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MACRO AND MICRO-NUTRIENT CONTENTS OF 18 MEDICINAL PLANTS USED TRADITIONALLY TO ALLEVIATE DIABETES IN NUEVO LEON, NORTHEAST OF MEXICO

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Abstract

Although several medicinal plants has been documented to alleviate diabetes in Nuevo Leon, Northeast of Mexico, no systematic study has been undertaken to determine the efficacy of these plant species. The present study was undertaken to determine micronutrients (Cu, Fe and Zn) and macro-nutrients (K, Mg and P), C, N and C/N and to select plants with high macro and micronutrient contents for high efficacy in 18 medicinal plants collected from botanical gardens of Forest Science Faculty, UANL, Mexico used in Nuevo Leon in Northeast of Mexico, at the experimental station of Facultad de Ciencias Forestales, Universidad Autonoma de Nuevo Leon. Following standard protocols, carbon and nitrogen were determined using a CHN analyzer (Perkin Elmer, model 2400). Mineral contents were using the wet digestion technique (Cherney, 2000).

The present study indicated the presence of large variation in the contents of several macro and micronutrients among these 18 species of medicinal plants utilized traditionally to control diabetes and other diseases in Nuevo Leon, Mexico. Among these species containing high nitrogen content (%) are *Moringa oleifera* (6.25), *Melia azadirachta* (5.85), *Marrubium vulgare* (4.56) and *Phoradendron villosum* (4.9). The C/N values ranged from 8 to 30. The species having high C/N were *Agave macroculmis* (30), *Arbutus xalapensis* (26) and *Rhus virens* (22). The species *Melia azadirachta*, *Marrubium vulgare*, *Buddleja cordata*, *Tecoma stans*, *Hedeoma palmeri*, *Phoradendron villosum*, *Opuntia ficus-indica*, *Arbutus xalapensis* exhibited large variations in the contents of macro and micronutrients which, could be considered to be used effectively for the control of diabetes. Few species viz. *Marrubium vulgare*, *Buddleja cordata*, *Tecoma stans*, *Hedeoma palmeri*, *Phoradendron villosum*, *Opuntia ficus-indica* and *Arbutus xalapensis* on the basis of high nutrient content with respect to C, N, C/N, Cu, Fe, Zn, K, P and Mg are selected and recommended to control diabetes.

Key words: Macro and Micro-nutrients Diabetes, Medicinal plants

Introduction

Mexico is one of the country exhibiting the highest diversity of plants in the world (Mittermeier, 1988; Mittermeier & de Mittermeier 1992; Villaseñor, 2003). Medicinal plants are most commonly used by the persons in rural and urban areas to alleviate various diseases in Mexico (Mittermeier, 1988; Huerta, 1997; Ankli, 2000; Villaseñor, 2003; Vega-Avila *et al*., 2009). In the north of Mexico, though various studies have been undertaken on ethnobotany (Bell & Castetter, 1937) only a few studies are available in the northeastern area (Hernández-Sandoval *et al*., 1991). In Nuevo Leon, Northeastern Mexico, populations both in the rural and urban areas cities use several medicinal plants to cure various diseases such as diabetes, respiratory problems, digestive problems, cardiac diseases, headache, kidney problems etc. Different parts of plants are used traditionally for medicinal uses. Various studies have been undertaken in Northeast Mexico (Estrada *et al*., 2006, 2007, 2012; Estrada-Castillón *et al*., 2012 and Macouzet *et al*., 2013) to identify the available medicinal plants in the regions and their ability in combating diseases. Different micronutrients, although required in minor quantities are essential for good health of mankind and animals. The deficiency of these elements cause abnormalities leading to infection of diseases. Copper (Cu) is an essential trace element for the health of all living beings, the deficiency of which cause genetic disease. It is necessary for stimulating antioxidant reactions. Copper combines with certain proteins to produce enzymes that act as catalysts to help a number of body functions (Rahman, 2007). Similarly, Zinc is an essential trace element required for normal growth and a healthy immune system function. It is required for new protein synthesis, DNA replication, RNA transcription, cell division, and cell activation and cell division as well for different chemical reactions (Shankar & Prasad, 1998). On the other hand, Magnesium is involved in hundreds of enzyme reactions in the body. It performs an array of biological functions as activation of muscles and nerves, digestion of proteins, carbohydrates, fats, and building block for RNA and DNA synthesis (Swaminathan, 2003).

Iron requirement is very essential as it forms a part of protein haemoglobin an oxygen carrying pigment. It forms a part of many enzymes involved in a array of cell functions. The daily requirements of iron vary with age. For example, infants of 7-12 months; 11 mg/day, males of 14-18 years: 11 mg/day, females of 14-18 years: 15 mg/day (Anon., 1998).

In addition to micronutrients, we need some major elements in higher amounts for good health. In this respect, phosphorus is a major element for many biochemical reactions taking place in the body, such as conversion of foods to energy. Helps with muscle contractions, nerve conductions, normal kidney functions and helps to build strong bones. (Soetan *et al*., 2010).

Potassium is needed for the maintenance of total body and fluid volume and electrolyte balance and normal cell functions. It functions as an electrolyte and it regulates the amount of water in the body and the acidity of the blood. Muscle cells need potassium to grow and the heart depends on potassium to maintain normal electrical activity (Soetan *et al*., 2010). The Institute of Medicine recommends males and females over the age of 14 to consume 4,700 milligrams of potassium per day. Seelig (1982) mentioned that most American diets are adequate in magnesium (Mg). The Recommended Dietary Allowances (RDA) for magnesium is of 300-400 mg per day for adults. It is an activator of numerous enzyme systems to control carbohydrate, fat and electrolyte metabolism, nucleic acid and protein synthesis and membrane integrity and transport. This level of intake may have serious risks. A Mg deficiency causes symptoms, as convulsions and cardiac arrhythmia and a variety of other acute and chronic disorders. Sufficient research inputs have been directed on the beneficial effects of micronutrients on diabetic patients.

Several medicinal plants possess micronutrients and are useful in diabetes. Few medicinal plants are reported to be effective to control blood sugar such as mulberry leaf, soybean, black bean, Persian shallot, *Zizyphus lotus*, etc. Some Mexican plants significantly decrease the hyperglycemic peak and/or the area under the glucose tolerance curve (Alarcon-Aguilara *et al*., 1998). Various authors have reported that Carbon, Nitrogen and C/N ratios are related to the production of secondary metabolites and antioxidants, flavonoids useful for health care of human beings. It has been reported that the process of oxidation in human body in old age causes affect on normal cell functions, structure, lipid and DNA leading to the development of chronic diseases such as cancer (Devasagayam *et al*., 2004, Serafini *et al*., 2002). Food provides energy liberating free radicles by normal oxidation. Antioxidants provide many health benefits such as to reduce inflammatory properties, promote cardiovascular health (Mandel & Youdim, 2004), inhibits cancerous tumour (Shoskes *et al*., 1999) and reduce ageing process in the brain and nervous system (Shaheen *et al*., 2001). Antioxidants delay or inhibit oxidation (Halliwell & Gutteridge, 1989). Antioxidant compounds are reported in fruits, vegetables *viz.*, *Ocimum sanctum*, *Terminalia bellerica*, *Zingiber officinale* and several Chinese and Indian spices such as *Piper cubeba*, *Allium sativum*. Majority of the antioxidant activities are contributed by flavones, isoflavones, flavonoids, anthocyanins, coumarins ligans, catechin and isocatechin found in plants (Aqil *et al*., 2006).

High peroxidation of secondary metabolites was elicited in plants with high C/N ratio and low nitrogen fertilization especially when exposed to elevated CO_2 levels. Under low nitrogen, the growth and photosynthesis in plant show increase in C/N ratio and increase the production of secondary metabolites (Shaheen *et al*., 2001). Therefore, high C/N ratio might be attributed to low nitrogen absorption of plants (Lindroth *et al*., 2002). The rates of high production of secondary metabolites and antioxidants were highly correlated to low nitrogen content and high C/N ratio thereby showing correlation between secondary metabolites and antioxidant activity in *Labisia pumila* the consumption of which may promote several antioxidant activities (Ibrahim & Jaafar, 2011). The two alpine medicinal plants *Aconitum naviculare* (Brühl) Stapf and *Neopicrorhiza scrophulariiflora* (Pennel) Hong in a trans-Himalayan dry valley of central Nepal, varied in their habitat. The C/N ratio of soil was more suitable in *A. naviculare* habitat than that of N *scrophulariiflora* for N supply. Warm and sunny site with N rich soil was found to be suitable for cultivation of *A. naviculare*, while moist and cool site with organic soil for *N. scrophulariiflora* (Shrestha & Jha, 2009).

In medicinal plants litter degradation was found to be affected by the UV radiation. Elevated influx of ultraviolet-B radiation (UV-B) as a consequence of depletion of stratospheric ozone (O3) layer may affect litter decomposition directly/modifying the plant tissue quality. UV-B modified the decomposition rate of leaf litter of test medicinal plant species, altered strongly the tissue chemistry particularly leaf phenolics, N and P concentrations and affected the decay rate which was species specific (Agrawal & Kumari, 2013). Although, these studies revealed the usage of these medicinal species traditionally in combating particular diseases, very little information is available in determining the efficacy of medicinal species with respect to their nutritional contents viz., macronutrient or micronutrient contents. It is well known that the presence of macronutrients or micronutrient in a medicinal plant species is very important in alleviating its utility to combat diseases. The chemical analysis of macronutrients or micronutrients in these medicinal plant species is rarely reported. Hence, the present study was undertaken to determine micronutrients (Cu, Fe and Zn) and macronutrients (K, Mg and P), C, N and C/N ratio of 18 medicinal plants used in Nuevo Leon in Northeast of Mexico and select plants with high macro and micronutrient contents for high efficacy.

Materials and Methods

This study was carried out at the experimental station of Facultad de Ciencias Forestales, Universidad Autonoma de Nuevo Leon, located in the municipality of Linares (24^{o}47´N, 99^{o}32´W), at elevation of 350 m. The climate is subtropical or semiarid with warm summer, monthly mean air temperature vary from 14.7^{o}C in January to 23^{o}C in August, although during summer the temperature goes up to 45^{o}C. Average annual precipitation is around 805 mm with a bimodal distribution. The dominant type of vegetation is the Tamaulipan thorn scrub or subtropical thorn scrub wood land. The dominant soil is deep, dark grey, lime-grey, vertisol with montmorrillonite, which shrink and swell remarkably in response to change in moisture content.

Medicinal plants traditionally used for diabetes (Andrade-Cetto & Heinrich, 2005) and for the control of various disease in Nuevo Leon, Northeast Mexico were collected from botanical gardens of the Forest Science Faculty, UANL, Mexico. The study was directed in two phases viz., 1. Analysis of micro- (Cu, Fe, and Zn) and macro-nutrients (K, Mg, and P) of 18 medicinal plants, 2) Analysis of C, N, C/N of 18 medicinal plants used in diabetes.

Chemical analysis: Medicinal plant samples were collected and placed to dry on newspaper for a week. The leaves were separated from the rest of the plant and were passed twice through a mesh of 1 x 1 mm in diameter using a mill Thomas Wiley and subsequently dried for more than three days at 65^{o}C in an oven (Precision model 16EG) to remove moisture from the sample and later these were placed in a desiccators. A 2.0 mg of the sample was weighed in a AD6000 Perkin Elmer balance in a vial of tin, bent perfectly. This was placed in a CHONS analyzer Perkin Elmer model 2400 for determining carbon and nitrogen (% dry mass basis). For estimating the nutrient contents of K, Mg, Cu, Fe, and Zn the samples were incinerated in a muffle oven at 550^{o}C for 5 hours. Ashed sample is digested in a solution containing HCl and HNO_3, using the wet digestion technique (Cherney, 2000) and nutrients measured through atomic absorption spectrophotometry (Perkin-Elmer model Pinnacle 900F). Phosphorous (P) content was determined spectrophotometrically using a spectrophotometer (Perkin-Elmer model Lamda 25) at 880 nm (Anon., 1997).

Results and Discussion

The medicinal plants collected in Nuevo Leon, Northeast Mexico from the botanical gardens of Forest Science Faculty, UANL, Mexico, used traditionally for treatment of diabetes are presented below (Table 1).

The present study shows (Table 2) large variation in the contents of several macro and micronutrients among 18 species of medicinal plants utilized traditionally to control diabetes and other diseases in Nuevo Leon, Mexico. Based on the maximum content of the macro and micronutrients, the following species were selected and grouped under different categories as follows.

Macronutrients

1. Species containing high Potassium (K) content (mg g^{-1} dw): *Opuntia ficus-indica* (101.47±9.19), *Phoradendron villosum* (100.58±7.63), *Moringa oleifera* (95.59±7.56), *Marrubium vulgare* (91.27±3.70), *Melia azadirachta* (90.99±7.21), *Hedeoma palmeri* (76.50±1.42), *Croton suaveolens* (75.62±3.67), *Agave macroculmis* (78.45±1.07).

2. Species containing high Magnesium (Mg) content (mg g^{-1} dw): *Opuntia ficus-indica* (6.39±0.90), *Melia azadirachta* (3.41±0.80), *Phoradendron villosum* (2.29±0.68), *Eriobotrya japonica* (1.78±0.36), *Bauhinia forficata* (1.45±0.31).

3. Species containing high Phosphorus (P) content (mg g^{-1} dw): *Celtis laevigata* (4.03±0.29), *Carya illinoinensis* (2.89±0.06), *Phoradendron villosum* (2.40±0.04), *Arbutus xalapensis* (1.78±0.40), *Hedeoma palmeri* (1.40±0.03), *Marrubium vulgare* (1.85±0.05).

4. Species containing with high Carbon (C, %) capacity of Carbon dioxide fixation: *Rhus virens* (50.35), *Arbutus xalapensis* (49.09), *Cinnamomum verum* (49.34), *Tecoma* stans (48.79), *Eriobotrya japonica* (47.98), *Hedeoma palmeri* (46.38), *Moringa oleifera* (45.96), *Buddleja cordata* (45.70), *Carya illinoinensis* (44.27).

5. Species containing high Nitrogen (N, %) content: *Moringa oleifera* (6.25), *Melia azadirachta* (5.85), *Marrubium vulgare* (4.56), *Phoradendron villosum* (4.92), *Carya illinoinensis* (3.76), *Buddleja cordata* (3.26), *Celtis laevigata* (3.01).

Table 1. List of medicinal plants used for diabetes and studied to determine the leaf nutrient content.

Common name	Scientific name	Family	Growth habit
Maguey Todaro	*Agave macroculmis* Todaro	AGAVACEAE	Rosetophyllous
Madroño	*Arbutus xalapensis* Kunth	ERICACEAE	Bush
Pata de vaca	*Bauhinia forficata* Link	FABACEAE	Tree
Tepozan	*Buddleja cordata* Kunth	SCROPHULARIACEAE	Tree
Nogal	*Carya illinoinensis* (Wangenh.) K.Koch	JUGLANDACEAE	Tree
Palo blanco	*Celtis laevigata* Willdenow	ULMACEAE	Tree
Canela	*Cinnamomum verum* J.Presl	LAURACEAE	Tree
Salvia	*Croton suaveolens* Torr.	EUPHORBIACEAE	Bush
Níspero	*Eriobotrya japonica* (Thunb.) Lindl.	ROSACEAE	Bush
Betónica o poleo de hoja ancha	*Hedeoma palmeri* Hemsl.	LAMIACEAE	Bush
Manrrubio	*Marrubium vulgare* L.	LAMIACEAE	Herb
Neem	*Melia azadirachta* A.Juss	MELIACEAE	Tree
Moringa	*Moringa oleifera* Lam.	MORINGACEAE	Tree
Nopal	*Opuntia ficus-indica* (L.) Mill.	CACTACEAE	Bush
Injerto	*Phoradendron villosum* (Nutt.) Nutt.	VISCACEAE	Bush
Lantrisco	*Rhus virens* Lindh. ex A. Gray.	ANACARDIACEAE	Bush
Sauce	*Salix lasiolepis* Benth.	SALICACEAE	Tree
Tronadora	*Tecoma stans* (L.) Juss. ex Kunth	BIGNONIACEAE	Bush

Table 2. Leaf nutrient content in different plant species used for diabetes purposes. Data are means and standard deviation (n=5).

Plant species	Leaf macro-nutrient content (mg g^{-1} dw)			Leaf macro-nutrient content (%)		C:N	Leaf micro-nutrient content (µg g^{-1} dw)		
	K	Mg	P	C	N		Cu	Fe	Zn
Agave macroculmis	78.45 ± 1.07	1.38 ± 0.29	0.73 ± 0.02	41.32 ± 0.74	1.36 ± 0.21	31.05 ± 5.11	18.76 ± 2.87	210.53 ± 17.37	55.20 ± 3.39
Arbutus xalapensis	30.65 ± 13.9	0.54 ± 0.60	1.78 ± 0.40	49.1 ± 0.42	1.86 ± 0.30	26.94 ± 3.72	33.40 ± 20.18	347.58 ± 104.20	25.07 ± 2.65
Bauhinia forficata	8.29 ± 1.27	1.45 ± 0.31	1.37 ± 0.11				12.86 ± 0.73	161.65 ± 5.30	10.73 ± 0.28
Buddleja cordata	39.30 ± 1.82	0.17 ± 0.09	0.56 ± 0.10	45.70 ± 0.56	3.26 ± 0.40	14.16 ± 1.44	29.90 ± 1.85	148.00 ± 26.25	40.26 ± 3.39
Carya illinoinensis	31.16 ± 1.89	0.85 ± 0.34	2.89 ± 0.06	44.27 ± 1.00	3.76 ± 0.71	12.04 ± 1.81	25.74 ± 1.70	166.49 ± 20.45	57.69 ± 7.74
Celtis laevigata	16.10 ± 4.59	1.51 ± 0.67	4.03 ± 0.29	39.45 ± 0.51	3.01 ± 0.18	13.13 ± 0.70	33.88 ± 12.60	213.15 ± 49.80	23.53 ± 1.91
Cinnamomum verum	16.14 ± 1.35	0.27 ± 0.03	0.53 ± 0.05	49.34 ± 0.48	2.49 ± 0.20	19.89 ± 1.70	24.53 ± 2.77	217.14 ± 9.90	9.49 ± 1.47
Croton suaveolens	75.62 ± 3.67	0.22 ± 0.09	2.43 ± 0.14	45.17 ± 0.35	2.33 ± 0.53	20.16 ± 4.52	26.87 ± 1.66	229.13 ± 24.25	34.55 ± 4.11
Eriobotrya japonica	18.77 ± 1.68	1.78 ± 0.36	2.20 ± 0.20	47.98 ± 1.18	3.03 ± 0.35	15.98 ± 1.58	22.04 ± 3.44	177.91 ± 13.45	17.13 ± 1.56
Hedeoma palmeri	76.50 ± 1.42	0.18 ± 0.14	1.40 ± 0.03	46.38 ± 1.66	2.83 ± 0.78	17.14 ± 3.33	23.98 ± 1.20	334.23 ± 9.96	53.54 ± 2.88
Marrubium vulgare	91.27 ± 3.70	0.64 ± 0.42	1.85 ± 0.05	40.48 ± 0.32	4.56 ± 0.58	8.99 ± 1.03	25.14 ± 1.07	374.78 ± 13.18	46.79 ± 3.07
Melia azadirachta	90.99 ± 7.21	3.41 ± 0.80	1.98 ± 0.35	45.12 ± 0.87	5.85 ± 0.32	7.73 ± 0.32	24.20 ± 5.26	265.59 ± 21.75	52.57 ± 11.28
Moringa oleifera	95.59 ± 7.56	0.81 ± 0.89	1.91 ± 0.15	45.96 ± 0.23	6.25 ± 0.25	7.37 ± 0.31	10.59 ± 2.22	773.04 ± 198.33	26.74 ± 4.75
Opuntia ficus-indica	101.47 ± 9.19	6.39 ± 0.90	0.84 ± 0.07	25.54 ± 0.99	2.36 ± 0.43	11.1 ± 1.94	22.76 ± 1.66	135.18 ± 10.44	50.05 ± 4.80
Phoradendron villosum	100.58 ± 7.63	2.29 ± 0.68	2.40 ± 0.04	40.4 ± 0.63	4.92 ± 0.20	8.22 ± 0.44	25.30 ± 1.28	151.30 ± 10.06	52.02 ± 6.85
Rhus virens	14.77 ± 2.64	0.33 ± 0.15	1.41 ± 0.26	50.34 ± 0.59	2.27 ± 0.45	22.92 ± 4.67	22.98 ± 6.24	98.28 ± 23.19	12.75 ± 1.54
Salix lasiolepis	15.66 ± 3.34	1.24 ± 0.17	1.19 ± 0.07				8.73 ± 3.27	444.82 ± 24.76	216.31 ± 10.83
Tecoma stans	57.22 ± 8.90	0.31 ± 0.11	1.36 ± 0.02	48.79 ± 1.21	3.28 ± 0.47	15.17 ± 2.34	25.67 ± 3.33	263.66 ± 32.88	29.49 ± 1.27

6. Species containing high C/N ratio: *Agave macroculmis* (30.43), *Arbutus xalapensis* (26.45), *Rhus virens* (22.18), *Cinnamomum verum* (19.78), *Croton suaveolens* (19.37), *Hedeoma palmeri* (16.39), *Eriobotrya japonica* (15.83).

Micronutrients

1. Species with high Zinc (Zn) content (μg g^{-1} dw): *Tecoma stans* (216.31), *Celtis laevigata* (57.69), *Arbutus xalapensis* (55.20), *Marrubium vulgare* (53.54), *Moringa oleifera* (52.57).

2. Species with high Copper (Cu) content (μg g^{-1} dw): *Cinnamomum laevigata* (33.88), *Bauhinia fortificata* (33.40), *Carya illinoiensis* (29.90), *Eryobotria japonica* (26.87)

3. Species with high Iron (Fe) content (μg g^{-1} dw): *Opuntia ficus-indica* (773.04), *Tecoma stans* (444.82), *Melia azadirachta* (374.78), *Bauhinia forficata* (347.58), *Marrubium vulgare* (334.23).

On the basis of the contents of macro and micronutrients the following species are selected for high contents of different nutrients: (after excluding those common species).

1. Potassium, Magnesium and Phosphorus: Opuntia ficus-indica, Phoradendron villosum, Moringa oleifera, Melia azadirachta, Celtis laevigata, Carya illinoinensis

2. Nitrogen: *Moringa oleifera*, *Melia azadirachta*, *Marrubium vulgare*

3. C/N: *Agave macroculmis*, *Arbutus xalapensis*, *Cinnamomum verum*, *Croton suaveolens*, *Hedeoma palmeri*

4. Zinc: *Tecoma stans*, *Celtis laevigata*, *Arbutus xalapensis*

5. Copper: *Cinnamomum laevigata*, *Bauhinia forficata*, *Carya illinoinensis*

6. Iron: *Opuntia ficus-indica*, *Tecoma stans*, *Melia azadirachta*

Taking into account of all aspects we recommend that these species viz., *Melia azadirachta, Opuntia ficus-indica, Phoradendron villosum*, *Moringa oleifera*, *Marrubium vulgare*, *Celtis laevigata*, *Carya illinoinensis*, *Agave macroculmis*, *Arbutus xalapensis*, *Cinnamomum verum*, *Croton suaveolens*, and *Hedeoma palmeri* could be considered to be used effectively for the control of diabetes.

In this respect, large variations were observed in carbon, nitrogen and C/N among 18 medicinal plants used for diabetes. The species fixing 45% carbon fixation and above were *Rhus virens* (50%) *Arbustus xalapensis* (49%), *Tecoma stans* (49%), *Eriobotrya japonica* (48%), and *Buddleja cordata* (46%). It is expected that carbon being the source of energy these species have great potential to provide energy to diabetic patients.

It is well known that nitrogen contributes to protein metabolism and enzymatic activities in the body. Large variations in nitrogen contents among the species indicate that these species could supply nitrogen to the diabetic patients. Among these species containing high nitrogen content are *Moringa oleifera* (6.25%), *Melia azadirachta* (5.85%), *Marrubium vulgare* (4.56%), *Phoradendron villosum* (4.92%), *Carya illinoinensis* (3.76%), *Tecoma stans* (3.28%), *Buddleja cordata* (3.26%), *Celtis laevigata* (3.01%). Therefore, these species can provide greatly in protein metabolism and enzymatic activities in diabetic patients.

With respect to C/N, most of the species had more than 10, the C/N values ranging from 8 to 30. The species having high C/N were *Agave macroculmis* (31), *Arbutus xalapensis* (26), *Rhus virens* (22). As has been reported in several research works Carbon, Nitrogen and C/N ratio are related to the production of secondary metabolites and antioxidants, flavonoids related to health care of human beings. The role of antioxidants has been documented in cell functions, structure, lipid leading to the non development of chronic diseases such as cancer (Serafini *et al*., 2002; Devasagayam *et al*., 2004), it provides many health benefits and reduce inflammatory properties, promote cardiovascular health (Mandel & Youdim, 2004), inhibits cancerous tumour (Shoskes *et al*., 1999), involved in reducing ageing process in the brain and nervous system (Shaheen *et al*., 2001). Besides, it delays or inhibit oxidation (Halliwell and Gutteridge, 1989). Antioxidant compounds are present in fruits, vegetables such as *Ocimum sanctum*, *Terminalia bellerica*, *Zingiber officinale* and several Chinese and Indian spices such as such as *Piper cubeba*, *Allium sativum*. Majority of the antioxidant activities are attributed to flavones, isoflavones, flavonoids, anthocyanin, coumarin ligans, catechin and isocatechin found in plants (Aqil *et al*., 2006). The natural antioxidants have been reported over a range of compounds including flavonoids, phenolics, nitrogen compounds and carotenoids (Schramm *et al*., 2003). Many plant species possess antioxidant properties. Ibrahim & Jaafar (2011) reported that high peroxidation of secondary metabolites was elicited in plants by C/N ratio and low nitrogen fertilization especially when exposed to elevated CO_2 levels. Under low nitrogen, the growth and photosynthesis in plant show increase in C/N ratio and gives increase in the production of secondary metabolites (Shaheen *et al*., 2001). Therefore, high C/N ratio might be attributed to low nitrogen absorption of plants (Lindroth *et al*., 2002).

An indigenous Malaysian herb, kacip Fatimah (*Labisia pumila* Blume) used in South East Asia is found to possess health promoting properties. The high production of secondary metabolites and antioxidants were highly correlated to low nitrogen content and high C/N ratio showing correlation between secondary metabolites and antioxidant activity. Therefore, the consumption of *L. pumila* promotes several antioxidant activities (Ibrahim *et al.*, 2011). It is recommended to analyse the antioxidants and secondary metabolites of the species selected for high C/N ratio viz. *Agave macroculmis*, *Cinnamomum verum*, *Rhus virens*, *Arbutus xalapensis*, *Tecoma stans*, *Eriobotrya japonica* and *Buddlleja cordata.*

Conclusion

The present study shows large variations in macro and micronutrients among 18 medicinal plant species used traditionally to control diabetes in Nuevo Leon, Northeast Mexico. The species *Melia azadirachta*, *Marrubium vulgare*, *Buddleja cordata*, *Tecoma stans*, *Hedeoma palmeri*, *Phoradendron villosum*, *Opuntia ficus-indica*, *Arbutus xalapensis* exhibiting large variations in the contents of macro and micronutrients, could be considered to be used effectively for the control of diabetes. Few species are selected and recommended to control diabetes on the basis of high nutrient contents with respect to C, N, C/N, Cu, Fe, Zn, K, P and Mg. viz. *Marrubium vulgare*, *Buddleja cordata*, *Tecoma stans*, *Hedeoma palmeri*, *Phoradendron villosum*, *Opuntia ficus*-indica, and *Arbutus xalapensis*. Further research is needed to analyse biochemical ingredients and the antioxidants of these species.

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