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CHEMICAL COMPOSITION AND MINERAL CONTENTS OF LEAFLETS, RACHIS AND FRUITS OF *CHAMAEROPS HUMILIS* L.

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Abstract
The aim of the this investigation was to study chemical composition in leaflets, rachis and fruits (pericarp) of Chamaerops humilis L. The moisture, ash, total soluble solids, crude fiber, protein and lipids analysis, and mineral composition, were performed using standards analytical methods. Inductively coupled plasma-mass spectrometry (ICP-MS) was used to determine the concentrations of constituent elements in the leaflets, rachis and fruits of Chamaerops humilis L. collected from West coastal region of Algeria. The protein value ranged from 22.04±1.60 to 30.27±1.60%, fat was 0.53±0.20 to 2.13±0.49%, crude fiber was 18±1 to71±2 %, ash was 3.0±0.5 to 5.1±0.2%, total soluble solids (TSS) was 2.4±0.0 to 4.0±0.0% and moisture was 17.37± 0.12 to 51.68± 0.16%, Titratable acidity was 0.23±0.0 to 0.28±0.01%. The concentration of the minerals ranged from 7,322±0.69 to 1092,549±2.5 µg kg-1 for potassium, 74,760±1.06 to 111,343±1 µg kg-1 for Magnesium, 7,309±1.22 to 62,328±1.9 µg kg-1 for calcium and 14,169 ± 2.01 to 18,456 ± 1.01 µg kg-1for zinc. These results showed that the plant samples would serve as good sources of K, Mg, Ca, Zn and Sr but moderate sources of Fe, Cu and Na while Hg was not detected. All plant parts were rich in proteins, fibers and minerals.

Keywords: Arecaceae; Dwarf palm; Proximate analysis; Minerals; ICP-MS

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1. INTRODUCTION

Palms are an economically important family of Monocot comprising 188 genera and 2600 species (Dransfield et al., 2008, Baker et al., 2009) divided into five subfamilies (Dransfield et al., 2005).

Chamaerops humilis L. belongs to the Commelinids clade, Arecales order, Arecaceae (Palmae) family, Coryphoideae subfamily (Creté, 1965). It is variously called European fan palm, or Mediterranean dwarf palm. The genus Chamaerops is monotypic comprising a single specie. In Algeria, it grows in arid to semi-arid areas and has an important ecological function in preventing soil erosion.

The above ground vegetative organs are composed of short trunks, the leaves, which emerge in a terminal tuft, have woody rachis armed with thorns and fan-shaped blades which fold along the midribs. Leaves have numerous fibres (Benahmed-Bouhafsoun et al., 2007). It is dioecious and blooms in spring. The fruit is a globular reddish-brown drupe, ovoid; measuring 1-4 cm. Inside the fruit there is a single seed which is very hard .The palm yields fruits during the summer and autumn seasons.*C. humilis* L. Is one of the more cold-hardy palms used in landscaping in temperate climates (Herrera, 1989).

Besides its potential use in regenerating vegetation cover in arid areas and its application as an ornamental plant, this palm has traditionally been used for other purposes.

In folk medicine, the fruits have been used as an astringent because of their high tannin content (Benmehdi et al., 2012), it is also used to treat diabetes (Gaamoussi et al., 2010). In addition, some compounds of Chamaerops extracts have been reported to possess antioxidant properties (Benahmed-Bouhafsoun et al., 2013; Gonçalves et al., 2018) and antilithic (Beghalia et al., 2008) activity.

Regarding mineral composition, to our knowledge no data were available on the three parts of *Chamaerops humilis* L. of Algerian origin. Several analytical methods can be applied for elemental quantification of biological samples, including inductively coupled plasma-mass spectrometry (ICP-MS) and ICP-optical emission spectrometry (ICP-OES) (Salt et al., 2008). The multi-elemental capacity in combination with an excellent precision makes ICP-MS a perfect choice for analysis of digested plant samples (Hansen et al., 2009).

The present work has the main objective to determine the chemical composition of leaflets, rachis and fruits samples of *Chamaerops humilis* L., including moisture, TSS, pH, ash, proteins, lipids, crude fiber content, and to assess the minerals composition by using ICP-MS.

2. MATERIALS AND METHODS

Chamaerops humilis L. Var. argentea was collected from western Algeria (Oran) in June of 2016. Samples consisting of leaflets, rachis and fruits (pericarp) of *Chamaerops humilis* L. were dried and stored for detailed chemical analyses.

2.1. Chemical composition

Physicochemical characterization of Chamaerops has been performed in order to explore their potential use. The pH values were measured using a digital pH-meter (InoLab pH 7110) with a precision of ± 0.002 pH units. Titratable acidity was determined by a titrimetric method according to the (AOAC, 2000). Total soluble solids content (TSS) was determined using a digital refractometer, all measurements were performed at 25 °C (AOAC, 2000) and results were expressed as °Brix. Moisture was determined through gravimetry, using ventilated oven at 100°C until reaching constant weight (Audigie et al., 1995).

Ash content (AOAC, 2000) was measured through gravimetry after incineration in a furnace (Linn High therm GmbH) at 550°C for 5 hours (sample of 2 g). All measurements were performed in triplicate.

2.2. Lipid content

Lipid content was measured using a Soxhlet extractor. Petroleum ether was added to 2g sample and placed in an extraction apparatus; after which the petroleum ether had evaporated to dryness and only lipid remained in the flask. The amount of fat was obtained as the difference in the weight of the flask before and after drying off the petroleum ether. All measurements were performed in triplicate.

2.3. Total proteins

Powdered micro-samples (5mg) were combusted in an elemental analyser (Costech ECS 4010) to determine the nitrogen contents. Then, the total protein contents were determined according to Kjeldahl system using conversion factor 5.68±0.30 required for nutritional applications. (Sosulski and Imafidon, 1990).

2.4. Crude fibers

Leaf powder (5 g) was treated twice with a chloroform-methanol (v/v) mixture for 14 h. The insoluble material was incubated with ethanol for 2h at room temperature, then in boiling ethanol for 2 h. The insoluble residue was recovered by filtration through a nylon mesh, and then dried at 50°C for 48 h to yield a crude fiber.

2.5. Minerals determination

Surface of the samples were washed twice with deionized water. Samples were air-dried in a clean drying chamber for 15 days under shadow. The dried leaves samples were ground into a fine powder using a mill (IKA werke, GMBH & Co., Germany). The powder was stored in air sealed plastic containers at room temperature until analyzed.

Powdered samples (0.5 g) were digested in closed vessel devices with concentrated 65% Nitric acid HNO_3 (6 mL) and 30% ultrapure hydrogen peroxide H_2O_2 (2 mL) by Milestone microwave program under temperature and pressure of 110-200°C and 45 bar, repectively for 45 min. After cooling, the obtained digestate was filtered to get the clear solution. The filtrate was diluted to 20 mL with deionized distilled water. The digested samples were analyzed to determine the content of Ca, Mg, P, K, Fe, Cu, Zn, Mn, Na and Se by ICP-MS (inductively coupled plasma-masse spectrometry) (Agilent Technologies 7700X G3281A, Japan).

2.6. Statistical analysis

Descriptive statistical analyses were performed using Excel software (Microsoft Office 2010) to calcule the means and their standard errors. The assays were carried out in triplicate and the results expressed as mean value ± standard deviation (SD).

3. RESULTS AND DISCUSSION

3.1. Proximate analysis

Proximate analysis is an important index to classify the nutritional value of a food material (Sousa et al., 2014). The physicochemical analyses were carried out on the leaflets, rachis and fruits (pericarpe) of *Chamaerops humilis* L., and the results were reported on Table 1. Protein, crude fibers and lipids are the most vital biochemical constituents of plants.

In the present study, the content of total protein (dry weight basis) in rachis was slightly higher than in leaflets (23.85±1.26% and 22.04±1.60%) respectively, but substantially higher in fruits (30.27±1.60%). Ahmed et al. (2015) reported low value of protein (7.3%) in Chamaerops fruit from Egypt. Other studies have described lower content in Arecaceae 13.93% for *Phœnix dactylifera* fruit of Saudi Arabia (Trabzuni et al., 2014) and 16.44±0.93% for the *Acrocomia aculeata* fruit (Lescano et al., 2015).The high content of total protein (30.27±1.60%), is an indication that the fruits were good sources of protein for humans and could also be utilized as feed stocks for animals. Total lipids were found to be generally low. The content of rachis were less (0.53±0.20%) than leaflets and fruits (2.13±0.49, 1.13±0.23%) respectively. This value is higher than that of the dates of *P. dactylifera*, (1.73±0.04%) (Shaba et al., 2015) and than that of the doum palm from Soudan (*Hyphaene thebaica*) (0.90±0.00 %) (Salih and Yahia, 2015), but it was lower than *Acrocomia aculeata* and A. *intumescens* fruits (23.62%, 29.60%) respectively, (Lescano et al., 2015 ; Silva et al., 2015).

Chamaerops humilis L. contained a high concentration of crude fiber which is considered the main component. The highest content was observed in the leaflets (71±2%) followed by rachis (63±1%). The fruits were the poorest in crude fiber (18±1%). A study on leaves of *Phœnix canariensis* have shown a similar content of crude fiber of 69% (Bouhafsoun et al., 2017). However, studies on the other Arecaceae fruits have found a lower content of crude fiber (11.42%, 13.89%) in *Livistona chinensis* and *Acrocomia aculeata* respectively (Daho and Mala, 1997 ; Lescano et al., 2015).Crude fiber has pivotal role in human diet. It is considered as the material left after digesting the tissue. It is mainly composed of cellulose, hemicelluloses, lignin and some minerals. Crude fiber decreases the absorption of cholesterol from the gut in addition to delaying the digestion and conversion of starch to simple sugars, an important factor in the management of diabetes (Cust et al., 2009).

The proximate analysis showed the moisture content percentage of the leaflets, rachis and fruitd as of *C. humilis* as 51.68±0.16%, 41.84± 0.10% and 17.37 ± 0.12%, respectively. These results are consistent with values previously described in *Phœnix canariensis* (59.4%) (Ghlam, 2014). However, another study reported higher values of moisture in *Butia odorata* (79.58 ± 0.04%) (Ferrão et al., 2013).

Ash content is an important characteristic in plants because it represents the mineral content in the plant and is part of proximate analysis for nutritional evaluation. The analysis of the Chamaerops ash revealed interesting amounts of minerals (Table 1).

Table 1. Physicochemical composition of *Chamaerops humilis* L.

Parameters	**Leaflets**	**Rachis**	**Fruits (pericarp)**
Protein (%)	22.04±1.60	23.85±1.26	30.27±1.60
Lipid (%)	2.13±0.49	0.53±0.20	1.13±0.23
Crude fibers (%)	71±2	63±1	18±1
Ash (%)	5.1±0.2	3.0±0.5	4.2±0.7
Moisture (%)	51.68± 0.16	41.84± 0.10	17.37±0.12
TSS (°Brix)	2.4±0.0	2.4±0.0	4.0±0.0
pH	6.50±0.01	5.50±0.01	5.0±0.0
Titratable acidity (%)	0.28±0.01	0.25±0.00	0.23±0.00

Each value is the mean±SD (n=3).

The values obtained varied from 3.0 to 5.1%, the highest being in Chamaerops leaflets and the lowest being from the rachis. These findings were in accordance with ash content mean values of legumes of 2.4 to 5.0% recommended by FAO (1989). The result of the ash content in the sample is a suggestion of a low deposit of mineral elements in the samples compared to the recommended values by the FAO. This may indicate that palm fruits (dates) would likely contain very high qualities of essential minerals. Since ash content is an index in evaluating the nutritive quality of foods.

The pH and acidity are important criteria for plant, whereas the TSS can be used to evaluate the amount of sugars present in plant (Bhat et al., 2011).The pH of *Chamaerops humilis* samples varied from 5.0 to 6.5.The highest was from the leaflets (6.50±0.01), while that from fruits showed the lowest value (5.00±0.01). Compared to that of the other Arecaceae, this value was similar to that of the fruit of the date palm *Phœnix dactylifera* L. 5.33±0.06 (Noui et al., 2014) and higher than that of fruit of *Hyphaene thebaica* 4.84± 0.02 (Aamer, 2016).

Titratable acidity of Chamaerops fruit was 0.23 ±0.00 % and was 0.28±0.01% and 0.25±0.01% for leaflets and rachis, respectively. These values were slightly different. Similar results were observed in *Hyphaene thebaica* 0.22±0.00% (Aamer, 2016).

Brix is the total of dissolved solids expressed on a weight basis as determined by the refractometer. It is actually the percentage of sucrose by weight. The TSS content of the Chamaerops ranged between 2.4 (leaflets and rachis) and 4°Brix (fruits), that could be directly related to the amount of sugars present in samples (Chitara & Chitara, 1990). Thus, fruits presented a higher sugar content than the other parts of Chamaerops. However, the TSS observed in other arecaceae as *Butia odorata* (9.5±0.0) (Ferrão et al., 2013) were higher than that of all Chamaerops parts.

3.2. Minerals content

Few studies reporting centesimal composition of mineral content of *Chamaerops humilis* leaves showed that it contained K, Ca, Na, Mg, Al, Fe, Mn, Cu, and Zn and was also a source of vitamin E (Siles et al., 2013; Khoudali et al., 2016). Our investigation revealed that among the analyzed minerals of Chamaerops fruits, leaflets and rachis Potassium (K), Magnesium (Mg), Calcium (Ca), Zinc (Zn), Iron (Fe), Chromium (Cr), Strontium (Sr), Copper (Cu), Rubidium (Rb), Vanadium (V), Barium (Ba), Silver (Ag), Lithium (Li). As shown in Table 2, mineral contents in *C. humilis* were found in the following order: K > Mg > Zn > Ca > Sr > Cu > Rb in leaflets, K > Mg > Ca > Zn > Sr > Cu > Rb in fruits and Mg > Zn > K > Ca > Sr > Cu > Rb in rachis.

The most abundant element found in the *C. humilis* was K with concentrations of 1092,549±2.5 and 350,164±1.23µg kg^{-1} in fruits and leaflets, respectively. Potassium has been reported to be the principal cation in body cells and critical to normal heart beat (Postlethwait et al., 1991).

Table 2. Mineral compositions (μg kg^{-1}) of *Chamaerops humilis* L.

Minerals	**Leaflets**	**Rachis**	**Fruits (pericarp)**
Calcium Ca	14,456 ±0.96	7,309±1.22	62,328±1.9
Iron Fe	948±1.50	628±0.72	3,710±0.6
Sodium Na	539±0.80	11.26±0.23	1,681±0.69
Potassium K	350,164±1.23	7,322±0.69	1092,549±2.5
Magnesium Mg	90,560±1.22	74,760±1.06	111,343±1
Chromium Cr	1,000 ± 0.65	1,145 ± 0.48	1,158 ± 0.5
Lead Pb	1,795 ± 0.03	187 ± 0.01	201 ± 0.06
Copper Cu	3,806 ± 0.40	5,910 ± 1.03	9,422 ± 0.91
Zinc Zn	18,456 ± 1.01	14,169 ± 2.01	15,463 ± 0.70
Vanadium V	248 ± 0.07	47.70 ± 0.30	60.19 ± 0.02
Cadmium Cd	5.21 ± 0.36	2.14 ± 0.02	11.93 ± 0.29
Strontium Sr	7,733 ± 2.07	6,621± 1.03	12,941 ± 1
Selenium Se	54.73 ± 0.58	26.69 ± 0.78	151 ± 0.39
Arsenic As	90.20 ± 0.13	33.8 ± 0.73	46.42 ± 0.98
Lithium Li	183 ± 0.93	540 ± 0.38	197 ± 0.57
Cobalt Co	27 ± 0.42	11.24 ± 0.16	10.06 ± 0.70
Nickel Ni	350 ± 0.52	504 ± 0.93	526 ± 0.68
Cesium Cs	9.14 ± 0.03	2.82 ± 0.01	9.75 ± 0.01
Silver Ag	176±0.06	335±0.10	54.60±0.02
Barium Ba	1,169±0,41	170±0.40	463±0.88
Mercury Hg	ND	ND	ND
Thallium Tl	0.37 ± 0. 20	0.67 ± 0. 20	0.64 ± 0. 20
Rubidium Rb	1,968 ± 0.85	5,590 ± 0.20	7,980 ± 0.45
Beryllium Be	2.16±0.09	N.D.	N.D.

The data are presented as mean value±standard deviation of triplicate analyses ($p \leq 0.05$).
N.D.= not detected

In this context, it could be said that *C. humilis* is a rich source of Potassium .This result is in agreement with the report of Ahmed et al. (2015) and Khoudali et al. (2016), who found that the dominant mineral in various samples of *C. humilis* L. was K.

The second most abundant element was Mg with concentrations of 111,343±1; 90,560±1.22 and 74,760±1.06 μg kg^{-1} in fruits, leaflets and rachis, respectively. Many studies in the literature showed that Magnesium has many roles including supporting the functioning of the immune system; and assisting in preventing dental decay by retaining the calcium in tooth enamel. Magnesium also helps maintain normal muscle and nerve function (Elinge et al., 2012), and improve insulin resistance, and keeps heart rhythm steady (Volpe et al., 2008).

Furthermore, Calcium concentrations being the third most prevalent element next to K and Mg found in *Chamaerops humilis* L., with content higher in fruits (62,328±1.9 μg kg^{-1}) than in leaflets and rachis, (14,456±0.96 and 7,309±1.22 µg kg^{-1}), respectively.

Ca is known to help ease insomnia, regulate the passage of nutrients through cell walls and stimulate muscle (Dawson-Hughes et al., 1997).

Zinc concentration was of 18,456 ± 1.01 µg kg^{-1}in leaflets while lower in fruits and rachis. Zn is an essential trace element and plays an important role in in glucose metabolism (Isbir et al., 1994). It helps in the utilization of glucose by muscle and fat cells and is involved in brain development, behavioral response, bone formation and wound healing.

In fruit, the content of strontium was considerably important (12,941 ±1 µg kg^{-1}) followed by leaflets and rachis. Sr is a chemical element similar to calcium, scientific studies have shown that Sr may have positive effects on bone diseases like osteoporosis and bone cancer (Giammarile et al., 2001).The copper content of *C. humilis* L. fruits, rachis and leaflets was 9,422 ± 0.91 ; 5,910 ± 1.03 and 3,806 ± 0.40 µg kg^{-1}, respectively. Copper is essential for maintaining the strength of the skin, blood vessels, and plays also a role in the production of hemoglobin, myelin, melanin and it also keeps thyroid gland functioning normally (Harris, 2001). In addition, the other traces elements were found in various proportions in the three samples. Some elements such as Se, and Cu were reported to be included in human cell defense mechanisms against reactive oxygen species (ROS) (Negi et al., 2012). These minerals act as cofactors of several antioxidant enzymes. They were detected in all Chamaerops parts. Among the Chamaerops minerals, mercury was not detected and the contents of cadmium were very low, no more than 11.93±0.29 µg kg^{-1}; this confirms that Chamaerops is a good source of beneficial minera**l**s (Khoudali et al., 2016).

4. CONCLUSION

The above results provide useful information about some parameters of the chemical composition of *C. humilis* of Algeria. We concluded that fruits can be considered as valuable sources of protein and minerals, especially potassium, magnesium, calcium, and zinc. The values of total fat were relatively low. Leaflets and rachis were a good source of crude fibers. *C. humilis* is very nourishing and might be further used as a food supplement.

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