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Determination of Essential and Non-Essential Elements in Diet and their Deficiency

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Abstract

The present review describes the biological effects of essential and non-essential elements in diet and various diseases associated with their deficiency. Iron is needed for the proper and smooth functioning of many biological process such as electron transfer reactions. Manganese is a naturally-occurring metal is an essential nutrient that is needed in trace amount for human health. Zinc is the active center of about 300 enzymes and play a crucial role in human body. Copper is essential element that play a vital role in oxygen transportation and biological electron transport. Cd initiates various pathological conditions in humans and animals and stimulates free radical production. One of the major role of Chromium was that it potentiates the action of insulin in vivo and in vitro. Nickel is an essential element so its deficiency can disrupt the plant growth. In agriculture nitrogen, phosphorous and potassium are the three nutrient that are extensively required for monoculture crops. Magnesium plays an important role in the structural and the functional development of the human body. Calcium regulates nerve and muscle function and is required for membrane permeability and in neuromuscular excitability. Also the presence of various elements in *Alpinia allughas* and *Alpinia malaccensis* has also been reported.

Keywords: Elements, Essential, Non-Essential, Biological Effects, Deficiency.

Introduction

Minerals are the structural components of body tissues. Their main function is the maintenance of acid-base balance, regulation of body fluids and muscle contractions (Murray et al, 2000). The importance of some elements are discussed as below:

Importance of Iron (Fe)

Iron an essential nutrient is a potential toxicant to cells. It requires a set of regulatory approaches in order to meet the requirement of cells. For the proper and smooth functioning of many biological process such as electron transfer reactions, neural functioning and transport of oxygen (Beard and Dawson, 1996). Iron deficiency is a major cause of anemia, increase of infection, decrease of myoglobin content and electron transport capacity in skeletal muscle (Davies et al, 1982) Rich source of iron in diet includes meat, fish, beans, poultry, leafy vegetables and fortified breakfast cereals (Hoppe et al, 2005).

Importance of Mangnese (Mn)

Manganese is naturally-occurring metal is an essential nutrient that is needed in trace amount for human health. Intake is normally sufficient with a balanced diet (U.S. Centers for Disease Control (ATSDR), 2000). Manganese plays an important role in amino acid, carbohydrate and lipid metabolism. Compounds containing manganese are used as anticancer and MRI contrast agents (Dorkov et al, 2008). Mangnese exposure to infants and children occur through diet, air and drinking water. Manganese concentrations in these media are usually not at levels of concern, though in children with certain types of liver disease (U.S. Centers for Disease Control (ATSDR), 2000).

Mangnese toxicity effects central nervous system, tremors, lack of coordination, difficulties with breathing or swallowing, impaired male fertility (SCF(Scientific Committee on Food, 2000). Rich sources of manganese are cereal-based products, fruits, nuts, chocolates, pulses are rich sources of manganese. Various food products consist of manganese salts such as manganese chloride,manganese manganese ascorbate (Rose et al, 2010).

Importance of Zinc (Zn)

Zinc plays a fundamental role in cell development, expression and replication and is a trace essential mineral essential to all forms of life. It is the active center of about 300 enzymes and play a crucial role in human body (Yanagisawa, 2002). It is also used as the cofactor in various enzymes such as tranferases, oxidoreductases, lyases, hydrolases etc. It plays crucial role in carbohydrate, lipid metabolism, control of gene transcription and several other biological processes (Dhawan and Chadha, 2010**).** Zinc deficiency can be characterized by skin disorders, short stature, impaired immune function, hypogonadism, cognitive dysfunction and anorexia (Prasad, 1991**).** Low Dietary intake of zinc affect human health specially prominent in children**.** The main rich source of zinc comprise of organs, poultry, fish, pork, seeds, legumes, eggs, fruits, and vegetables (Hotz and Brown, 2004).

Importance of Copper (Cu)

Copper is essential trace element essential to all living organisms since it is a key constituent of the respiratory enzyme complex cytochrome c oxidase. Copper play a vital role in oxygen transportation and biological electron transport (Vest et al, 2013). Copper compounds possess various properties such as bacteriostatic, fungicidal and as wood preservatives (Lide, 2005). For proteins such as superoxide dismutases, copper is required for catalyzing the decomposition of superoxides to oxygen and hydrogen peroxide. Copper deficiency produces neutropenia, anemia, osteoporosis, hypopigmentation. Copper is present in foods such as nuts, legumes and grains (Bonham, 2002).

Importance of Cadmium (Cd)

Cd is a non essential element and shows various mechanisms of toxicity in particular species and stimulates free radical production, resulting in oxidative deterioration of lipids. Cd is taken up by plants which affects several cellular and metabolic processes (Gratao et al, 2005). Industrial and agricultural practices has led to the accumulation of Cd in the environment (Cuypers et al, 2010). The fruits and food in which the exposure of Cd is maximum are livestock meat, apples, bananas, fish, milk and dairy products (European Food Safety Authority (EFSA, 2012).

Importance of Chromium (Cr)

Chromium, in the trivalent form Cr (III) in small amount is needed by the body and is important part of a balanced human diet. Lack of Cr(III) in proper amount affects glucose and lipids metabolism in humans and animals. On the other hand swallowing large amounts of Cr (III) may lead to lung cancer (Costa, 1997). One of the major role of Chromium was that it potentiates the action of insulin in vivo and in vitro (Mertz, 1993). In contrast, hexavalent Cr (VI) is highly toxic, carcinogenic in nature. If swallowed in greater concentration leads to death of animals and humans. It is also an environmental pollutant due to its high toxicity. It is released as a result of various industrial and agricultural activities (Zayed and Terry, 2003). Insulin contributes to chromium deficiency and Insulin injection is known to increase chromium excretion (Alpers et al, 1983).

Importance of Nickel (Ni)

Nickel is the most important transition metal found in the active site of large number of enzymes. Nickel plays a metabolic role in plants. Foliar Ni applications is applied to crops such as wheat, potato and broad bean (Bai et al, 2007). Nickel plays a very important role in activation of urease Enzyme in organs. Since nickel is an essential element so its deficiency can disrupt the plant growth and can even lead to a disorder termed as little leaf or can potentially affect resistance to plants (Reilly et al, 2005) It can disrupt many primary and secondary physiological processes, such as carbon anabolism and nitrogen catabolism. Young foliage of severely Ni-deficient pecan trees exhibits metabolic disruption of N metabolism via ureide catabolism, amino acid metabolism, and ornithine-cycle intermediates (Bai et al, 2006).

Importance of Nitrogen (N), Potassium (K), Phosphorous (P), Calcium (Ca) and Magnesium (Mg)

In agriculture nitrogen, phosphorous and potassium are the three nutrient that are extensively required for monoculture crops in which depletion of soil minerals takes place rapidly (Amtmann et al, 2006). A balanced supply of these mineral nutrients is essential for both quantity and quality of the crop. However imbalanced potassium is well known these days and is an important limitation to crop production in many areas (Cakmak, 2010). Potassium (K) is a cofactor of many enzymes and is an essential macronutrient. It plays vital role in metabolism and is required for transport of metabolites and charge balance (Marschner, 1995). Magnesium (Mg) is one of the abundant ion found prominently in living cells. It plays important roles in the structural and the functional development of the human body. Skeleton comprises of about 60% of magnesium and an adult human body comprise of about 25 grams of magnesium (Celio et al, 1996). Magnesium plays a structural role in bone formation and chromosomes. Many antioxidant such as glutathione requires magnesium for its synthesis (Hartwig, 2001). For normal functioning of cell and maintenance of total body fluid volume and electrolytic balance potassium is needed (Young, 2001). A variety of food and fruits are rich in potassium. Processed food should never be preferred in diet as the amount of potassium reduces considerably (Webster et al, 2010). Lack of potassium in diet is associated with cardiovascular diseases as well as hypertension. An appropriate consumption levels of it could be protective against these conditions (WHO, 2012). Meta-analysis have reported an inverse relation in between potassium intake and risk of stroke (D'Elia et al, 2011**).** Other meta-analyses showed that increased potassium intake lowers blood pressure [35]. Further review concluded that decreased blood pressure. Cabbage, spinach, carrots, onions, tomatoes, cucumbers, bananas, papayas and dates are some rich source of potassium (WHO, 2012).

For the maintenance of osmotic balance between cells and interstitial fluids the elements sodium, potassium and chlorine play a key role. Also excess of sodium intake is also associated with high blood pressure, cardiovascular and renal disorders and often discouraged in patients who suffer from hypertension (Soetan et al, 2010).Calcium is a constituent of teeth and bones. It regulates nerve and muscle function. It plays a vital role in enzyme activation and is required for membrane permeability, muscle contraction and in neuromuscular excitability. The disadvantages associated with the decreased blood calcium involves spontaneous discharges of nerve impulses leading to tetany (Murray et al, 2000). Calcium is required for maintenance of firmness of fruits, cell wall stability and membrane integrity (Olaiya, 2006).

Aim of the study

To do the elemental profiling of *Alpina allughas* and *Alpinia malaccensis* as well as illustrating the importance of essential and non-essential elements.

Material and methodology

Elemental Analysis by Atomic absorption spectroscopy Total nitrogen content in plant samples was determined by Micro-Kjeldhal method (AOAC (2005) No. 2001:11) with some modifications as:

1. Pelican digestion unit Model No. KPS-012L and auto distillation Kjeldhal unit Model No. Kelpus D-EMC was used instead of digestion unit and manual titration.
2. 0.05 N H_2SO_4 was used instead of HCl. Total N content was multiplied by the factor 6.25 to obtain protein content.

The minerals [Potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn) and lead (Pb)] contents were determined after wet digestion of the powdered plant samples. Briefly, 0.5 g powdered dry samples were weighed into 150 ml Erlenmeyer flask. 10 ml of diacid mixture (10 HNO_3: 4 $HClO_4$) was added to the samples and allowed to react overnight. The following morning The flasks were carefully heated until clear solutions were obtained. Care was taken to ensure that the samples did not dry. The residue was filtered and solutions were precisely transferred to 100 mL standard volumetric flasks and made to volume with deionized water. A blank digest was carried out in the same way.

The micro-nutrient (Fe, Mn, Zn, Cu and Pb) contents of the samples were analysed by Atomic Absorption Spectrophotometer(Electronic Corporation of India, Model No. 4141) following the method of (Elwell and Gridley, 1967) and total Ca and Mg content was analysed by complexometric method (Association of Analytical Chemists, AOAC, 1990). Determination of total Potassium (K) was performed on the Flame photometer Systronic India Ltd, Model 128 (Jackson, 1973). Photoelectric colorimeter, Model, 104 was used for phosphorus analysis following the molybdenum blue spectrophotometry (Jackson, 1973).

Result and discussion

Elemental analysis was carried out for the determination of Fe, Mn, Zn, Cu, Cd, Cr and Ni has been reported in ppm (parts per million) with the help of atomic absorption spectroscopy (AAS) (Table 1). The basic functions performed by the minerals are: they are structural components of body tissues, are involved in the maintenance of acid-base balance and in the regulation of body fluids, in transport of gases and in muscle contractions (Malhotra, 1998; Murray et al, 2000). The detailed elemental profiling has been recorded in Table 1, Fig 1, 2.

No report exist in literature regarding elemental contituents in *A. allughas* and *A. malaccensis*. However the presence of these elements is present in the plants of family Zingiberaceae has been reported (Tanzima et al, 2011, Tanveer et al, 2014). The maximum amount 625.8ppm was detected in AAF followed by AMF (616.4ppm) and the least amount was detected in AAL (287.4 ppm). It was found that AMF possess the maximum amount of Mn (320.8), followed by AAF (227.6ppm) and the least amount of iron was exhibited by AAR (38.2 ppm). The different quantity of Zn detected in AAR, AAL, AAF s was 15.8ppm, 28.2ppm and 89.6ppm and in AMR, AML and AAF was 34.2ppm, 45.8 ppm and 68 ppm respectively. It was found that AML possess the maximum amount of Cu (55.6ppm), followed by AMF (35.8ppm) and the least amount was detected in AAL (24.6 ppm). It was found that AML possess the maximum amount of Cd (38ppm) and the least amount was detected in AAR (9.8 ppm). Different amount of Ni was detected in AAR (31.8ppm), AAF (0ppm), AMF (0ppm), AMR (0ppm), AML (0ppm) and AMF (0ppm) respectively. This is the first report on *A. allughas* and *A. malaccensis.* In present study N was not detected in both the aforementioned species. It was found that AAF possess the maximum amount of N (1.21%) as compared to the others. However the phosphorous content was found to be highest in the AAL (0.24%). The potassium, calcium and magnesium content was found to be highest in the AMF containing 1.24%, 1.27% and 1.24% respectively.

Table 1: Elemental profiling of A. allughas and A. malaccensis

S. N	Sample	Amount											
		(ppm)							%				
		Fe	Mn	Zn	Cu	Cd	Cr	Ni	N	P	K	Ca	Mg
1	AAR	390.00	38.20	15.80	0.00	9.80	0.00	31.8	0.46	0.09	0.59	0.98	0.92
2	AAL	287.40	209.20	28.20	24.60	36.00	0.00	0.00	0.25	0.24	0.41	0.72	0.96
3	AAF	625.80	227.60	89.60	29.80	36.00	0.00	0.00	1.21	0.23	0.28	1.24	1.01
4	AMR	397.80	169.60	34.20	0.00	11.20	0.00	0.00	0.22	0.08	1.40	0.76	0.66
5	AML	445.80	138.20	45.80	55.60	38.00	0.00	0.00	0.48	0.29	1.20	1.17	0.74

6	AMF	616.40	320.80	68.00	35.80	36.00	0.00	0.00	0.86	0.22	1.24	1.27	1.24

AAR: *Alpinia allughas* rhizome, AAL: *Alpinia allughas* leaves, AAF: Alpinia allughas fruit, AMR: *Alpinia malaccensis* rhizome, AML: Alpinia malaccenisis leaves, AMF: *Alpinia malaccensis* flower

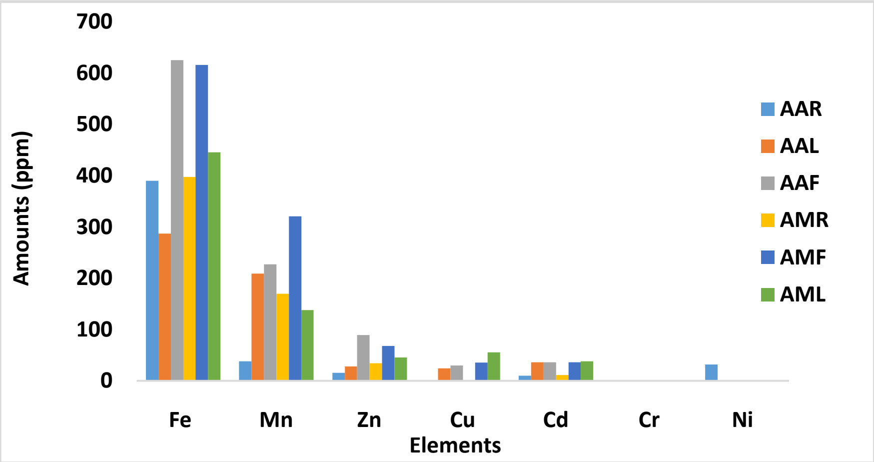

Fig 1: Elemental analysis of various elements in ppm

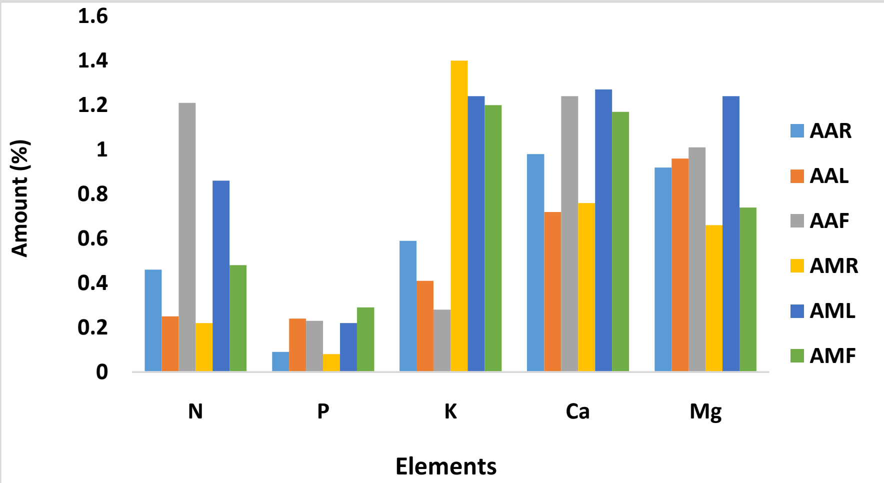

Fig 2: Elemental analysis of various elements in %

Conclusion

The presence of these element in *Alpinia allughas* and *Alpinia malaccensis* in various proportion indicates the potential of these plants in terms of their medicinal values. Thus further studies related to antioxidant and antifungal potential of these plants are needed to be done to obtain proper information regarding the practical effectiveness.The elements whether essential or non essential play a crucial role in human as well as animal life. These elements are either a cofactor of many enzymes and directly or indirectly needed either in minor amount or macroamount for the proper functioning of various system associated with human, animals as well as plants. Their absence affect the metabolism of many macromolecules (Sethi et al, 2014). Due to valuable importance of these elements an attempt has been made to evaluate the presence of essential and non essential elements in various parts of plants of *Alpinia allughas* and *Alpinia malaccensis* belonging to the family Zingiberaceae. The elemental profiling of *A. malaccensis rhizome* has already reported by our group (Sethi et al, 2014).

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