CHAPTER I

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The fact that food and health are so closely related as to be interdependent, hardly needs any emphasis. The role of carbohydrates, proteins and fats - the major constituents of our diet - has been extensively studied and their metabolism established. The importance of vitamins and major minerals like calcium, phosphorus, magnesium and iron has been well recognised.

Science and technology over the years have brought many benefits to mankind. Not least has been, a marked increase in food supply and nutritional status. Concomitantly, these benefits have been accompanied by increased dangers as evinced by the increasing death-tolls by fatal diseases like cancer, hypertension, etc., despite better medical facilities.

The need for a balanced diet has been drummed for years into public consciousness by nutritionists. Natural foods are naturally 'balanced', the need to balance the diet does not exist in any living creature other than man and his animals. The public is becoming health conscious, and is convinced that the mass production of food and its necessary refinement,
processing and storage add subtle toxins to food and remove some essential factors. Public concern over contaminants such as pesticides, chemical additives and heavy metals in food area has been aroused.

Certain changes in the natural environment of man have appeared as a by-product of modern civilization. Among them are an increased exposure to certain elements unnecessary for or even toxic to health, most of which are mined from the earth and get into food, water and air. In other cases, certain micronutrients necessary for health and even for life itself, have been partly removed during the refining of foods.

The importance of inorganic elements in biochemical and physiologic processes is now well established at all levels of cellular complexity. Although more than sixty elements have been discovered in bacteria, fungi, higher plants, animals and man, few of them have been studied intensively. Elements which occur in amounts large enough to be measurable are calcium, carbon, chlorine, hydrogen, iodine, iron, nitrogen, magnesium, oxygen, phosphorus, potassium, sodium and sulphur.

Trace elements, minor elements, or micronutrient elements are the terms applied to the remaining elements occurring constantly, though in traces, in biologic systems. These elements are vital for health, and are more important in nutrition than are the vitamins, in
the sense that they cannot be synthesized by living matter, as is the case with vitamins\textsuperscript{1,4}. Thus they are the basic sparkplugs in the chemistry of life, on which the exchanges of energy in the combustion of foods and the building of living tissues depend. Every natural food contains the micro nutrients necessary for its metabolism. It is only when natural foods are altered by man-cooked, partitioned, preserved, frozen, canned, dried, processed or packed - that they lose or gain micronutrients or toxins, which can affect health over the long term\textsuperscript{1}. The following are generally included among the trace elements: aluminium, antimony, arsenic, barium, boron, bromine, cadmium, chromium, cobalt, copper, gallium, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silver, strontium, tin, titanium, vanadium and zinc. They have been grouped together quite arbitrarily but have in common, the uncertainty of assigning to them definite physiologic functions, and difficulty in measuring their concentration in biologic fluids which varies from $1 \times 10^{-6}$ to less than $1 \times 10^{-12}$ gms/gm. wet weight of tissue\textsuperscript{3}.

Iron, iodine and fluorine, though occurring in these concentration ranges, are generally considered as distinct from the trace element group, because, their established importance to health, and their medical significance is no longer questioned\textsuperscript{3}. 
Elements which are necessary for biologic functions are known as essential i.e., without them life does not exist. In terms of optimal function of living things, this definition may be broadened to include elements necessary for special purposes which provide health but without which life can still exist at an unhealthy level. Mertz has suggested a variety of criteria to determine essentiality, such as the presence of a trace mineral in healthy tissue. If the element also appears in the fetus and the newborn, an even better case is made for its nutritional need. Additional evidence is provided if the body maintains homeostatic control over the rate of its excretion or uptake into blood or tissue. Consistent changes in blood levels, tissue concentrations, or distribution within a metabolic pool as a result of physiologic activity further affirm its essentiality, as does the identification of the element in an enzyme or as the activator of an enzyme. Finally, animal studies provide the most conclusive evidence. If specific symptoms can be produced as a result of the total or partial absence of the element and then alleviated by its addition to the diet, the element can be considered essential.

At present, fourteen elements are believed to be essential for animal life, viz. iron, iodine, copper
zinc, manganese, cobalt, molybdenum, selenium, chromium, nickel, tin, silicon, flourine and vanadium. It is possible that future studies will identify additional essential elements.

In more recent times, interest in metallic elements in food has increased from the detection of gross criminal malpractices of adulteration and use of non-permitted synthetic colour additives to food-stuffs, as well as investigations of not only the harmful effects on health of trace amounts present as contaminants but also the beneficial and nutritional requirements of these essential trace elements. Loss of these essential trace elements during refining, processing and storage, especially in the more developed countries has also given impetus to such investigations. Such investigations require methods of analysis that are capable of measuring low levels of a wide variety of metals in different organic substrates (food, feeding stuffs, animal and plant tissues). Many elements are present in the living tissues only at levels that are at or even below the limit of detection of the analytical methods formerly available. Now-a-days, with the use of advanced instrumental and analytical techniques like atomic-absorption spectroscopy and neutron activation analysis, the limits have been lowered significantly and most elements can be measured with an accuracy and precision that are more than adequate for the study and interpretation of toxicological factors.
In unrefined foods, minerals are present in various forms mixed or combined with proteins, fats and carbohydrates. Processed or refined foods, such as fats, oils and sugar almost contain no minerals. The total mineral content of a food is determined by burning the organic or combustible part of a known amount of a food and weighing the resulting ash. The ash, then, is analysed for individual mineral elements. Minerals such as iodide, fluoride, copper and other trace elements that are essential for life may be found abundantly in drinking water in certain areas or in foods grown in the soil of those areas, whereas in other parts of the country the same minerals are deficient both in soil and water. Still other elements, such as sodium, potassium, chlorine and sulphur - all necessary in human nutrition - are so universally present in foods that there is no need to worry about deficiencies.

Questions about the relative availability of the mineral elements for physiologic processes continue to stimulate new investigations in this field. Fifty or more years ago, the opinion prevailed that the organic form of minerals found in plant and animal foods were utilised better than the inorganic forms. However, modern research has disproved this theory. Today, we are aware that many minerals occur in inorganic forms in natural foods and are absorbed from the digestive tract.
Besides the essential trace elements, certain toxic elements are present in foods to a greater or lesser extent as contaminants, as a result of the increasing industrialization and associated pollution of the biosphere. Contamination may arise from a number of different sources. Thus, crops will contain various amounts of contaminants according to the nature of soil, fertilizers and/or insecticide-treatment and proximity to industrial activity. Subsequent harvesting, storage, processing, packaging and domestic operations may also affect the level of contaminants in the food as consumed. Not all such processes will increase the contamination, for example, rejection of outer leaves, washing and cooking, may lead to reduction also. The existence of such factors (many of which apply to nutrient elements) has stimulated a world-wide study of concentration of metals, in general, in foods, in order to assess both the safety and adequacy for human diets.

Studies on trace metals have been quite useful in explaining disease states as diverse as cancer, arteriosclerosis, hypertension, arthritis, porphyria, lupus erythematosus, multiple sclerosis and amyotrophic lateral sclerosis.

The essential trace elements chromium, copper and zinc have been chosen for the present investigation on account of their importance in nutrition, their
relation with various diseases and their presence in a large number of metabolic enzymes. Studies on cadmium, though non-essential and toxic, have also been included because cadmium is intimately related to zinc.

Chromium is associated with glucose metabolism, possibly as a cofactor for insulin\textsuperscript{7,8}. In studies with human diabetics, improved glucose tolerance tests were reported following chromium supplementation\textsuperscript{8,9}. Glucose tolerance is also restored by chromium in children suffering from Kwashiorkor\textsuperscript{10} or protein-energy malnutrition\textsuperscript{11}. A possible relationship between chromium deficiency and cardiovascular disease has also been postulated\textsuperscript{12}. Atherosclerosis has been attributed to chromium deficiency\textsuperscript{13}.

Meats, cheese, whole grains and condiments are good sources of available chromium. It appears to be less available from the leafy vegetables and is very low from polished rice, refined flours and sugar\textsuperscript{6}.

Copper containing enzymes are involved in a number of reactions that affect a variety of tissues and body functions. Copper is required for mobilization of body iron, the production of normal erythrocytes, the formation of the hair and skin pigment melanin, and the maintenance of cellular energy supply (ATP)\textsuperscript{14,15}. It has been postulated that mild copper deficiency may be a possible etiological factor in atherosclerosis\textsuperscript{16}. 
On the basis of the recent studies\textsuperscript{17,18}, it has been suggested that daily copper intake for adults may be 0.5 - 2.0 mg. per day.

Zinc is essential to the normal growth of animals. Clinical signs of zinc deficiency in people living in Iran and Egypt included short stature, marked hypogonadism, hepatosplenomegaly and anaemia\textsuperscript{19,20}. Zinc is closely associated with various proteins\textsuperscript{21}. The large number of zinc metalloenzymes which have been isolated, signify the importance of this metal in metabolism. Zinc influences many body systems and functions, including growth, bone formation, brain development, behaviour, reproduction, fetal development and immune mechanisms. Zinc is also supposed to have some relation with diabetes, while zinc-cadmium ratio is said to be related to hypertension\textsuperscript{7}.

Animal products in general are important sources of zinc. Sea foods, meat, liver, eggs and milk are good sources and contribute about 60\% of the total intake. Legumes and whole grain products also contribute zinc to the diet. Zinc from vegetable sources is less available to the body; for this reason, persons who consume primarily vegetable diets are at greater risk of zinc deficiency\textsuperscript{6}. The zinc content of the pattern dietary has not been calculated because of the unavailability of adequate food analysis data for zinc.
Studies representing hundreds to thousands of analyses, have led to the conclusion that cadmium in kidneys, in relation to zinc, is a contributing, if not sometimes the whole cause of high blood pressure. In areas where the ratio is low, the incidence of hypertension is high and vice versa.

Food is the major source of cadmium for most people, heavy smokers can receive significant amounts of cadmium from smoke inhalation. The other sources of accumulation of cadmium in the kidney of man with age is water and air. If cadmium can displace zinc in human body, it is likely that food containing more than usual amounts of cadmium and less than the usual amounts of zinc might slowly lead to accumulation of cadmium because its excretion is very low. An excess of zinc would prevent accumulation of cadmium, a slight deficiency allows it. Cadmium interferes with the metabolism of iron, calcium, zinc and copper. Thus, cadmium may be a greater hazard in areas where anaemia is endemic, or in children and pregnant women, in whom iron and calcium intake may be inadequate. O'Dell has made studies on the effects of some nutrients on the availability of zinc. A few studies have also been made by White on the intake and output of zinc. White analysed the diets of high school girls' and college women for zinc. He found the mean daily intake of 12 mg for the former and 13.8 mg for the latter. Coons and
Moyer reported intakes of 6.5 - 9.0 mg zinc per day for preadolescent girls. College women on an average intake of 13.2 mg zinc/day had a retention of 6.6 mg and losses of 5.6 mg in urine and faeces.

**PRESENT INVESTIGATION:**

Though the literature on metals in foods is vast, and few comprehensive but critical reviews have appeared in recent years, information regarding the food consumed by Indians is scanty. Recently Rao et al. analysed the food material of seven States of India for some of the trace elements but they have not included the State of Madhya Pradesh in their studies. A survey of literature reveals that not much data is available on zinc, cadmium, chromium and copper contents of food, as consumed by the people of India in general, and this region of Madhya Pradesh State, in particular.

It was, therefore, thought worthwhile to take up investigations on the foodstuffs consumed by the people of the Chhattisgarh region of Madhya Pradesh. Rice is the staple food of people of this region. Different varieties of rice cultivated in this region as well as those developed by the local Rice Research Centre of J.N. Agriculture University, have been analysed for their chromium, copper, cadmium and zinc content. Besides rice, wheat, pulses, vegetables, fruits, condiments and water have also been analysed for the trace element content.
In order to assess loss in the mineral content due to polishing of rice, polished and unpolished rice samples have been analysed. Loss in the mineral content due to refining has also been determined in case of wheat.

In view of the fact that, not much work has been done on the bioavailability of the trace elements under study, investigations on bioavailability of copper, cadmium, chromium and zinc have been undertaken in subjects of age group 20-30 years. The intake and excretion of these elements have been computed.

The last phase of the investigation deals with estimation of some of these trace elements in blood and hair of subjects suffering from either diabetes or hypertension, as well as in the normal subjects. This part of the investigation has been done to ascertain the diagnostic importance or clinical application of these studies, in view of the fact, that variations in metal ion concentration of tissues and body fluids are commonly observed in many disease states.
LITERATURE CITED

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