African Journal of Pharmacy and Pharmacology Vol. 6(39), pp. 2782-2786, 22 October, 2012
Available online at http://www.academicjournals.org/AJPP
DOI: 10.5897/AJPP12.465
ISSN 1996-0816 ©2012 Academic Journals

Full Length Research Paper

Mineral analysis of *Phoenix dactylifera* L. leaves by inductively coupled plasma optical emission spectroscopy

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Accepted 13 July, 2012

***Phoenix dactylifera* L. (date palm) is well known for its innumerable health benefits and nutritional values. However, utilization of leaves as a source of element supplement has not been yet explored. Thus, the present study was aimed to employ inductively coupled plasma optical emission spectroscopy (ICP-OES) for the determination of macro and micro nutrients present in the leaves of three varieties (Rothana, Barhee and Sukri) of *P. dactylifera*. The results revealed that the date palm leaves, depending upon the variety contain significant but quite variable amounts of macro as well as micro elements. Varieties Barhee, Sukri and Rothana had calcium in abundance while var. Sukri and Barhee also had significantly high level of potassium (K). Positive correlation was observed between sodium (Na) and K (r = 0.868), iron (Fe) and zinc (Zn) (r = 0.945) in var. Barhee, Sukri and Rothana. Thus, it may be concluded that date palm leaves of three varieties of *P. dactylifera* have the potential to provide significant level of essential nutrients to human beings and thus, can cure various diseases.**

Key words: *Phoenix dactylifera*, mineral analysis, macronutrients, micronutrients.

INTRODUCTION

Plants are important source of traditional medicine and therefore have an important role to play in maintenance of health. The modern system of medicine has adopted a number of plant-derived drugs which have been used in traditional system of medicines. According to World Health Organization, medicinal plants can be a good source of variety of drugs. It is estimated that 80% of the people worldwide rely on plant based medicines for their primary healthcare (Alagesaboopathi, 2011). Plant derived drugs are gaining importance due to their minimal side effects, easy availability and acceptability. Furthermore, plant parts are used raw to overcome macro and micro nutrient malnutrition. Plants are now being increasingly used in cosmetics, food as well as alternative medicine (Bakhru, 1998; Asgarpanah and Ramezanloo, 2012). Most studies on such medicinal plants pertain to their organic contents, viz. essential oils, glycosides, vitamins, alkaloids and other active components and their pharmacological/therapeutic effects. Besides several organic compounds, it is now well established that many trace elements play a vital role in general well-being as well as in the cure of diseases (Prasad, 1993; Fraga, 2005; Nasri et al., 2012; Alam et al., 2012).

About 50 of the known elements occur in measurable concentrations in the living systems (Fraga, 2005). Every form of living matter requires these inorganic elements or minerals for their normal life processes (Hays and Swenson, 1985; Ozcan, 2004). Presence of inorganic elements is necessary for the maintenance of certain physicochemical processes which are essential to life. Although they yield no energy, they have important roles to play in many activities in the body (Malhotra, 1998).

In humans and other mammals, 23 elements have known physiological activities. From these elements, 11 can be classified as trace elements because of their essentiality and very limited quantity in humans. Trace

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elements include, at least, the transition metals vanadium, chromium, manganese, iron, cobalt, copper, zinc, and molybdenum; and the non-metals selenium, fluorine, and iodine. All of these belong to the category of micronutrients, which are needed by the human body in very small quantities (generally less than 100 mg/day), as opposed to elements considered macronutrients, such as sodium (Na), calcium (Ca), magnesium (Mg), potassium (K), chlorine (Cl), etc., which are required in larger quantities. These trace elements are essential components for biological activities, but at the same time they can be toxic at higher concentrations. Manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), and selenium (Se) accomplish functions essential to maintaining human health. An alarming statistic is that half of the world's population is deficient in Fe and Zn (Hotz and Brown, 2004; Welch and Graham, 2004). Deficiency in any of these element leads to undesirable pathological conditions that can be prevented or reversed by adequate supplementation. Plants are one of the sources of these elements. The leaves of the plants are still used in several countries, for their therapeutic effects. Since these trace elements constitute a minute fraction in different parts of the medicinal plants, a sensitive and reliable analytical technique is a prerequisite for obtaining precise and accurate data (Lokhande et al., 2010).

The date palm is a major fruit tree in most of Arabian Peninsula and it is considered one of the most important commercial crops. Dates, the fruits of date palm constitute a substantial part of the diet in the Arabian world. Presently, 2000 or more different cultivars of date palm are cultivated worldwide (Al-Hooti et al., 1997). The beneficial health and nutrition values of date palm, for human and animal consumption have been claimed for centuries (Duke and Boca, 2001; Vayalil, 2002; Tahraoui et al., 2007). Phytochemically, the whole plant contains carbohydrates, alkaloids, steroids, flavonoids, vitamins and tannins. The phenolic profile of the plant revealed the presence of mainly cinnamic acids, flavonoid glycosides and flavanols (Dowson, 1982; Biglari et al., 2008). Four free phenolic acids and nine bound phenolic acids have been tentatively identified (Ziouti et al., 1996; Eong et al., 2006). The pharmacological studies conducted on *Phoenix dactylifera* indicate the immense potential of this plant in the treatment of conditions such as diarrhea, gastric ulcer, skin disorders, cardiovascular disorder, and inflammatory ailments including liver and kidney disorders, microbial and viral infections, cancer. Date palm is considered as a potentially safe and effective plant that has important medicinal values and benefits (Baliga et al., 2011). The numbers of date palm in the Kingdom of Saudi Arabia are estimated to be over 23.5 million. These trees are estimated to yield about 210,000 tons of fronds. Every year about 3 million palm trees are pruned and the portion becomes a waste (Anonymous, 2009).

Most of the available literature on element content of date palm deals with fruits rather than vegetative parts such as leaves, though some studies were carried out on role of elements in growth and development of plant (Mohamed and Khamis, 2004; Saleh, 2009). Thus, the study was planned to find out the possible use of date palm leaves as a source of element/mineral supplement. The element content of date palm leaves were determined by inductively coupled plasma optical emission spectroscopy (ICP-OES). The inter-elemental correlation was also examined between three varieties of date palm.

MATERIALS AND METHODS

Collection and storage of date palm leaves

Fresh leaves of three cultivars of date palm, Barhee, Sukri and Rothana were kindly provided by Mr. Abdulmohssin Al-Shamlan from his Al-Shamlan date farm (Onaizah, Al-Qassim). Samples were labeled and stored at 4°C in polythene bags till they were processed.

Sample preparation

Surface contaminants of the leaf samples were removed by washing twice with deionized water and then with deionized double distilled water. The leaves were air dried in a clean drying chamber for 15 days. The dried leaves samples were ground well into a fine powder with the help of mill (IKA werke, GMBH & Co., Germany). The powder was stored in air sealed plastic containers at room temperature until analyzed.

Digestion and analysis of sample

Powdered leaves samples (0.5 g) were digested with concentrated sulphuric acid (3.5 ml) and 30% hydrogen peroxide (3.5 ml) by heating at 25°C for 30 min. After cooling, 30% hydrogen peroxide (1 ml) was added and filtered to get the clear solution. The filtrate was diluted to 20 ml with deionized distilled water (Westrman et al., 1990). The digested samples were analyzed to determine the content of Ca, Mg, P, K, Fe, Cu, Zn, Mn, Na and Se by ICP-OES, Perkin-Elmer Optima 4300 DV ICP-OES.

RESULTS AND DISCUSSION

The results of the ICP-OES analysis of date palm leaves showed the presence of Ca, Mg, P, K, Na, Cu, Zn, Mn and Se (Table 1). It was observed that Ca was the most abundant element of the leaves of all three varieties of *P. dactylifera* whereas K was found in relatively high concentration in var. Sukri and Barhee. The other elements were found in various proportions in the leaves of three varieties of *P. dactylifera*.

Na content of var. Sukri was 139.6 mg/kg followed by Rothana and Barhee. It is important here to note that Na and K balance is finely tuned. Plant products contain much higher ratio of K to Na. Na and K regulates osmotic pressure, helps to maintain the pH and water balance of

Table 1. Element content in the leaves of *P. dactylifera* var. Rothana, Barhee and Sukri analyzed by ICP-OES.

Variety	Element									
	Ca	Mg	Na	K	P	Fe	Zn	Cu	Mn	Se
	mg/kg									
Rothana	4092.0	2214.0	105.9	2068.0	1015.0	142.2	13.0	6.9	13.2	3.5
Barhee	5268.0	2010.0	122.6	7814.6	937.5	218.3	15.0	6.1	13.2	2.7
Sukri	4822.0	2190.0	139.6	7885.3	855.0	110.6	13.1	7.0	10.8	3.7

Ca, Calcium; Mg, magnesium; Na, sodium; K, potassium; P, phosphorus; Fe, iron; Zn, zinc; Cu, copper; Mn, manganese; Se, selenium.

the body. Hyponatremia causes loss of body weight and nerve disorder. K is accumulated within human cells by the action of the Na^+- K^+ (sodium potassium pump) and it is an activator of enzymes particularly coenzyme for normal body growth and muscle building (Birch and Padgham, 1994). It helps in the protein and carbohydrate metabolism. It is the principle cation of the intracellular fluid, but it is also a very important constituent of the extracellular fluid because it influences muscle activity particularly the cardiac muscle. K deficiency causes nervous disorder, diabetes, and poor muscular control resulting in paralysis (Murray et al., 2000).

Ca content in leaves of date palm varies from 5268 to 4092 mg/kg. Ca is essential for healthy bones, teeth and blood (Hughes, 1972; Charles, 1992). The health of the muscles and nerves depends on Ca. It is required for the absorption of dietary vitamin B, for the synthesis of the neurotransmitter acetylcholine, for the activation of enzymes such as the pancreatic lipase. It helps to regulate the activity of skeletal muscle, heart and many other tissues. Deficiency of Ca causes rickets, and osteomalacia. The recommended daily dietary allowance of Ca for children is between 500 and 1000 mg and 800 mg for adults. The higher Ca content in the leaves of Barhee suggests its possible use to overcome deficiency of Ca. In plants, Ca is taken up in the ionized form (as Ca^{2+}); the leafy parts are relatively high in Ca and low in P, whereas, the reverse is true of the seeds (Merck, 1986).

P was relatively high in var. Rothana (1015 mg/kg), while level of Mg was almost same in var. Rothana and Sukri (2214 mg/kg). It is well known that P is an essential component of adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. It has immense role in cell function. It also helps in the formation of bones and teeth in human body and controls the acid base balance of the body. P is an essential macronutrient for plants and one of the three nutrients generally added to soils in fertilizers because of its vital role of energy transfer in living organisms and in plants. Adequate P availability stimulates early growth and hastens maturity in plants (Sharma et al., 2008). Mg is an important cofactor for enzymes that convert ATP to adenosine diphosphate (ADP), with the subsequent release of energy. It also controls neuromuscular functions. Acute Mg deficiency results in vasodilatation, with erythemia and hyperaemia. Its deficiency can be prevented by adequate consumption of salt or grain mixture/ green leafy vegetables (Hays and Swenson, 1985).

Metals Mn, Fe, Cu, and Zn and the non-metal Se are essential trace elements for all forms of life. The biological activities of Cu, Fe, Mn, and Se are strongly associated with the presence of unpaired electrons that allow their participation in redox reaction (Fraga, 2005). Leaves of all three varieties of *P. dactylifera* contain significant amount of iron that varied from 218.3 to 110.6 mg/kg. The role of iron in the body is clearly associated with hemoglobin and the transfer of oxygen from lungs to tissues. Fe deficiency is the most prevalent nutritional deficiency in humans and is commonly caused by insufficient dietary intake, excessive menstrual flow or multiple births (Lokhande et al., 2010). The use of date palm leaves in general tonic preparation may be advised to compensate Fe deficiency. Appreciable amount of Zn was also found in all three varieties of *P. dactylifera*. Nearly 100 different enzymes depend on Zn for their ability to catalyze vital chemical reactions. Zn also seems to support normal growth and development in pregnancy, childhood and adolescence. Its deficiency is common in underdeveloped countries and is mainly associated with malnutrition, affecting the immune system, wound healing, the senses of taste and smell, and impairing DNA synthesis.

Leaves of three varieties of date palm also have Mn, Cu and Se which ranges from 13.2 to 2.7 mg/kg. Mn positively affect insulin secretion/ action, protect against diabetes and its complications. Also reduces blood pressure. Cu plays important roles in treatment of chest wounds and prevent inflammation in arthritis and similar diseases. Se is incorporated into proteins to make selenoproteins, which are important antioxidant enzymes. The antioxidant properties of selenoproteins help prevent cellular damage from free radicals. There are evidence that Se deficiency may cause Keshan disease, hypothyroidism, and affect immune system (Combs, 2000; Zimmermann and Kohrle, 2002). Also, it has been

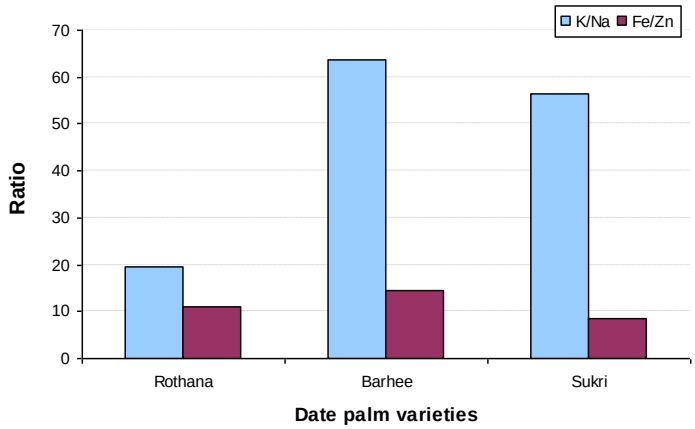

Figure 1. K/Na and Fe/Zn ratio of *P. dactylifera* var. Rothana, Barhee and Sukri.
K, Potassium; Na, sodium; Fe, iron; Zn, zinc.

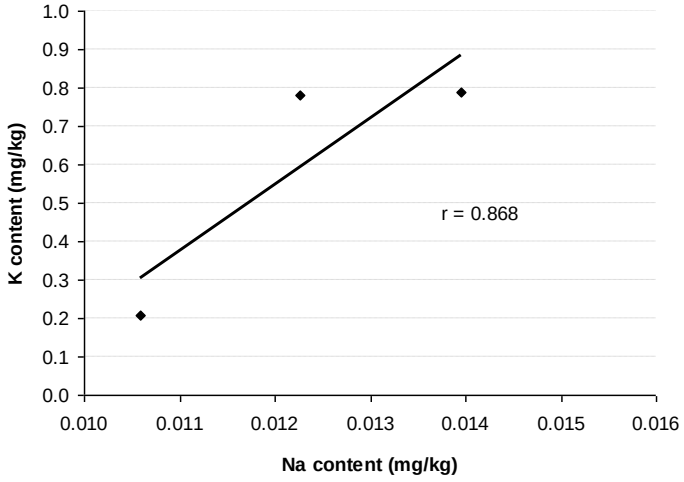

Figure 2. Correlation between Na and K concentration in *P. dactylifera* var. Rothana, Barhee and Sukri.
r, Correlation coefficient; Na, sodium; K, potassium.

that Se deficiency does not usually cause illness by itself. Rather, it can make the body more susceptible to illnesses caused by other nutritional, biochemical or infectious stresses (Levander and Beck, 1997). In humans, Mn, Fe, Cu, Zn, and Se accomplish decisive functions to maintain human health. Deficiency in any of these trace elements leads to undesirable pathological conditions that can be prevented or reversed by adequate supplementation. In sufficiently nourished persons, supplementation should be carefully controlled, given the toxic effects ascribed to trace elements when present in quantities exceeding those required for accomplishing their biological functions (Fraga, 2005). The leaves of the date palm contain good amount of these elements thus,

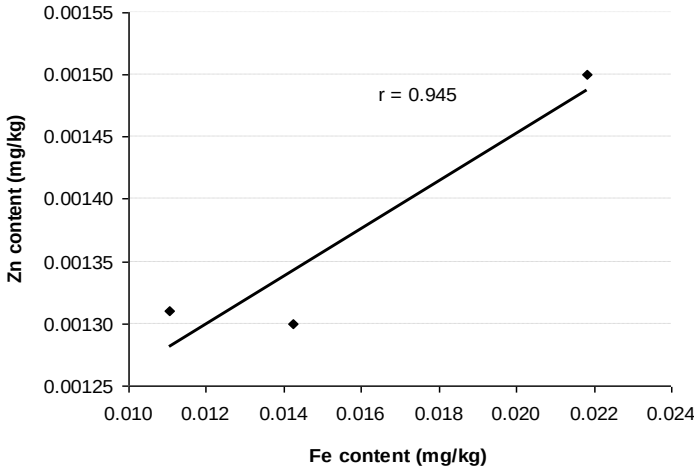

Figure 3. Correlation between Fe and Zn concentration in different varieties of *P. dactylifera* var. Rothana, Barhee and Sukri.
r, Correlation coefficient; Fe, iron; Zn, zinc.

further research can be carried out in the direction of development of suitable supplements.

Inter-elemental correlations

Several reports have suggested interrelationship of essential elements like K, Na, Fe and Zn (Herber and Stoeppler, 1994; Lokhande et al., 2010). The regulation of metal ion flow, especially of K^+ and Na^+, is crucial to life and is most clearly exemplified by the ionic movements that occur in nerve cells during excitation and transmission of the action potential. The regulation of K is intimately involved with that of Na and the two are largely interdependent. The ratio of K/Na and Fe/Zn in three varieties of date palm is shown in Figure 1. It was observed that K/Na ratio were 63.54, 56.32 and 19.51 in var. Barhee, Sukri and Rothana, respectively. Whereas Fe/Zn ratio was highest in var. Barhee (14.55) followed by Rothana (10.94) and Sukri (8.44).

Figure 2 shows a positive correlation between Na and K (r = 0.868), while Fe and Zn concentrations in different varieties of date palm leaves have strong positive correlation, r = 0.945 (Figure 3). Thereby, it indicates the inter-connected physiological mechanisms for their uptake/translocation in the leaves.

The relationship between elemental content and curative capability is yet to be established; however such studies are important for understanding the pharmacological action of medicinal plants. The data obtained in the present study will be helpful in the development of supplements for human as well as animals and also for synthesis of new drugs which can be used for the control and cure of various diseases.

ACKNOWLEDGEMENT

The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding the work through the research group project No. RGP-VPP- 066.

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