Progress in Nutrition 2016; Vol. 18, N. 2: 161-165

Original article

Quantitative analysis of minerals in the selected formulations of spices and herbs using ICP-MS

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Summary. The purpose of this study was to assess minerals contents of three different formulations of spices and herbs, that is mixed herbs (F1), mixed spices (F2) and mixed spices & herbs (F3) predominantly formulated for general health and wellbeing. Minerals namely K, Ca, Mg, Cr, Mn, Zn, Cu and Fe, which are considered vital for good health were studied. The samples were processed, digested and the aforementioned minerals were quantitatively analyzed in the said formulations of spices and herbs by using ICP-MS. The analysis was performed in triplicates and the post-hoc (tukey) test was applied to determine the mean difference amongst the mineral contents of the three formulations with $p<0.05$ was considered significant. The formulation F1 (mixed herbs) showed significantly ($p<0.05$) higher contents of Mg, K, Ca, Fe, Cu and Zn, whereas the F2 (mixed spices) and F3 (mixed spices and herbs) showed significantly ($p<0.05$) higher contents of Mn and Cr respectively. The high mineral contents in the three formulations particularly the F1 makes them nutritionally effective to control various diseases occurring due to mineral deficiencies.

Key words: spices, herbs, minerals, antioxidant, ICP-MS (Inductively Coupled Plasma-Mass Spectrometry)

Introduction

Spices and herbs are used traditionally for culinary and medicinal purposes due to which they are ambitiously studied in relation to various health conditions (1). Contemporary literature describes that the efficacy of spices and herbs against these conditions is mainly due to their mineral & phenolic contents (2, 3). Due to metabolism taking place in living cells a number of reactive oxygen species (ROS) which are commonly known as free radicals are frequently produced (4-6). These free radicals interact with cellular organelles resulting in tissue injury (6, 7). These ROS are considered the causative factors for the occurrence of various diseases particularly the non-communicable diseases namely diabetes mellitus, cancer and atherosclerosis (8, 9). However, the body naturally contains certain endogenous antioxidant mechanisms that protect the body cells from these free radical hits (10, 11). Enzymatic antioxidants such as superoxide dismutase (SOD) is one the most important natural protective tool against the superoxide radicals (12, 13). Minerals such as zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) act as co-factors of superoxide dismutase aiding to its antioxidant activity (14). Other than the co-factor role minerals play a vital role in proper physiological functioning of the human body systems (15). Chromium (Cr) plays role in the insulin sensitivity of the body cells as well as it is highly protective against cardiovascular diseases (16, 17). Manganese (Mn) has a remarkable antioxidant potential that exhibits a protective role for nervous, immune and reproductive sys-

tems (18). Furthermore zinc (Zn) is essential for the synthesis of nucleic acids, cell division and hormonal balance (19, 20). Copper (Cu) promotes the health of nervous and cardiovascular systems (21). Iron (Fe) being a major component of hemoglobin is important for efficient oxygen transportation within the body (22). Magnesium acts as a controller of cardiac energy supply as it influences the functioning of enzymes involved in glycolysis and Kreb's cycle (23). Potassium supplementation is highly beneficial for the cardiac health as well as for the treatment and prevention of myocardial infarction (24). In elderly women those having osteoporosis calcium supplementation improves the bone health and prevents fractures (25). The present study focuses on the mineral contents of the selected formulations of spices and herbs using ICP-MS. The aim behind the quantification of the mineral contents of the said formulations is to highlight their potential efficacy against certain health conditions which occur mainly due to mineral deficiencies.

Materials and Methods

The spices and herbs used for this study were purchased from the local market. The edible parts were cleaned, and then processed for further analysis. The processing of samples included washing with distilled water, air drying and finally the freeze-drying. The freeze dried spices and herbs were then ground to fine powder and mixed homogeneously to obtain three different combinations/formulations of spices and herbs. The first formulation F1 comprised of mixed herbs that is 25% by weight each of the powdered curry leaves (*Murraya koenigii*), holy basil (*Ocimum tenuiflorum*), coriander (*Coriadrum sativum*) and bunching onion (*Allium fistulosum*). Second formulation F2 comprised of mixed spices that is 25% by weight each of the powdered onion (*Allium cepa*) , ginger (*Zingiber officinale*), clove (*Syzygium aromaticum*) and lemongrass (*Cymbopogon citratus*) while the third formulation F3 was the mixture of above two formulations consisting of 12.5% by weight, the powder of each of the four spices and four herbs used in this study.

To avoid any interference by the sample matrix so as to achieve maximum accuracy of results and to decrease the processing time, acid digestion of sample was performed prior to mineral analysis. The three formulations of spices and herbs were rendered to a microwave acid digestion process, using ELBA B 1214 (WH) microwave oven. A sample of 0.3g of the three formulations in powdered form was digested separately in digestion vessels, adding 5ml of nitric acid and 2 ml of Hydrogen peroxide. The vessels were loaded into the vessel holder and were placed into the microwave oven. After being digested, the entire content of digestion vessels was transferred into a 25ml flask and the volume was made up with deionized water (26). The microwave oven was set according to the specifications mentioned in Table 1.

The ICP-MS grade standards (0.1%) of the eight minerals under test were prepared separately by dissolving 1g of each standard in 14ml of deionized water along with 7ml of Nitric acid and then making up the volume to one liter with deionized water. After the preparation of standards and the acid digestion of samples, they were run into AGILENT inductively coupled plasma mass spectrometer (ICP-MS) equipped with Argon plasma. The ICP-MS was adjusted according to the specifications mentioned in Table 2.

Results and Discussion

The results of the mineral contents of the formulations of mixed spices and herbs as mentioned in Table 3, show that K was determined as the most abundant mineral with formulation F1 (mixed herbs) showed significantly ($p<0.05$) higher K content as compared

Table 1. Microwave digestion Temperature control program (26)

Steps	Maximum Power(W)	Pressure (Psi)	Temperature (oC)	Hold Time (min)
1	1200	300	120	5
2	1200	300	190	10

Table 2. Operational Settings of ICP-MS (26)

Method Parameters	Values
Power (W)	1200
Plasma Flow (L/min)	14.0
Nebulizer Flow (L/min)	0.98
Auxiliary Flow (L/min)	1.20
Sampling Depth (mm)	2.0
Scanning Times	200
Pump Rate (rpm)	20
Rinse time (s)	10
Replicates	3
Replicate read time (s)	10
Instrument Stabilization (s)	10
Sample delay uptake (s)	60

to F2 and F3. The K contents range from 16117ug/g to 33589ug/g in the tested formulations of spices and herbs. Similarly the mineral contents of Ca and Mg were determined significantly ($p<0.05$) higher in F1 than the other two formulations. The mineral contents determined through ICP-MS are highly in line with mineral contents of the selected spices and herbs being used in a recent study performed by Gonzálvez et al., testing mineral contents of seasoning products consisting of a variety of spices and herbs (27). Along with the other minerals certain trace elements were also isolated in considerable amounts in the tested formulations of spices and herbs. Amongst the trace elements Fe, Cu and Zn were determined in significantly ($p<0.05$) higher amounts in F1. The content of Mn, an important trace element was observed significantly ($p<0.05$) higher in F2 (mixed spices). The quantitative findings of the trace elements studied here are highly comparable to the same set of trace elements being studied in a study performed by Tokalıoğu on medicinal herbs commonly consumed in Turkey (18). Considering the Cr content yet another trace element, F3 showed significantly ($p<0.05$) higher content of Cr as compared to the other two formulations and the Cr content of F3 was determined higher than the Cr content of the herbs being determined in a similar study performed by Dzung and coworkers (28).

As these formulations were designed to be used as nutritional supplements for general health and well-being by the prevention of certain diseases that occur mainly due to poor mineral supply in daily diet, the isolation of the minerals in significant amounts is quite encouraging. High K and Ca contents outline the effectiveness of these formulations against various cardiovascular diseases as argued by McCarron and Reusser (29). As Ca is highly important for bone health high Ca contents of these formulations could effectively minimize the risk of fractures in post-menopausal women (25). Weng et al., while studying the causative factors of T2DM in Taiwanese people suggested that Mg deficiency is one of the major cause of T2DM. High Mg contents of these formulations could be highly preventative for the incidence of T2DM (23). Zelko et al., (2002) has enlisted Zn, Cu, Fe and Mn as the most important minerals for human health due to their role as co-factor of endogenous enzymatic antioxidant systems (13). The significant presence of these minerals in the tested formulations of spices and

Table 3. Mineral Contents of the formulations of spices and herbs as determined by ICP-MS

Minerals	Formulation F1 (Mixed Herbs)	Formulation F2 (Mixed Spices)	Formulation F3 (Mixed Spices & Herbs)
Mg	3148 ± 48.9*	2485 ± 97	2643 ± 13
K	33589 ± 841*	16117 ± 428	20947 ± 318
Ca	19116 ± 207*	6198 ± 175	10910 ± 70
Cr	0.085 ± 0.01	0.382 ± 0.02	1.47 ± 0.01*
Mn	323 ± 0.01	398 ± 7.5*	221 ± 2.4
Fe	43.1 ± 0.82*	24.54 ± 2	41.91 ± 0.5
Cu	0.76 ± 0.01*	0.574 ± 0.2	0.602 ± 0.01
Zn	31.4 ± 0.41*	7.46 ± 0.3	17.02 ± 0.2

*n=3 *p<0.05*

herbs could be highly beneficial for the control of certain non- communicable diseases as they enhance the antioxidant scavenging potential of endogenous antioxidants particularly the superoxide dismutase (30). Anderson described a strong relationship of insulin resistance with Cr, as Cr is the constituent of insulin hormone and a natural insulin sensitizer being isolated in significant ($p<0.05$) amount in F3 thus making this formulation a highly potent tool against T2DM (31).

Conclusion

The use of spices and herbs in daily dietary supplements could be highly beneficial for human health as spices and herbs could supply the sufficient contents of essential minerals required to optimize the performance of various physiological systems of human body either by preventing the certain diseases which occur due to mineral deficiency or by acting as co-factor of endogenous enzymatic antioxidants. However before the use of the said formulations as nutritional supplements, an in- vivo investigation to determine their minimum and maximum effective dose against various indications namely type 2 diabetes mellitus (T2DM) and atherosclerosis is highly recommended. However it could be suggested here that the spices and herbs used to prepare the said formulations are highly edible and safe for human use as they have been frequently used in culinary in nearly every culture of the world.

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