAND. 2007;7:3.
33. Yisa J, Egila JN, Darlinton AO. Chemical composition of *Annona senegalensis* from Nupe land, Nigeria. Afr J of Biotech. 2010; 9(26):4106-4109.
34. Gonza´lez-Barrio R, Periago MJ, Luna-Recio C, Garcia-Alonso FJ, Navarro-Gonza´lez I. Chemical composition of the edible flowers, pansy (*Viola wittrockiana*) and snapdragon (*Antirrhinum majus*) as new sources of bioactive compounds. Food Chem. 2018;252:373-380.
35. Rana YS, Tiwari OP, Krishan R, Sharma CM. Determination of nutritional potential of five important wild edible fruits traditionally used in Western Himalaya. Int. J. of Life Sci. 2018;6(1):79-86.
36. Mbemba F. Aliments et denrées alimentaires traditionnels du Bandundu en RD Congo : Répertoire et composition en nutriments, Ed L'Harmattan, Paris; 2013.
37. Guzelsoy NA, Ucurum O, Tokat E, Tan A, Ay ST, Ozbek K. Nutritional Properties of some Wild Edible Plant Species in Turkey. Anadolu. 2017;27(2):39–45.
38. Vunchi M A, Umar A N, King M A, Liman A A, Jeremiah G, Aigbe C O. Proximate, vitamin and mineral composition of *Vitex doniana* (black plum) fruit pulp. NJBAS. 2011;19(1):97-101.
39. Yıldırım E, Dursun A, Turan M. Determination of the nutrition contents of the wild plants used as vegetables in upper Çoruh Valley. Turk J Bot. 2001;25:367-371.

40. Mbemba F, Tatola NK, Itoua Okouango SY, Moutsambote JM, Mvoula-tsieri M, Silou Th. Composition in mineral elements of the traditional vegetables leaves of *Cuervea isangiensis* (De Wild.) N. Hallé in Congo-Brazzaville. Current Res. J Biol Sci. 2012;4(6):738-742.
41. Palmer BF. Regulation of potassium homeostasis. Clin. J. Am. Soc. Nephrol. 2015;10:1050–1060.
42. Umerah NN, Asouzu AI, Okoye JI. Effect of processing on the nutritional composition of *Moringa olifera* Leaves and Seeds. Eur J Nutr Food Saf. 2019; 11(3):143-155.
43. Bello MO, Falade OS, Adewusi SRA, Olawore NO. Studies on the chemical compositions and anti- nutrients of some lesser known Nigeria fruits. Afr. J. Biotech. 2008;7:3972–3979.
44. Elinge CM, Muhammad A, Atiku FA, Itodo AU, Peni IJ, Sanni OM, Mbongo AN. Proximate, mineral and anti-nutrient composition of pumpkin (*Cucurbita pepo* L.) seeds extracts. Int. J. Plant. Res. 2012; 2:146–150.
45. Theobald HE. Dietary calcium and health. Nutr. Bulletin. 2005;30:237–277.
46. Senga KP, Opota OD, Tamba VA, Tona LG, Kambu KO, Covaci A, Apers S, Pieters L, Cimanga K. Chemical composition and nutritive value study of seed oil of *Adenanthera pavonina* L. (Fabaceae) growing in Democratic Republic of Congo. Int J Pharma Tech Research. 2013;5(1): 205-216.
47. Alakali JS, Kucha CT, Rabiu IA. Effect of drying temperature on the nutritional quality of *Moringa oleifera* leaves. Afr. J. Food Sci. 2015;9(7):395-399.
48. FAO/WHO. Human Vitamin and Mineral Requirements. 2001;268.
49. Al-Farga A, Zhang H, Siddeeg A, Shamoon M, Chamba MV, Al-Hajj N. Proximate composition, functional properties, amino acid, mineral and vitamin contents of a novel food: Alhydwan (*Boerhavia elegana* Choisy) seed flour. Food Chem. 2016;211:268–273.
50. Roe M, Church S, Pinchen H, Finglas P. Nutrient analysis of fruit and vegetables. Analytical Report, Institute of Food Research, Norwich Research Park, Colney, Norwich; 2013.
51. Kibar B, Temel S. Evaluatıon of mıneral composition of come eıld edible plants growıng in the eastern Anatolıa Regıon Grasslands of Turkey and consumed as vegetable. J. Food Process. Preserv. 2016;40(1):56–66.
52. Food and Nutrition Board, Institute of Medicine United States National Academics. Dietary Reference Intakes: Water, potassium, sodium, chloride and sulphur; 2005.
53. Dias JS. Nutritional quality and health benefits of vegetables: A review. Food and Nutr Sci. 2012;3(10):1354-1374.
54. Kieliszek M, Błazejak S. Current Knowledge on the Importance of Selenium in 24. Food for Living Organisms: A Review. Molecules. 2016;21:609.
55. Welch RM, Graham RD. Breeding for micronutrients is staple food crops from human nutrition perspective. J. Exp. Bot. 2004;55:353-364.
56. Emmanuel O, Ugbogu AE, Odungide AA, Atani CS. Proximate, antinutritional and mineral estimation of some selected consumed green vegetables in Afaha Eket, Akwa-Ibom State, Nigeria. AJFST. 2017; 5(5):182-191.
57. Otten JJ, Hellwig JP, Meyers LD. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements; Institute of Medicine: Washington DC, USA; 2006.
58. Kabata-Pendias A, Mukherjee AB. Trace elements from soil to human. Springer Science and Business Media, Heidelberg, Germany. 2007;550.
59. Food Standards Agency. Safe Upper Levels for Vitamins and Minerals: Report of the Expert Group on Vitamins and Minerals. Food Standards Agency, London, UK. 2003;360.
60. Williams US. A Textbook of Biology, Third Edition; 1992.

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