بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of graduate studies

Effect of Nutrition on Inorganic Elements Deficiency in Humans

تأثير التغذية على نقص العناصر غير العضوية في الإنسان

A Thesis Submitted in Partial Fulfillment of the Requirements for Master degree in chemistry

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استهلال

بسم الله الرحمن الرحيم

قال تعالى :(**وَآيَةٌ لَّهُمُ الْأَرْضُ الْمَيْتَةُ أَحْيَيْنَاهَا وَأَخْرَجْنَا مِنْهَا حَبًّا فَمِنْهُ يَأْكُلُونَ**)

سورة يس الآية (33)

صدق الله العظيم

Dedication

To my

Parents,

Husband, Children,

Brothers and sister

Acknowledgement

Praise to Allah almighty for giving me health and help me to complete this work.

My thanks go to my supervisor Prof. Mohamed Abbo for his encouragement and help. My thanks are extended to the members of petroleum laboratories for research and studies, and the members of industrial research and consultancy center for. Technical Support lap facilities.

Abstract

The aim of this study is to know the effect of food behavior on protection and treatment of diseases caused by inorganic elements deficiency in human body.

Four different food samples were collected from Sudan (Khartoum) markets. The samples included Triticum (Wheat), *Sorghum bicolor (Sorghum)*, local name Fatarete, *Cicer arietinum (Chickpeas), local name Kabkaby and Solanum lycopersicum (Tomatoes).*

Minerals of each sample were measured by Atomic absorption spectroscopy and Flame photometer, Protein was measured by Micro Kjeldhal method, Ash was measured by Ignition, Fats were measured by Soxhlet apparatus and fibers were measured by treatment with boiling solution of Sulfuric acid and Potassium hydroxide. Calcium, Sodium and Potassium were measured by FPH, Cadmium, Copper, Iron, Magnesium, Manganese, Nickel, and Zinc were measured by AAS.

All the analyzed species were found to be rich in Magnesium's (1932 - 1280). The highest Calcium concentration was shown by Tomatoes (120 ppm), and the lowest concentration was in Wheat and sorghum (0.10 ppm). The highest concentration of Sodium was shown by sorghum (440 ppm), and the lowest concentration was in Wheat (40 ppm). The highest Potassium concentration was in Tomatoes (4160 ppm), and the lowest concentration was in Wheat (40 ppm). The Wheat showed the lowest concentrations in Cadmium (< 0.02), Cupper (< 0.03) and Nickel (< 0.10). All analyzed species showed low concentrations of Manganese (31.20_ 11.80), Zinc (62.80_ 42.60), Nickel (< 0.10) and Cupper (16.18_ 0.03). The high concentration of Iron was shown by tomatoes (481.2 ppm), and the other species showed low concentration of Iron (37.20_ 29).

The highest ash percentage was shown by Chickpeas (8.5%), and the lowest one was in Wheat (1.395 %).

All species showed convergent protein percentage (18.47_ 12.81).The highest Fiber percentage was shown in Tomatoes (18.77%), and the lowest one in Wheat (1.82%).

المستخلص

هدفت هذه الدراسة لمعرفة تاثير السلوك الغذائي في وقاية الامراض الناتجة من تقص العناصر الغذائية في جسم الانسان.

تم جمع اربع عينات من اسواق السودان(ولاية الخرطوم). وقد شملت العينات الحمص, الذرة, القمح والطماطم. تم قياس المحتوى المعدني باستخدام مطيافية الامتصاص الذري ومطيافية اللهب, البروتين, نسبة الرماد, الدهون والالياف لكل عينة. كل الفصائل التي تم تحليلها كانت غنية بالماغنسيوم (1932_1280). اعلى تركيز للكالسيوم وجد في الطماطم(120), واقل تركيز وجد في القمح و الفيتريته(0.10). اعلى تركيز للصوديوم في الفيتريته(440) و اقل تركيز في القمح(40.).اعلى تركيز للبوتاسيوم في الطماطم(4160) واقل تركيز في القمح(40). وجدت ادنى تراكيز للقمح في الكادميوم(0.03) ,النحاس (0.02) و النيكل (0.10). كل العينات التي تم تخليلها اظهرت تراكيز منخفضة من النيكل (0.10), الزنك (62.80_42.60) ,النحاس (16.18-0.03) والمنجنيز (31.20- 11.80). اعلى تركيز للحديد وجد في الطماطم(481.2) وبقية العينات اظهرت تراكيز منخفضة من الحديد (37.20_29).اعلى نسبة رماد كانت في الكبكبي (8.5%), و اقل نسية كانت في القمح(1.395%). كل العينات اظهرت نسب متوسطة من البروتين 18.47-12.81). اعلى نسبة الياف كانت في الطماطم(18.77) واقل نسبة في القمح(1.82%).

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List of abbreviations

Abbreviation	Term
ULS	Upper intake levels
DRIs	Dietary reference intake
FNB	Food and nutrition board
RDAs	Recommended dietary allowances
EFSA	European food safety authority
CNS	The central nervous system
PTH	Parathyroid hormone
TSH	Thyroid stimulating hormone
IQ	Intelligence quotient
ATP	Adenosine triphosphate
DNA	Deoxyribonucleic acid
RNA	Ribonucleic acid
GI	Gastrointestinal

Chapter 1

Chapter one

Introduction and literature Review

1.1 Food behavior

Food behavior is all actions related to food including acquiring, preparing, and serving, eating, storing. (Hand book of behavior, food and nutrition.Ronald.2011)

1.1.1 The effect of food behavior on general health

Where can we find the minerals and nutrients that are essential to health longevity- In principle the source would be our diet, which basically consists of plant and animal products (with the animals diet consisting of the same plants as ours).This is because, by drawing from the air the carbon necessary to manufacture the chains from which vitamins, amino acids, and essential fatty acids are synthesized, plants should be able to provide a large part of the nutrients we need. In order to meet daily need, however, it is necessary not only that we consume some twenty different vegetables in the proper proportions, but that these vegetables have been grown in soil that is sufficiently rich in nutrients and free from poisoning by the many different chemical products that are now in common use. As we shall see, it has become fairly difficult to meet these criteria. But the fact remains: we cannot live without minerals and we will live wretchedly if we suffer from a mineral deficiency. Numerous epidemiological studies have provided ample proof that regular consumption of fruits and vegetables is essential for the prevention of a large number debilitating disease such as diabetes, cancer cardiovascular disorders, and so on. These illnesses are particularly common in western countries whose inhabitants eat too much fat, sugar, salt, and animal products and too few of the indispensable food fiber, vitamins, minerals, and other micronutrients necessary for our health.

We have moved far beyond the time when the human diet was regarded simply as a source of proteins and lipids. The quality of food and its richness in

micronutrients are now finally beginning to become a focus, even on the official level. This is particularly true of fruits and vegetables, especially when they are grown organically on healthy soils that are not depleted of essential elements. This is especially important given that plant_ based products are particularly rich in bioavailable antioxidants. The term bioavailable refers to a substance that occurs, in a form that is easily utilized by the body. Consumers are currently aware of the major role played by antioxidants in the fight against premature aging and in the prevention of a large number of diseases.

The benefits of these micronutrients point to importance of having them, and those like them, at our body's disposal in such a way that they are completely harmless in nature and can act in complete synergy to protect the body's cellular environment.

Today there is much discussion about vitamins, which actually enjoy good press. But while vitamins are indeed necessary, the daily intake of the appropriate quantity of good quality minerals is equally important for our health.

Minerals help regulate the body’s elimination functions and help regenerate the blood on the molecular level, because of the way they bond with many of the body’s enzymes.

In fact, mineral salts are the very foundation of all life. Simultaneously present in the mineral, plant, and animal realms, mineral salts are responsible for the transfer of the energy running through all their substances and organisms.

It has long been thought that the variety and abundance of the modern diet was enough to prevent any risk of nutrient deficiency. It is known, however, that there is no factual basis for this assumption. (Dr.Walter.(1977).

1.1.2 Diseases caused by UN balanced food.

Five diseases you can be avoided by eating healthy food.

Absence of nutritional diet make a person unhealthy. UN healthy persons are more susceptible to diseases or infections. Deficiency of nutrients in the diet results in number of deficiency diseases in human beings, e.g. night blindness, scurvy. UN balanced food may cause obesity.

A. Heart disease:

We have all time and again that saturated fat clogs arteries and causes heart disease. Doctors warn us against high cholesterol levels, and put us on cholesterol – lowering drugs in our levels are too high. Saturated fat is believed to raise cholesterol, and high cholesterol is believed to cause at herosclerosis, which is a buildup of plaque in the arteries, which in turn is believed to because heart disease is called the lipid Hypothesis or sometimes the Diet – Heart Hypothesis.

The highest rate of death from heart disease among male employees of the railways in India occurred in Madras in southern India, while the lowest rate occurred in Punjab the fat intake was 10-20 times higher.

When examining the results of both epidemiological studies and clinical trials, one needs to look beyond the reports by the popular media and go to the original articles. Even then, the authors sometimes state conclusions that are not appropriately reflected by the data. For example, they may state that some dietary change or drug was associated with reduced heart disease, but fail to mention that the group tested had higher all -cause mortality. Funding may be an issue here – it is difficult to get funding if one goes against the conventional Wisdom. (*Kerry.et/al, 2013*).

B. Osteoporosis:

Osteoporosis is the metabolic bone disease seen most commonly in the United States. In the classical sense, it is considered to be primarily, a disorder of bone matrix formation with deficient sites for the deposition of calcium salts. However, most types of osteoporosis are most likely due to excessive bone re sorption rather than lack of bone formation, and some recent evidence indicates that chronic calcium depletion may be another cause. Adrenal cortical glucocorticoid excess either in the form of naturally occurring Cushing's syndrome or, more frequently seen nowadays , with the excessive administration of cortisol and its derivatives leads to a severe osteoporosis, presumably due to excessive bone catabolism. Long standing hyperthyroidism may, at times, cause osteoporosis on much the same basis. Vitamin C depletion with scurry used to be a common cause of nutritional osteoporosis.

Among the rare causes of osteoporosis are cirrhosis of the liver, achlorhydria, and long standing diabetes with acidosis.

There are only a few signs or symptoms, and osteoporosis is often found accidentally, on X ray survey, only after 30 percent or more of the mineral content of bone has been lost. A partial collapse of the vertebral bodies, with hemeation of the nucleus pulposus, may be the only evidence of the disease. The principal involvement in post- menopausal osteoporosis is usually confined to the spine and pelvis and, rarely, to the skull bones, which show thinning of the cortex.

The lamina dura of the teeth is usually preserved.

The principal signs and symptoms are back pain, moderate kyphosis, and progressive loss of height. Ordinarily, normal calcium and phosphate absorption from the gut takes place, and the serum calcium and phosphate levels are normal.

The serum alkaline phosphatase level, except when there has been a recent fracture, is usually normal. As a rule, the urinary calcium is high in the initial stages of the disease, but normal or low in chronic or late states. The patients are often in negative nitrogen balance. (Robert.1997)

C. Cancer

China now has the highest cancer rate in the world. Recently, a study was completed here involving nutritional supplements: Test groups were given various minerals and vitamins at twice the recommended daily allowance. Thus one group received 120 mg of vitamin C, another group took zinc, another vitamin E, and so forth. At this stage a clear result emerged for only one group: that which had been given a combination of vitamin E, beta_ carotene, and selenium. In this group a morality rate reduction of 9 percent over 5 years was achieved _ a considerable improvement over the standard morality rate. For those people in the group suffering from cancer, particularly cancers of the stomach and esophagus, 21 percent survived as compared to the control group that did not receive Vitamin E, beta_ carotene, and selenium. This improved result was obtained when only three basic nutrients in low doses were supplied to a test group_ yet the human body requires close to one hundred nutrients every day. (Ref) Alice.

D. Type 2 diabetes

The incidence of type 2 diabetes in the adult population of the United States is increasing at an alarming rate. Since 1990, it has risen 33 percent among all age groups and over 70 percent in people between the ages of 30 to 39 years .Diabetes, 90 percent of which is type 2 diabetes, affect 6.5 percent of the population. This increase in cases of diabetes is closely associated with the increase in the number of cases of obesity. Which rose from one in eight in 1991 to one in five in 1998. The risk of developing diabetes is estimated to increase 4.5 percent for every 2.5 pounds of extra body weight, thus people who are obese are prime candidates for type 2 diabetes. (Ref) Alice

E. Obesity

Differences in genetic makeup exert an influence on body weight as they do in all other aspects of the human condition. Some people become obese while others, who seemingly eat the same foods, stay slim. Regardless of the genetic tendencies that govern a person's body weight, the biochemical reactions that direct the deposition of fat in the obese person are the same as those that direct fat deposition in the slim person. (Alice and franc 2002)

1.1.3 Nutritious diets protect against diseases

Foods can have direct impact on the ability to enjoy life to its fullest. Perhaps the most obvious positive effect of food is the pleasurable feeling you get from eating a good meal.

Diet can have long term effects on your health as well. Diet plays a major role in promoting and maintaining good health, preventing some chronic diseases and treating others, and speeding recovery from injuries. In earlier times, diseases such as goiter and pellagra were relatively common _ both are caused by nutritional deficiencies and cured by diets containing sufficient amount of a particular nutrient.

Although it is unlikely that will ever suffer from an illness caused by pronounced dietary deficiency, the foods you eat can exert more subtle and, in the long run, no less harmful effects on your health. During the past few decades, scientists have identified several dietary factors that play important roles in the development of specific diseases. Diets high in certain types of fat, for example, appear to increase the risk of developing coronary heart disease and certain cancers, and among susceptible people, too much salt in food is believed to increase the chances of developing hypertension .Other scientific evidence suggests that the current average American diet- which is high in fatty foods and low in fruits and

vegetables – can increase the risk of developing certain forms of cancer , especially cancers of the esophagus , colon , prostate, and breast. Certain dietary patterns can increase the likelihood of dental caries. In addition , habitually eating more calories than the body uses for maintenance and physical activity produces obesity and increases the risk of several chronic diseases including noninsulin dependent diabetes mellitus , a form of diabetes that does not usually require daily insulin injections but has many adverse complications and generally appears after age 40.

As the body of research on diet – disease connections has grown over the past have century , scientists, policy makers, officials of the food industry, consumer groups , and others have engaged in a debate about how much and what kind of evidence justifies giving dietary advice to the public. They have also argued about how best to control risk factors on which there is general agreement among scientists.

The central problem in this debate is one that characterizes all science: absolute proof is difficult to obtain. This is particularly true in a science such as nutrition, in which many factors age, sex, genetics, social behavior, and cultural differences, for example can play a role in what food we eat and how it affects our bodies. (Catherine. 1992)

1.1.4 Foods with powerful medicinal properties

Almond soup is an excellent substitute for beef tea for convalescents. It is made by simply blanching and pounding a quarter of a pound of sweet almonds with half a pint of milk, or vegetable stock. Another pint of milk or stock is then to be added and the whole warmed. After this add another pint and a half of stock if the soup is to be a vegetable one, or rice water if milk has been used.

An emulsion of almonds is useful in chest affections. It is made by well macerating the nuts in a nut butter machine, and mixing with orange or lemon juice.

Almonds should always be blanched, that is, skinned by pouring boiling water on the nuts and allowing them to soak for one minute, after which the skins are easily removed. The latter possess irritating properties.

Bitter almonds should not be used as a food. They contain a poison identical with prussic acid.

- **Blackberry.** Fresh blackberries are one of the most effectual cures for diarrhea known. Mr. Broadbent records the case of a child who was cured by eating an abundance of blackberries after five doctors had tried all the known remedies in vain.

- **Brazil nut.** Brazil nuts are excellent for constipation. They are also a good substitute for sent in puddings. Use 5 oz. nuts to 1 Ib. flour. They should be grated in a nut mill or finely chopped.

- **Beans, peas, and lentils.** Beans, peas, and lentils are tabooed by the followers of Dr. Haig, the gout specialist, on account of the belief that they tend to increase the secretion of uric acid. But this evil propensity is stoutly denied by other food- reformers for myself I am inclined to believe that their supposed indigestibility, etc., arises from the fact that they are generally cooked in hard water. They should be cooked in distilled or boiled and filtered rain water. The addition of lemon juice while cooking renders them much more digestible.

Carrot. Carrots are strongly antiseptic. They are said to be mentally invigorating and nerve restoring. They have the reputation of being very indigestible on

account of the fact that they are generally boiled, not steamed. When used medicinally it is best to take the fresh, raw juice. This is easily obtained by grating the carrot finely on a common penny bread grater, and straining and pressing the pulp thus obtained.

Date. The nourishing properties of dates are well known. They are easily digested, and for this reason are often recommended to consumptive patients.

According to Dr. FERNIE half a pound of dates and half a pint of new milk will make a satisfying repast for a person engaged in sedentary work.

Cinnamon. Cinnamon is a very old_ fashioned remedy for soothing the pain of internal or unbroken cancer. One prescription is the following: Take 1 Ib. of Ceylon sticks. Simmer in a closed vessel with 1 quart of water until the liquid is reduced to 1 pint. Pour off without straining, and shake or stir well before taking. Take half a pint every twenty_ four hours. Divide into small doses and take regularly.

Cinnamon has a powerful influence over disease germs, but care must be taken to obtain it pure. It is often adulterated with cassia.

Cinnamon tea may be taken with advantage in cases of consumption, influenza, and pneumonia. (Florence.2021)

1.2 Requirements and recommended dietary intake

The model for risk assessment of nutrients used to develop tolerable upper intake levels (ULS) is one of the key elements of the developing framework for dietary reference intakes (DRIs). DRIs are dietary reference values for the intake of nutrients and food components by Americans and Canadians. The U.S. National Academy of sciences recently released two reports in the series (IOM, 1997,

1998). The overall project is a comprehensive effort undertaken by the standing committee on the Scientific Evaluation of Dietary Reference Intakes (DRI Committee) of the food and Nutrition Board (FNB), Institute of Medicine, National Academy of Sciences in the United States, with active involvement of Health Canada. The DRI project is the result of significant discussion from 1991 to 1996 by the FNB regarding how to approach the growing concern that one set of quantitative estimates of recommended intakes, the Recommended Dietary Allowances (RDAs), was scientifically inappropriate to be used as the bases for many of the uses to which it had come to be applied. (Linda 2006).

1.3 Minerals (our inalterable body component)

Vitamins and minerals form the group of what are called micronutrients, because we need only very small amounts of them,(unlike macronutrients, of which we need to consume much larger amounts); however, not achieving even those small amounts practically leads to illness.

In the context of nutrition, minerals are part of the group of what are called essential nutrients, we call them essential nutrients because they are indispensable to live, and our bodies cannot make them.

There are minerals in the rocks, in the soil and in the water. Plants get the minerals from the soil, and we humans get them by eating plants and animals and by drinking water.

Minerals are simpler elements and much less fragile than vitamins. They are not destroyed when storing or cooking food, or when exposed to the air, as with vitamins. They are practically unalterable. That’s why it’s easier to get minerals than vitamins.

There are many minerals, but only a few are necessary to keep us healthy. We have shortages of some of them, because we do not consume enough, while we consume an excess of others.

The main minerals travel through the body in various way. Potassium, for example, is quickly absorbed into the blood stream, where it circulates freely, and is excreted by the kidneys, much like a water soluble vitamin. On the contrary, calcium requires a transporter to be absorbed and transported. That is to say, we need a transporter both to get hold of it and to get rid of it. This indicates that this mineral is valuable and scarce, since the organism uses this strategy of transporters with the most precious compounds, so that nothing escapes, or very little.

1.3.1 Macro minerals

The body needs and stores relatively large quantities of: Sodium, Potassium, Calcium, Phosphorus, Magnesium and Sulfur. And also, Chloride, a chloride compound. There are the main minerals. As we need more, we accumulate more. Calcium and Phosphorus together weigh almost 2 kg in a 75 kg person. An adult woman has between 0.9 and 1 kg of calcium, and an adult man approximately 1.2 kg. 99% of the calcium is in the bones and the teeth, and the remaining 1% in the extracellular fluids and in the cells.

But the main minerals are neither more nor less important for your health than the rest of the minerals; they are simply present in the body in larger quantities.

1.3.2 Micro minerals

Micro minerals or trace minerals are minerals that we need in small quantities. And yet, their contributions to the functioning of the body are as essential as those of the major minerals. Trace minerals, like the micro minerals, perform vital functions in the body.

1.3.3 Uses of minerals

The body uses minerals for many different functions, they participate in reactions that catalyze many enzymes; sometimes they are even part of them. In short, they make the body work. They are essential, for example, for heart and brain to work properly. They maintain the volume of water and the most suitable salt composition in each of the cells.

One of the key tasks of minerals is to maintain the proper electrical balance of the body's cell membranes. This is an essential; property for the transport of nutrients and messengers in and out of the cell and for them to communicate well with each other. Sodium and Potassium take over in these processes. Three other important minerals- calcium, phosphorus and magnesium- have similar activities and are also important in maintaining healthy bones. Potassium plays a critical role in muscle, cardiac and renal function, and in the regulation of blood pressure.

Some minerals help block the damage that is infected on the body's cells. Several has structural functions, providing stability and a three dimensional structure to certain molecules. Sulpher, for example, helps stabilize proteins, including those that make up hair, skin and nails. Other minerals control and regulate important biological processes; they activate hormones, help cells communicate with other cells and with the outside and induce the expression of some genes.

Iron, for example, is essential for oxygen to be transported throughout the body, while fluoride strengthens bones and prevents tooth decay. Copper helps form various enzymes, one of which helps metabolize iron and synthesize haemoglobin, the protein that carries oxygen in the blood.

Zinc helps the blood to coagulate; it is essential for the senses of taste and smell, and for immune response. But not only that. The variety of functions that zinc exerts in our bodies is reflected in the number of health claims that the European

food Safety Authority (EFSA) has approved for this minerals: 18 scientifically proven functions.

1.3.4 Major minerals

Unlike the nutrient molecules you have studied so far, minerals are inorganic elemental atoms or ions. Unlike carbohydrate, protein and fat, minerals are not changed during digestion or when the body uses them. Unlike many vitamins, minerals are not destroyed by heat, light, or alkalinity. Calcium remains calcium, be in it seashells, milk, or bones. Iron remains iron, weather it is part of a cast iron skillet or carried in the bloodstream as part of hemoglobin. This is true for all minerals.

Minerals play many essential roles in the body. Some minerals, such as magnesium, participate in the catalytic activity of enzymes. Others serve a structural function: for example, calcium and phosphorus are among the minerals that make our bones hard. Minerals are categorized as major or trace minerals, based on the amount needed in the diet and the amount of the minerals in the body. The body requires more than 100 milligrams per day of each major mineral, while the dietary need for each trace mineral is less than 100 milligrams daily. Figure 1 shows the relative amounts of the major and trace minerals in the body: This classification of minerals is unrelated to the minerals biological importance. For example, iron is a trace mineral but it plays a critical role in many major metabolic reactions.

1.3.5 Minerals in foods

Foods from both plants and minerals are sources of minerals. Generally speaking, animal tissue contains minerals in the proportion that the animal needs, so animal derived foods are more reliable mineral sources.

Plant foods can be excellent sources of several minerals, but the mineral content of plants can vary dramatically depending on the minerals in the soil where the plants are found. Even the maturity of a vegetable, fruit, or grain can influence its mineral content. Because actual mineral content varies so much, the values are omitted. Like plant foods, drinking water has variable mineral content. Nevertheless, it sometimes can be a significant source of minerals like sodium, magnesium, and fluoride.

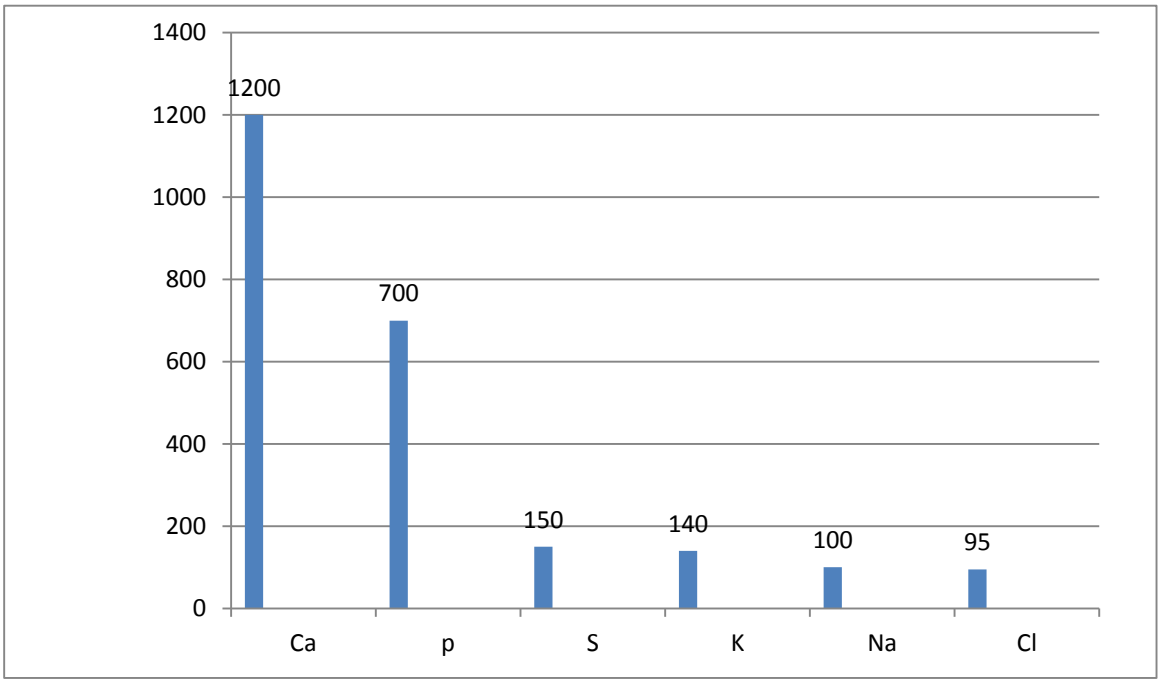

Figure 1: Minerals in the human body.

Fiber and other components of food also affect mineral bioavailability. High fiber diets reduce absorption of iron, calcium, zinc, and magnesium. Phytate (a component of whole grains) binds minerals and carries them out of the intestine unabsorbed. Oxalate (found in spinach and rhubarb) binds calcium, markedly reducing calcium absorption.

1.3.5.1 Sodium

Many people do not realize that sodium is an essential nutrient. We know sodium best as a component of sodium chloride (table salt): and we have heard for years

that we should not eat too much salt. The dietary guidelines suggest that Americans “choose and prepare foods with less salt”. (Nutrition and your health.Butein.2000) Nevertheless, some sodium in the diet is essential for normal body function.

1.3.5.1.1 Functions of Sodium

The typical American diet contains 3000 to 6000 mgs of sodium daily. Not only do Americans consume more than the recommended amounts of sodium, but they also are poor judges of the amounts of sodium in their diets. (Clinical hypertension.Williams.1998). Surprisingly, processed foods not table salt contribute the most sodium. (Shastuck.2001)

1.3.5.1.2 Dietary Recommendations for sodium

There is no RDA for sodium. We rarely eat too little, in fact, most of us eat substantially more than we need. The Food and Nutrition Board estimates that healthy adults require a minimum of 500 mg daily. (Food and nutrition.Wilson.2001). The American Heart Association recommends limiting sodium to 2400 mg per day (the amount in about1 teaspoon of table salt) this level is used for the Daily Value on food labels.

1.3.5.1.3 Functions of sodium

Sodium is the major cation in extracellular fluid and a critical electrolyte in the regulation of body fluids. It acts in concert with potassium, the major cation in intracellular fluid, and chloride, the major anion in extracellular fluid, to maintain proper body water distribution and blood pressure. Sodium also helps control the body acidity, and aids the absorption of some nutrients such as glucose.

Table 1 Sodium content of various food

Food	Sodium(mg)
Cucumber (1 large)	6
Wheat bread (1 slice)	150
Fresh tomato (1 medium)	6
Milk (240 ml)	115
Baked potato (1 medium)	20

1.3.5.1.4 Hyponatremia

Blood sodium concentration sometimes can drop too low, usually as a result of severe diarrhea, vomiting, or intense prolonged sweating (with replacement of water but not sodium). Consuming only water without food or other mineral sources also can depress blood sodium levels. The primary symptoms of low blood sodium, hyponatremia, resemble dehydration symptoms and the treatment is similar_ replacement of fluid and minerals through liquids and foods or intravenous solutions if necessary. If severe hyponatremia is not treated, extracellular fluid moves into cells, causing them to swell. As brain cells swell and malfunction, the afflicted person can experience headache, confusion, seizures, or coma. Many illnesses, including cancer, kidney disease, and heart disease, can cause low blood sodium concentration. In these situations, treatment usually targets the underlying condition that caused the electrolyte imbalance. (Cogan.1991).

1.3.5.1.5 Hypernatremia

Rapid intake of large amounts of sodium (e.g., drinking seawater) can cause the retention of sodium and water in the blood. This causes hypernatremia, abnormally high concentration in the blood, and hypervolemia, an abnormal increase in blood volume. This leads to edema (swelling) and a rise in blood pressure. A healthy person with normal kidneys and ample water intake rapidly excretes sodium, so hypernatremia usually is seen only in patients with congestive heart failure or kidney disease. Eating too much sodium over a long period of time can contribute to high blood pressure in some people. Excess dietary sodium can also contribute to osteoporosis by increasing calcium loss in the urine.

1.3.5.2 Potassium

Just as sodium is the major extracellular cation, Potassium also can affect hypertension, but in a different way. If people with hypertension eat a diet rich in potassium containing foods (like fruit and vegetables), their blood pressure often improves. (Coleman.2001).

1.3.5.2.1 Functions of potassium

Intracellular fluid contains about 95 percent of the body's potassium, with the highest amount in skeletal muscle cells. The flow of sodium and potassium in and out of cells in an important component of muscle contractions and the transmission of nerve impulses. The central nervous system (CNS) zealously protects its potassium _ CNS potassium levels remain constant even in the face of falling levels in the muscle and blood .Potassium also helps regulate blood pressure. (Coleman.2001).

1.3.5.2.2 Dietary Recommendations for potassium

Although food manufactures often add sodium to processed foods, they do not routinely add potassium. If a person's diet includes a lot of processed foods, it

may fail to meet the minimum potassium recommendations. For healthy adults, the food and nutrition board estimates the minimum requirement to be 2000 mgs per day, and 3500 mgs in the daily value used for food labels. A balanced healthy diet supplies between 2000 and 4000 mgs of potassium per day. (Coleman.2001).

1.3.5.2.3 Sources of potassium

Fresh vegetables and fruits, especially potatoes, spinach, melons, and bananas, are major dietary sources of potassium. Soma salt substitutes contain potassium chloride. (Coleman.2001).

1.3.5.2.4 Hypokalemia

Hypokalemia, low blood potassium, results from potassium depletion, most commonly caused by vomiting, diarrhea, or diuretics. In many cases of hypokalemia, insufficient dietary potassium intake magnifies the effects of excess potassium loss. Symptoms include muscle weakness, loss of appetite, and confusion. Severe or rapid potassium depletion can disrupt heart rhythms a potentially fatal problem. (Coleman.2001).

1.3.5.3 Calcium

Our bodies contain more calcium than other mineral, about 1.5 to 2 percent of our total weight. Adequate calcium intake over one's life, time is essential for healthy bones and teeth that will remain strong into old age. While we associate calcium primarily with bones, it plays many important roles in the body. Getting enough calcium in your diet not only maintains healthy bones, but also may help prevent hypertension , decrease your odds of getting colon or breast cancer , improve weight control , and reduce the risk of developing kidney stones. (Coleman.2001).

1.3.5.3.1 Functions of calcium

Bones and teeth contain more than 99 percent of the body's calcium. This mineral makes bones hard and strong able to withstand tremendous force without breaking_ most of the time. The other 1 percent of body calcium is in blood and soft tissues, where it plays many equally crucial roles in such vital functions as muscle contraction, nerve impulse transmission, blood clotting, and cell metabolism.

In addition to playing a key role in bone health, calcium in blood and soft tissues for such diverse functions as blood clotting, muscle contractions, and nerve impulse transmission.

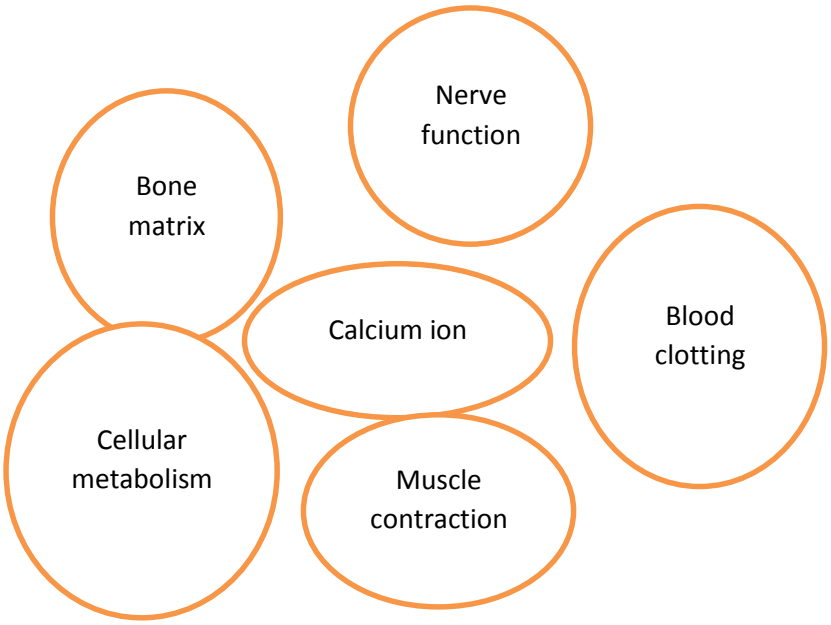

Figure2: Functions of calcium

Bone structure

Most of us think of bone as a simple structural framework for our bodies. We forget that bone is living tissue that changes in response to physical stresses. Bone

also encases the marrow, the source of many types of blood and immune cells, and it serves as the reserve site for minerals such as calcium and phosphorus.

Bone is made up of cells and an extracellular matrix. Two types of cells, osteoblasts and osteoclasts, continually remodel our bones_ building them up and tearing them down. Osteoblasts are the construction team and osteoclasts are the demolition team. Osteoblasts first secrete the collagen protein matrix that forms the initial framework for new bone. Then these bone builders help move minerals from the extracellular fluid to the bone surface, where the minerals become a hard crystalline material that surrounds the collagen fibers. Most of the calcium in bone is the form of hydroxyapatite- a crystalline mineral complex calcium and phosphorus by weight. (Gmike 1997).

1.3.5.3.2 Dietary Recommendations for calcium

Optimal calcium intake throughout life is extremely important. Bones become stronger and denser as children and young adults develop. Later in life, bones gradually become less dense. If children and young adults fail to take in enough calcium, they are more likely to develop osteoporosis later in life. The adequate intake level for calcium is 1000 mgs per day for adults aged 19 to 50, although calcium intake recommendations vary slightly among public health organizations. Adolescents need more calcium to maximize peak bone mass. The Al for adults aged 51 and older increases to 1200 mgs per day.

Unfortunately, many of us fall far short of these recommended calcium intakes. Although average calcium intake has increased slightly. (Loria.2001).

1.3.5.3.3 Sources of calcium

Dairy products provide more than half of the calcium in the typical American diet. Of all the dairy products, nonfat milk is the must nutrient dense because of its high calcium content and low fat and calorie content. Nonfat yogurt is another excellent

source of calcium. Cottage cheese has the least calcium of the dairy foods because processing removes much of its calcium.

Green leafy vegetables such as spinach, have high levels of calcium, but most of the calcium is bound to oxalate and therefore cannot be absorbed. Chinese cabbage kale, turnip greens, and calcium_ processed tofu contain significant amounts of bioavailable calcium. Canned fish with bones such as sardines provide lots of calcium as long as you eat the bones.

While eating a variety of healthful foods is always the best way to obtain nutrients, some people especially those with limited dairy intake, may need to take supplements to ensure adequate calcium intake. (Loria-2001)

1.3.5.3.4 Calcium Absorption

The body normally absorbs 25 to 75 percent of dietary calcium, depending on a variety of factors including age, presence of adequate vitamin D, the body's need for calcium, and calcium intake. For example, if a child and a healthy elderly person eat exactly the same meal, the child may absorb only 25 percent. Calcium absorption is particularly high during pregnancy and infancy, and is at its lowest in old age.

Calcium absorption is inversely related to calcium intake. The body adjusts the percentage it absorbs based on the amount in the diet an increase in dietary calcium reduces absorption and a decrease in dietary calcium enhances absorption. In the absence of vitamin D, calcium absorption can drop to less than 10 percent of dietary calcium. Phytates depress calcium absorption, as do high levels of phosphorus and magnesium from supplements.

Dietary fiber, except for wheat bran, has little effect on calcium absorption. High intakes of wheat bran have been found to depress calcium absorption from milk. Low estrogen levels, as seen in postmenopausal women, can lower calcium

absorption to about 20 percent. Many women take estrogen supplements after menopause to maintain calcium absorption and lower the risk of osteoporosis. Calcium from supplements is absorbed most efficiently when taken between meals at individual doses of 500 mgs or less. (Stein.et.al. 1994).

1.3.5.3.5 Hypocalcemia

A lower than normal level of calcium in the blood is called hypocalcemia. Because the body uses bone calcium to maintain normal blood calcium levels, hypocalcemia is relatively uncommon. The causes of hypocalcemia include kidney failure, parathyroid disorders, and vitamin D deficiency. Significant hypocalcemia can cause muscle spasms, facial grimacing, and convulsions.

A chronic dietary calcium deficiency can result in osteoporosis either by suboptimal bone growth in childhood and adolescence or increased rate of bone loss after menopause. Studies also link low calcium intake to an increased risk of hypertension, colon cancer, and preeclampsia. (Instan 1999).

1.3.5.3.6 Hypercalcemia

The two major causes of hypercalcemia are cancer and the overproduction of PTH by the parathyroid gland. Hypercalcemia can result in fatigue, confusion, loss of appetite, and constipation. Calcium may be deposited in the soft tissues where it can impair organ function. Very high levels of blood calcium can lead to coma and cardiac arrest. Excess calcium supplementation usually does not result in hypercalcemia, but may cause mineral imbalances by interfering with the absorption of other minerals, such as iron, magnesium, and zinc. Calcium supplements that contain citrate and ascorbic acid enhance iron absorption, but other forms can cut iron absorption in half. Calcium also may interfere with absorption of some medications, such as tetracycline. The Food and Nutrition board has established a UL for calcium of 2500 mgs per day. (Instan 1999).

1.3.5.4 Phosphorus

Phosphorus, like calcium, serves many roles in the biochemical reactions of cells and has a critical role in bone as part of the mineral complex hydroxyapatite. Phosphorus intake typically exceeds that of calcium because it is so widespread in the food supply. Most phosphorus in the body is in the form of the phosphate ion. In fact, phosphate is the most abundant intracellular anion.

1.3.5.4.1 Sources of phosphorus

Phosphorus is abundant in our food supply. In general, foods rich in protein also are rich in phosphorus. Food additives, especially those in processed meat and soft drinks, supply up to 30 percent of our phosphorus. Food manufacturers often add phosphate salts to processed foods to improve moisture retention and smoothness.

Since phosphorus density is higher in cow's milk than in most other foods, people with high dairy_ product intakes have high _phosphorus diets. This is also true for people who drink several colas daily or the few other soft drinks that contain phosphoric acid. One 12_ ounce cola contains about 50 mgs of phosphorus- only 5 percent of an adult woman's typical intake. However, when five or more are consumed daily, colas may contribute substantial amounts of phosphorus to the diet. (National institute of health.1994).

Our bodies directly absorb phosphorus from most food sources, with one major exception- plant seeds. All plant seeds contain phosphorus in a storage form, phytic acid. Our bodies do not produce the enzymes necessary to break down phytic acid. Still, we can absorb up to 50 percent of this phosphorus because other foods and bacteria in our large intestines contain the necessary enzymes. Yeasts also can break down phytic acid, so our bodies absorb more phosphorus from whole grains when part of leavened bread, for example, than from grains in unleavened bread and breakfast cereals. While excess calcium interferes with

phosphorus absorption _ possibly because unabsorbed calcium binds with phytic acid and prevents bacterial breakdown- typical dietary calcium levels have no effect.

Generally, we absorb between 55 and 70 percent of dietary phosphorus and the kidneys excrete and excess in the urine. UN like calcium absorption, phosphorus absorption does not decrease as dietary intake increases. (International medicine.steine.1994). On the other hand, the body's phosphorus needs can drive phosphorus absorption efficiency. While the efficiency of phosphorus absorption does not vary with increased dietary intake, it rises dramatically when the body has low phosphorus levels.

In the intestines, calcitriol enhances both calcium and phosphorus absorption. Parathyroid hormone, on the other hand, has opposite effects on calcium and phosphorus levels. PTH not only maintains calcium levels by stimulating the kidneys to reabsorb calcium, but also causes rapid loss of phosphorus in the urine. The two most important regulators of urinary phosphorus excretion are PTH and the amount of phosphorus in the diet. (Institute of medicine food and nutrition.1999).

1.3.5.4.2 Dietary Recommendations for phosphorus

The phosphorus RDA for adults is 700 mgs per day. Adolescents need more, about 1250 mgs per day, to support growth. The average adult intake is between 1000 and 1500 mgs per day, so phosphorus deficiencies due to dietary insufficiency are ready seen.

1.3.5.4.3 Functions of phosphorus

Bones are the major storehouse of phosphorus, holding nearly 85 percent of the body's supply. The remaining phosphorus is found in cells of soft tissues and extracellular fluid. It helps activate and deactivate enzymes in a process called

phosphorylation. Phosphorus is an essential component of ATP, the universal energy source for all cells. Phosphorus also is a component of DNA, RNA, and phospholipids in cell membranes and lipoproteins.

1.3.5.4.4 Hypophosphatemia

Phosphorus is so common in foods that only near_ total starvation will cause a dietary phosphorus deficiency. Rather, an underlying disorder typically causes hypophosphatemia, low blood phosphate, either by restricting absorption or enhancing excretion. Physicians commonly encounter hypophosphatemia, and about 2 percent of patients admitted to general hospitals suffer from it.

1.3.5.4.5 Hyperphosphatemia

Physicians also frequently see hyperphosphatemia, high blood phosphate, which most commonly is a consequence of kidney disease. Other causes include an underactive parathyroid gland, taking too many vitamin D supplements, and overuse of phosphate_ containing laxatives. Excess phosphorus can blind calcium, and since low calcium concentrations can cause nerve fibers to discharge repeatedly without provocation, this can lead to severe muscle spasms and convulsions.

If your diet contains excessive phosphorus and not enough calcium, you may be at risk for increased bone loss. However, a high phosphorus intake alone is unlikely to have an adverse effect on bone health. Replacing milk as a beverage with cola, a common practice among adolescents and Americans of all ages, increases phosphates in the diet, while reducing calcium intake. Some experts believe that this practice may be a significant factor in the development of osteoporosis later in life. The UL for phosphorus is 4000 mgs per day for people aged 9 to 70.

1.3.5.5 Magnesium

Magnesium is the fourth most abundant cation in the body and about one- sixth as plentiful in cells as potassium. About 50 t0 60 percent of the body's magnesium is in bone, with the remainder distributed equally between muscle and other soft tissue. The magnesium in bone provides a large reservoir in case deficiencies in soft tissue magnesium occur. Most magnesium resides in cells, with only 1 percent in extracellular fluid.

1.3.5.5.1 Functions of Magnesium

Magnesium participates in more than 300 types of enzyme- mediated reactions in the body, including those in DNA and protein synthesis. In the mitochondria, magnesium is essential for the production of ATP via the electron transport chain. Since ATP is the universal energy source for all cells, an absence of magnesium would quickly halt cellular activity. In the glycolysis pathway alone, seven key enzymes require magnesium.

Magnesium also participates in muscle contraction and blood clotting.

1.3.5.5.2 Dietary Recommendations for magnesium

Because of the large amount of magnesium in bone, blood magnesium levels may not be indicative of total body status. Therefor assessing deficiency and setting intake recommendations is difficult. The RDA for magnesium in adults is 400 mgs per day for men and 310 mgs per day for women. This value rises slightly.

Trace minerals that is minerals present in the body in small quantities, and therefor needed by the body in small quantities. Meat are the best food sources for some of these minerals- iron and zinc, for instance. Whole grains are also good sources of several minerals, including iron, copper, selenium, and manganese. And water is a major source of fluoride, a mineral that often occurs naturally in water or is added during municipal water treatment.

Trace elements differ from the major minerals in two ways. First, the dietary requirements for each of the trace elements are less than 100 mgs per day. For example, iron and zinc intake recommendations for adults range from 12 mgs to 15 mgs per day, while the adult daily calcium recommendation is 1000 mgs per day. Second, the total amount of each trace element found in the body is small, less than 5 grams. For example, the total amount of iron in the body is 2 to 4 grams, or about the amount of

Iron in a small nail. In contrast, a typical adult body contains more than 1000 grams of calcium.

1.3.6 Trace minerals

1.3.6.1 Importance of trace elements

Despite the minuscule amount in the body, trace elements are crucial to many body functions including metabolic pathways. Trace elements serve as cofactors for enzymes, components of hormones, and participants in oxidation_ reduction reactions. They are essential for growth and for normal functioning of the immune system. Deficiencies may cause, delayed sexual maturation, poor growth, mediocre work performance, faulty immune function, tooth decay, and altered hormonal function.

Technological advances in recent years have triggered an explosion of exciting new research because scientists can now track trace elements throughout the body more effectively. Working together, nutritionists, biochemists, biologists, immunologists, geneticists and epidemiologists are uncovering the mysteries behind many of these fascinating elements and finding new links between trace elements and a variety of diseases and genetic disorders.

1.3.6.2 Other characteristics of trace elements

Foods from animal sources particularly liver, are good sources of many trace minerals. Amounts in plant foods can differ dramatically from region to region, depending on the soil's mineral content. Since actual mineral content is so variable, the values published in food composition tables can be misleading. Food tables, even many of the popular computerized nutrient databases, often have incomplete information about trace mineral content.

Even if we are fairly sure of the amount of a particular mineral in a food, other components of the diet can affect the mineral's bioavailability.

Trace minerals are affected by the same factors that affect bioavailability of the major minerals, including fiber, phytate, poly phenols, oxalate, the acidity of the intestinal environment, and the person's need for that mineral. High doses of other minerals can compete with trace minerals and inhibit their absorption.Treatment for mineral toxicity sometimes exploits these antagonistic interactions between minerals. For example, high doses of zinc may be given to patients with a genetic disorder of copper overload because large amounts of zinc inhibit copper absorption.

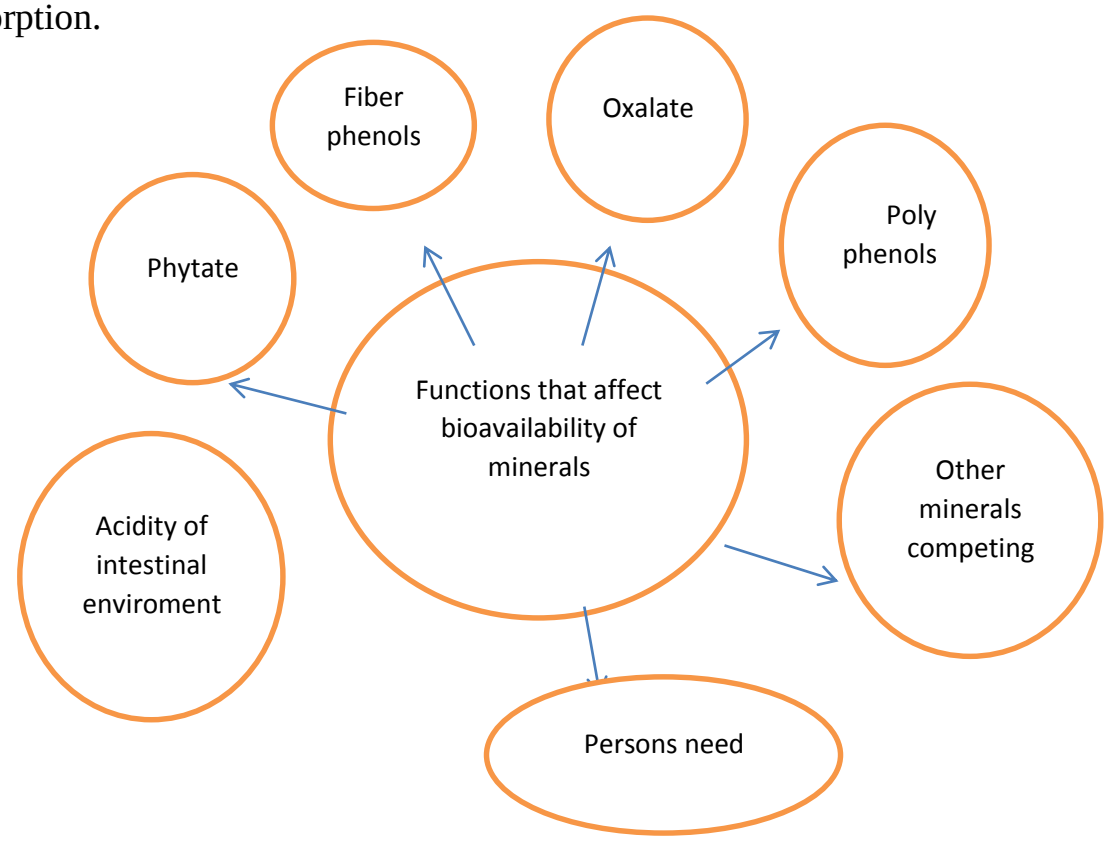

Figure 3: Factors that affect the bioavailability of minerals.

1.3.6.3 Iron

Iron is the fourth most abundant mineral in the earth's crust, yet iron deficiency is the most common nutrient deficiency in the world; from 500 to 600 million people suffer from iron_ deficiency anemia. On the other hand, hemochromatosis, a disease of excess iron absorption, is one of the most common inherited disorders. If not detected early, this disorder can damage organs severely, causing premature death.

Why is iron useful? Iron has a special property. It easily changes between two of its oxidation states – ferrous iron and ferric iron – by transferring electrons to other atoms. This property makes iron essential for numerous oxidation_ reduction reactions, and allows it to bind reversibly with oxygen, nitrogen, and sulfur. The ability of shift easily between oxidative states also endows iron with its "dark sides" _ the ability to promote formation of destructive free radicals.

1.3.6.3.1 Functions of iron

Iron is well known for its role in the body's use of energy; it is required for oxygen transport and is an essential component of hundreds of enzymes, many of which are involved in energy metabolism. In addition, iron plays a role in brain development and in the immune system. (Food and nutrition board. National academy press.1989).

1.3.6.3.2 Sources of iron

Beef is an excellent dietary source of iron, in terms of both amount and availability. Other excellent sources include clams, oysters, tofu and liver. Poultry, fish, pork, lamb, and legumes are also good sources.

Whole_ grain and enriched_ grain products contain less bioavailable iron than meat, but are significant sources of iron because they comprise a major part of our

diets. Fortified cereals also make an important contribution to iron intake in the United States.

A varied diet generally provides adequate iron.

Vegetarians who consume no animal tissue can maximize iron bioavailability from other sources by consuming vitamin C – rich fruit and vegetables with every meal.

In young women with iron deficiency but without anemia shows a similar decrease in their physical performance. More human studies are required to determine whether iron depletion affects other physiological processes.

The third and most severe stage of iron deficiency is anemia a disease characterized by insufficient and or defective red blood cells. Alack of iron inhibits production of normal blood cells. While normal cell turnover continuous to deplete the red blood cell population. Red blood cell production falters, producing red blood cells that are bale and smaller than normal. Hemoglobin and hematocrit levels also or low. This type of anemia, known for its small, bale red blood cells, is called microcytic hypochromic anemia. Inadequate vitamin B, and other conditions that impair hemoglobin synthesis also can cause microcytic hypochromic anemia. Another type of anemia, mega_ loblastic anemia, is known for its abnormally large, immature red blood cells. (Murray.2000).

1.3.6.3.3 Dietary recommendations for iron

Scientists base recommendations for iron intake on the replacement of daily iron loses and the bioavailability of dietary iron. The primary routes of loss are bleeding gastrointestinal losses, sloughing of skin, and sweet. The RDA for iron is based on average losses of 1 mg per day for adult men, and 1.4 mgs per day for premenopausal women, combined with an absorption percentage of 18 percent

from a mixed diet. The RDAs for adults are 8 mgs per day for men and postmenopausal women and 18 mgs per day for women of childbearing age.

Dietary intake of most men actually exceed their RDA, while women's intake are well below the RDA for most age ranges. Researchers attribute the women's lower intake to lower energy intake, since women consume on average 1800 kilocalories per day.

1.3.6.4 Zinc

It is hard to believe that a nutrient so important to health could go unnoticed until as recently as 40 years ago, but that is the case with zinc, some people may think of zinc only in connection with "zinc oxide" cream used topically as a sun screen or with zinc lozenges promoted as a treatment for colds; few consumer realize that dietary zinc is absolutely essential for health.

Scientists first recognized human zinc deficiency in young severely growth_ retarded. (Current concepts and perspective in nutrition.Levine.1999).

1.3.6.4.1 Functions of zinc

The body contains a small amount of zinc as in the galvanized nail, which has a thin layer of zinc to protect it from corrosion. Zinc is a component of every living cell. Zinc is best known for its participation in enzyme structure and function, but it also supports many other diverse biological activities through a role in controlling gene regulation. Figure 1.4 illusrates the functions of zinc in body

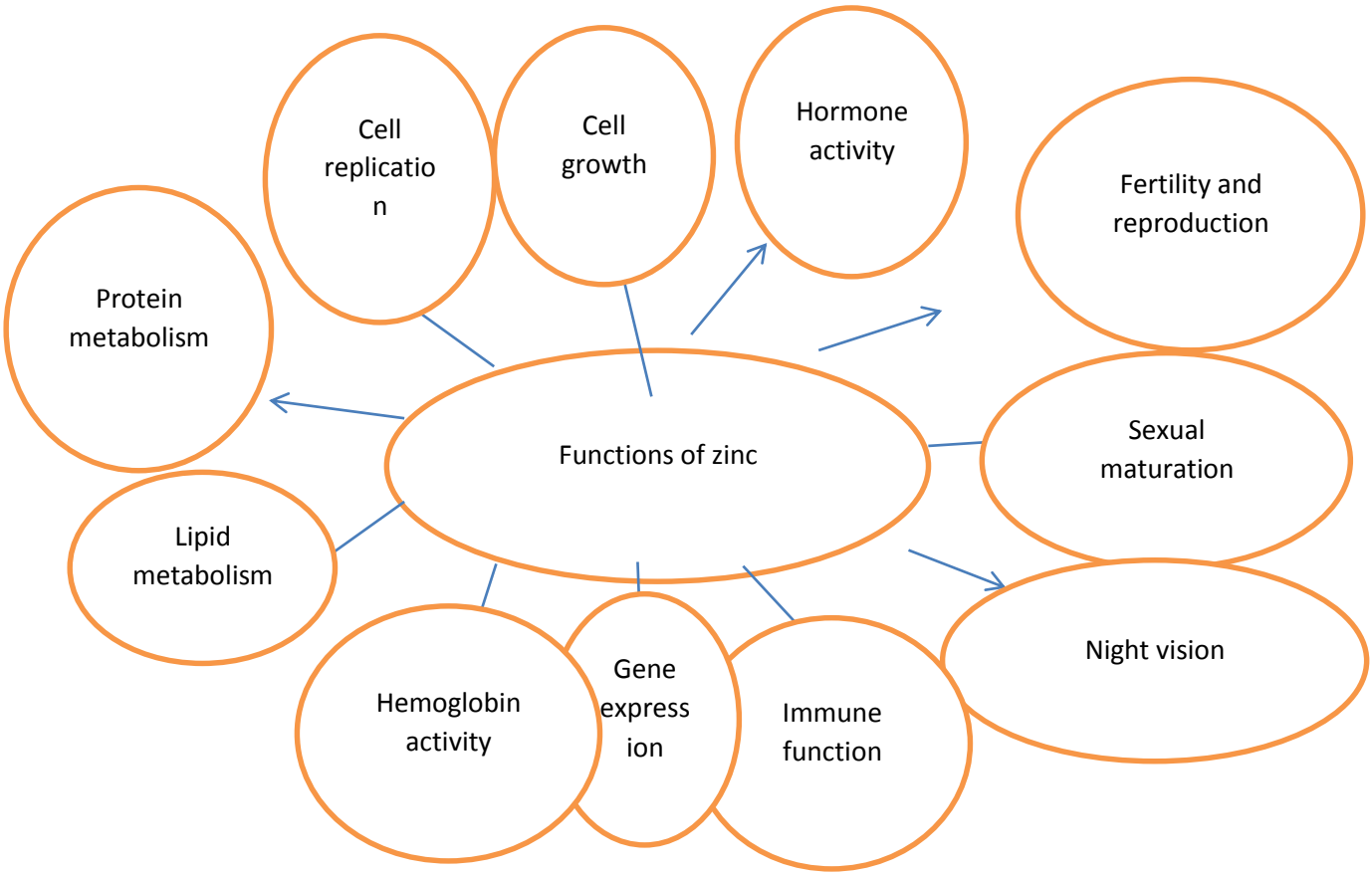

Figure 4: Functions of zinc in the body. Because zinc is involved in so many different functions, it is fortunate that overt zinc deficiency is rare. (Osteoporosis prevention, diagnosis, and therapy. National institutes of health.2000).

1.3.6.4.2 Dietary recommendations of zinc

The RDA for adult males is 11 mgs per day, and for females it is 8 mgs per day. Experts recommended increasing zinc intake to 11 mgs per day during pregnancy to provide for the growing fetus, and to 12 mgs per day during the first months of lactation.

Average zinc intake in the United States is slightly above the RDA. (Waltzer, 1998).

Although vegetarians consume approximately the same amount of zinc as non-vegetarians, high levels of phytates and fiber in vegetarian diets limit zinc

absorption and may increase the requirement for zinc. Long- term alcohol use also interferes with zinc absorption.

1.3.6.4.3 Sources of zinc

Zinc usually is abundant in foods that are good sources of protein, especially red meat, sea food, oysters, and clams. Dark meat is a richer source than white meat, and unrefined whole grains have more zinc than processed grains. However the bioavailability of zinc is just as important as the amount present.

Also wheat- bran bread has a relatively high amount of zinc, much of it is unavailable due to poor absorption. The bioavailability of zinc is highest from red meat, liver, eggs, and sea food. Fruits and vegetables generally are poor sources of dietary zinc. (Zemel.1997).

1.3.6.5 Selenium

The story of selenium is a recent one and becomes more complex as scientists explore its role at the molecular level. Historically, since animals grazing on selenium_ rich soils suffered selenium poisoning scientists focused on its toxicity. This changed in 1957, when researchers first demonstrated selenium's nutritional benefits in vitamin E- deficient animals. But not until 1979 did evidence emerge that selenium is essential for humans. Chinese scientists reported an association between low selenium status and Keshan disease, a heart disorder that strikes children in the keshan province of china. The Chinese scientists demonstrated that selenium supplements could prevent the disease. Although selenium deficiency does not cause the disease, it predisposes a child to heart damage after a particular type of viral infection. When selenium intake is adequate, the virus apparently does not cause Keshan disease.

1.3.6.5.1 Functions of selenium

Although scientists have identified nearly 50 selenium_ containing proteins, tow amino acid derivatives- seleno methionine, a methionine derivatives, and seleno cysteine contain most of the body's selenium.

Selenium is best known as a component of glutathione peroxidases, a family of antioxidant enzymes. The discovery of these enzymes resolved a puzzling overlap in the functions of selenium and vitamin E. Both nutrients play a role in preventing lipid peroxidation and membrane damage. (Bone and nutrition in elderly women.

1.3.6.5.2 Dietary recommendations for selenium

Selenium is one of the youngest nutrients for which an RDA exists. The first RDA for selenium was established in 1989. The RDA was based on data from Chinese scientists who conducted repletion experiments in selenium- depleted subjects living in areas where keshan disease was endemic. The RDA for selenium was revised in 2000. For both men and women the selenium RDA is 55 micrograms per day.

1.3.6.5.3 Sources of selenium

Since animals accumulate selenium in their tissues, the selenium content of food from animal sources generally is more consistent than the selenium.

1.3.6.6 Iodine

Few foods are rich in iodine; it is found mainly in milk, sea food, and some grain products.

1.3.6.6.1 Iodine deficiency

As early as 1830, iodine deficiency was linked to presence of goiter. We now understand that a deficiency of iodine inhibits the synthesis of thyroid hormones. As the body senses the lack of thyroid hormones, it produces more and more TSH.

TSH causes the thyroid gland to grow, eventually resulting in a goiter. Goiter in children has been linked to depressed IQ in addition to the usual symptoms of hypothyroidism- cold intolerance, weight grain, sluggishness, and a decreased body temperature.

1.3.6.7 Copper

Researchers first recognized the essential nature of copper for experimental animals in 1928, but not until the 1960s did evidence emerge that copper deficiency occurs in humans. Recent cloning of the genes for two genetic disorders of copper metabolism has fueled interest in copper and led to exciting new discoveries about its metabolism and physiological role. Although simple dietary copper deficiency is not a significant public health concern, excessive supplementation of other trace minerals can cause a secondary copper deficiency.

1.3.6.7.1 Functions of copper

Copper_ containing enzymes have many functions, including acting as an antioxidant, participating in the electron transport chain, and aiding in the biosynthesis of the pigment melanin and the connective tissue proteins collagen and elastin.

1.3.6.7.2 Copper deficiency

Over copper deficiency is relatively rare in humans. Copper deficiency occurs most commonly in preterm infants. These babies have low copper stores at birth and a rapid growth rate, which elevates needs. Because cow's milk has little copper and it is poorly bioavailable, infants who are inappropriately fed unmodified cow's milk are more likely to develop a deficiency than breast_ fed infants.

Copper deficiency most commonly causes anemia, decreased numbers of white blood cells, and bone abnormalities. In copper_ deficiency anemia, low cerulo

plasmin activity causes defective iron mobilization. Copper deficient young children often suffer bone abnormalities. Probably caused by poor synthesis of connective tissue, these abnormalities mimic the changes observed in scurvy. In experimental settings, copper deficiency causes elevated blood cholesterol, impaired glucose tolerance, and heart related abnormalities.

1.3.6.8 Manganese, Dietary recommendations and food sources

The adequate intake level for manganese is 2.3 mgs per day for men and 1.8 mgs per day for women. Before 2001, manganese recommendations were higher. These recommendations were questioned, however, because they were close to the toxic levels suggested by the environmental protection agency.

Tea, coffee, nuts, cereals, and some fruits are the best food sources of manganese. Some estimates suggest that coffee or tea supplies as much as 20 to 30 percent of our daily manganese intake. Meat, dairy products, poultry, fish and refined foods are poor sources; they contain little manganese.

1.3.6.8.1 Manganese deficiency

Although people who consume normal varied do not appear to be at risk for manganese deficiency, certain disorders may cause suboptimal status. Studies report low manganese or altered manganese metabolism in some patients with non-trauma, phenylketonuria.

Table3: Food sources of manganese. Manganese is found mainly in plant foods such as grains, vegetables, legumes, and some fruits.

Pineapple(1 cup)	2.3mg
Fresh cereals(1\2 cup)	1.7 mg
Wheat (1\4 cup)	2mg
Cooked potato(1 cup)	0.5mg
Cooked baked(1\2 cup) beans	0.4mg
Okra(1\2 cup)	0.3m g
Broccoli(1\2 cup)	0.2 g

1.3.6.9 Fluoride

Fluoride, the ionized form of fluorine, has the unique ability to prevent dental caries. Although people first observed this beneficial effect in the early 1800s, scientific proof did not emerge until the time of World War II. In 1945 many U.S. water suppliers began voluntarily fluoridating water to improve the dental health of children. Now that use of fluoridated toothpaste and mouthwash is widespread, some experts are raising concerns about potential harm from excessive fluoride intake.

1.3.6.9.1 Functions of fluoride

Bones and teeth contain nearly 99 percent of the body's fluoride. Fluoride supports the mineralization of bones and teeth by promoting the deposition of calcium and phosphate. Fluoride's cavity – prevention activity is an effect localized in the mouth. Bacteria in the mouth cause dental caries, an infectious disease. When a person eats food, especially carbohydrate foods, these oral bacteria multiply and produce organic acids that eat a way tooth enamel, especially beneath plaque. When food leaves the mouth, re mineralization begins. If re mineralization does not keep pace with demineralization, your teeth become pitted with dental caries? Fluoride decreases the demineralization the tooth enamel and accelerates the subsequent re mineralization process. It also inhibits bacterial activity in dental plaques. These cavity_ fighting action can help make your next trip to the dentist a pleasant one.

Regular ingestion of fluoride is especially important during the eruption of new teeth in children. When administered topically, fluoride's support of tooth enamel re mineralization can benefit people of all ages.

1.3.6.9.2 Dietary recommendations of fluoride

The adequate intake level for fluoride is 4 mgs per day for adult men, and 3 mgs per day for women. As of 1995, The American Dental Association and American Academy of Pediatrics no longer recommend fluoride supplementation from birth, and suggest it only for children whose drinking water supplies less than 0.6 mgs per liter. The AL for fluoride for infants to 0.01 mgs per day for ages 0 to 5months and 0.5 mgs per day for ages 6 to 11 months.

1.3.6.9.3 Sources of fluoride

Water is the main source of fluoride, weather the fluoride is naturally present or added. Artificially fluoridated water contains 0.7 to 1.2 mgs per liter. Fluoride

naturally present in drinking water may vary from less than 0.1 mg to more than 1 mg per liter. The environmental protection agency's regulations require public drinking water systems to remove excess fluoride so that it does not exceed 4.0 mgs per liter. Roughly 62 percent of the US population has fluoridated water, most other developed countries do not fluoridated their water.

The balance between the positive effects of just enough fluoride and the negative effects of too much fluoride has become the subject of debate. Some scientists argue the artificial fluoridation is an outdated practice. Fluoridation was instituted 50 years ago when it served as the exclusive source of fluoride for children. Now, however, there are other fluoride sources, including ready_ to_ feed infant formulas, fluoride supplements, mouthwash, toothpaste, and some beverages. The combination of all of these sources may put children at increased risk for excessive fluoride intake and fluorosis.

1.3.6.9.4 Fluoride Deficiency

Low fluoride intake increases the risk for dental caries, and may hamper the integrity of bone. Adequate fluoride intake in childhood can decrease the incidence of tooth decay by 30 to 60 percent. During tooth development, prolonged excessive fluoride intake can cause fluorosis. In mild fluorosis, white specks form on the teeth. Severe fluorosis can cause permanent brownish stains and weakened teeth. Consumption of water naturally high in fluoride is the main cause of fluorosis, but children who chronically swallow large amounts of fluoridated toothpaste are also at risk.

1.3.6.10 Chromium

Chromium plays an important but poorly understood role in moving glucose in the cells, and in lipid metabolism. Although researchers establisher chromium's essential role in glucose tolerance during the late 1950s and early 1960s, the development of reliable analytical methods took another 20 years. As with many

trace minerals, low levels in biological tissues and the potential for sample contamination make chromium assessment particularly challenging.

1.3.6.10.1 Functions of chromium

Chromium enhances the effects of insulin and is important for proper metabolism of carbohydrates and lipids. It also may play a role in metabolism of nucleic acids, and in immune function and growth. Athletes are especially interested in chromium because of its purported effects on body composition.

1.3.6.10.2 Dietary recommendations and food sources for chromium

In 2001, scientists are an adequate intake level for chromium. For adults 19 _50 year's age, the AI is 35 micrograms per day for men and 25 micrograms per day for women. The AI for older adults is 5 micrograms less. More data on actual requirements for chromium and chromium content of foods are needed for more specific dietary recommendations.

Rich sources of chromium are mushrooms, dark chocolate, prunes, nuts, asparagus, whole grains, wine, brewer’s yeast, and some brands of beer.

Animal products are poor sources; fruits, vegetables, and grains are variable. Cooking acidic foods in stainless steel contains leaches some chromium into

The food.

1.3.6.10.3 Chromium deficiency

The difficulty of assessing chromium status makes it hard to determine the effects of deficiency. Nevertheless, studies in animals and humans point to the following signs of chromium deficiency: decreased insulin_ mediated glucose uptake by cells, decreased insulin sensitivity, and elevated blood glucose and insulin and blood lipid abnormalities. Doctors have observed more severe signs, such as brain

and nerve disorders, in patients who subsist on total parenteral nutrition that has inadequate chromium.

1.3.7 Other trace elements and Ultra trace elements

The body contains minuscule amounts of Ultra trace minerals and may require less than 1 mg per day of each one. At least 18 minerals could be considered Ultra trace: aluminum, arsenic, boron, bromide, cadmium, chromium, fluoride, germanium, iodide, lead, lithium, molybdenum, nickel, rubidium, selenium, silicon, tin and vanadium. There is substantial research on iodine, fluoride, manganese, molybdenum, and selenium. The functions of the remaining minerals are less clear. While new evidence and media coverage have focused on arsenic, boron, nickel, silicon, and vanadium, data do not exist for the establishment of AI or RDA for these minerals. ULS have been set for boron, nickel, and vanadium.

1.3.7.1 Arsenic

Although arsenic has been an infamous poison for centuries, inorganic arsenic may actually be an essential Ultra trace element. As a colorless, tasteless toxin, arsenic trioxide can be fatal in a dose as low as 2 mgs. On the other hand, arsenic _ deprived laboratory animals have poor growth and abnormal reproduction. Arsenic may also participate in methionine metabolism. Estimates of dietary intake of arsenic range from 15 micrograms per day for children to 60 micrograms per day for adult males. The most concentrated food sources are oysters, mussels, and fish. In a typical diet, meat and fish supply about 30 percent of dietary arsenic, cereals and breads supply 20 percent, and starchy vegetables provide 15 percent. Given arsenic’s highly poisonous nature, much more careful research is required to establish recommended intake and UL levels.

1.3.7.2 Boron

Boron appears to play an important role in bone metabolism, probably in conjunction with other nutrients such as calcium, magnesium, and vitamin D. Boron deficiency depresses growth and is worsened by a vitamin D deficiency. Conversely boron supplementation lessens the bone abnormalities observed in vitamin D deficiency.

Fruits, nuts, vegetables, and legumes are the sources of boron. The body absorbs close to 90 percent of the amount consumed and then promptly excretes most of it in the urine, the usual dietary intake of boron is between 1 and 2 mgs per day. Based on average consumption as well as supplementation studies, scientists estimate that the daily boron requirement is 1 mg per day. Chronic boron toxicity symptoms include poor appetite, nausea, weight loss, and decreased sexual activity, seminal volume, and sperm count. More research is needed to set safe lower and upper limits for dietary intake. The UL for boron is 20 mgs per day.

1.3.7.3 Nickel

Nickel is a widely distributed throughout the body in very low concentrations that add up to a total body content of approximately 10 mgs. Most of the research on nickel has been conducted in animals, and by extrapolation scientists assume nickel is essential in humans.

A few nickel_ containing enzymes have been identified, and nickel can activate or inhibit a number of enzymes that usually contain other elements. Nickel alters the properties of cell membranes and affects oxidation_ reduction systems in cells. Nickel also may function in vitamin B12 and folic acid metabolism.

Nuts, legumes, grains, and vegetables are the best sources of nickel. Depending on the amount of plant foods consumed, dietary intake of nickel varies widely. An acceptable dietary intake of 100 to 300 micrograms per day has been proposed.

There is no known nickel deficiency in humans. Toxicity has occurred only in workers exposed to nickel dust or nickel carbonyl in industrial settings. The UI, for nickel is 1 mg per day.

1.3.7.4 Silicon

Silicon is the most common element in the earth's crust. The human body contains roughly 1.5 grams of silicon_ less than the amount of magnesium, but about the same as iron and zinc. Connective tissues including the aorta, trachea, tendon, bone and skin contain much of the body's silicon. From animal studies, scientists hypothesize that silicon helps strengthen collagen and elastin. Experimental diets lacking silicon caused poor growth and skeletal abnormalities in baby chickens. However, there are no known symptoms of silicon deficiency in humans. Studies suggest silicon may help prevent atherosclerosis in the elderly. This element is relatively nontoxic when ingested orally; however, breathing airborne silicon particles may cause silicosis, a type of silicon toxicity.

Unrefined grains, cereals, vegetables, and fruits supply most of our dietary silicon. Animal foods are poor sources. Determining a dietary recommendation is difficult because of the lack of human studies showing signs of deficiency. A balance study conducted in the late 1970s suggests adequate intake is between 21 and 46 mgs per day. The total diet study conducted in the United States reported silicon intake between 19 and 40 mgs per day.

1.3.7.5 Vanadium

In the body, vanadium can exist in a form that is structurally similar to phosphate. Interestingly, in the late 1970s it was noted that in vitro vanadium inhibits ATP synthase, an enzyme required for ATP production.

Presumably, vanadium replaces phosphate and blocks the reaction. In rats with experimentally induced diabetes, vanadium has also been shown to mimic insulin.

However, a precise function for vanadium in humans has not been found, and given the tiny amounts that we consume, deficiencies have not been observed. The UL for vanadium is 1.8 mgs per day. (Nutrition.Donross.2004).

1.4 Bioavailability

Your GI tract absorbs a much smaller proportion of minerals than vitamins and probably for good reason. Once absorbed, excess minerals often are difficult for the body to flush out. In many cases, the body adjusts mineral absorption in relation to needs. For example, a calcium deficient person absorbs calcium more readily than does a person with normal calcium status.

Mega dosing with single mineral supplements can hamper the absorption of other minerals. Minerals such as calcium, iron, zinc, and magnesium, for example, all have similar chemical properties and compete for absorption.

Literature review

1- Proximate analysis and mineral compositions of different cereal grain varieties available in kano state, Nigeria

Salamatu Ahmad Sulaiman (1), Afodia L Kassum (2), Shamsudeen Nassarawa Sanusi (3).

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In this study, the food composition of wheat and sorghum were chemically analyzed using the methods by Association of Analytical Chemist (AOAC). Calcium, potassium, Magnesium and Zinc in the cereal samples were determined by Micro plasma Atomic Emission Spectroscopy. Wheat presented the highest

protein content (12.28_ 15.59%).and the lowest fat (1.94- 1.71) .The ash content of wheat ranged from (1.20_1.60%) While that of sorghum ranged between (1.15 _ 1.61%). The fat content of sorghum were found to range between (2.44_ 2.62%). The fiber content of wheat and sorghum (1.4_ 1.7) and (0.92- 2.42) respectively. The result of the mineral composition showed that wheat was observed to have the maximum content of potassium, calcium, magnesium and zinc (243.5, 90.25, 20.04 and 0.67) respectively. On the other hand sorghum was found to have the highest level of potassium, calcium, magnesium and zinc (274.48, 194.26, 17.23 and 0.62) respectively.

2- Proximate, mineral and vitamin analysis of fresh and canned tomato.

Ismail Ismail Abdullah 1, Nasiru Abdullah, Abdullah Mohammad Abdo3 and Abdullah Salisu Ibrahim4

Department of biotechnology, Faculty of science and humanities, SRM University, India.

The study aimed at comparing the nutritional contents of canned and fresh tomato obtained from the market. Proximate, mineral and vitamin analysis conducted on three samples of canned tomato paste and fresh tomato show that, the fresh tomato has high percentage composition of fat (0.62) , and the least percentage of protein (1), crude fiber (1.21) and ash (0.85).Iron was found to be (34.45mg/kg), Sodium was found to be (21.52 mg/ kg), Magnesium was found to be (76.87 mg/kg),Potassium and calcium were found to be (61.90 mg/kg) and (1.60 mg/kg) respectively.

3- Nutritive value of chickpea

Benu Singhai and S.K. Shrivastava

Department of applied chemistry, Government engineering college, Jabalpur (M.P) India.

The approximate analysis of chickpea seeds included total ash (2.50_3.15%), crude protein (19.68_22.75%), fats (4.18-4.92%), calcium (0.068_0.149 %), phosphorus (0.31_0.62%) and crude fiber (0.26_1.43%).

4- **Proximate** composition and some functional properties of wheat.

Oppong David (, P.G. Student, Department of Horticulture, Kwame Nkrumah University of science and technology, Kumasi, Ghana).

The objective of this research was to assess the proximate composition and selected functional properties of wheat flour and cowpea flour. Crude protein of wheat was 10.23%, crude fiber was 0.51%, moisture content was 3.33%, Ash was 1% and fat was 1.33%. Crude protein of cowpea was 24.53%, crude fiber was 3.21%, moisture content was 10.90%, ash was 3% and fat was 1%.

5- Proximate analysis of selected sorghum cultivars

Jimoh, W.L.O. and Abdullah, M.S, Department of pure and industrial chemistry, Bayero University, Kano and National Biotechnology Development Agency, Abuja.

This research aimed to study approximate analysis of sorghum, the result revealed that protein content ranged 6.23 _ 13.81%, and moisture 9.75_16.32%, fat 3, 60_10.54%, fiber 1.65_7.94% and ash 1.12_1.68%.

The mineral composition of sorghum showed highest distribution pattern of Fe (31.95ppm), Cu (7.27 ppm), Zn (59.81ppm), Mg (110 ppm), Ca (40.85 ppm),Cu (8 ppm),Cd (0.99 ppm) and Pb (0.64 ppm).

6- Comparative study of Fieldpea, Chickpea and other cultivars.

Meenakshi Garg. Bhaskaracharya College of applied science.M Garg and P. Sabharwal \ International journal of nutrition and agriculture research.

This research aimed to study approximate analysis of chickpea, crude protein (22.75%), moisture (7.17 %), crude fat (4%), total ash (3.19 %) and total fiber (5.06%).

7- Supplementation of sorghum with chickpea and nutritional evaluation.

Omima Elsadig Fadlallah Mohamed. B.S.C. University of Khartoum (2002).Department if food science and technology. Faculty of Agriculture.

Study aimed to determine approximate analysis of sorghum and chickpea, protein of sorghum (9.27%), fat (2.23%), ash (1.15%), moisture (8.65%) and fiber (2.94%).

Protein of chickpea (22.47%), moisture (7.09%), ash (2.64%), fat 4.92 and fiber (9.22%).

Chapter 2

Chapter 2

Materials and methods

2.1 Materials

Four different samples were collected from Khartoum state markets, the samples included wheat [Triticum}, sorghum {fatraita}, kabkaby [cicer arietinum], and tomato.

2.2 Chemicals

Nitric acid [65%]

De ionized water

Anhydrous sodium sulfate [96%]

Copper sulfate [3.5%]

Sulfuric acid [98%]

Sodium hydroxide [40%]

Boric acid [2%]

Methyl red indicator

Hydrochloric acid [0.02 N]

Ether

Potassium hydroxide [0.23 N]

2.3 Instruments

Atomic absorption spectrometer P in A Acle 900F

Flame photometer [BWB technologies]

Muffle furnace

Electrical heater

Soxhlet apparatus

2.4 Methods of analysis

2.4.1 Atomic absorption spectroscopy analysis

0.25 g of analytical species were accurately weighed and put in microwave vessel for close digestion.

6 ml of concentrated nitric acid were added to the weighed samples and put in microwave for 45 minutes under pressure , then a clear solution was obtained and filtered , then the volume was completed up to 50 ml by deionized water .The samples were processed by atomic absorption spectrometer , the obtained results were tabulated below.

2.4.2 Flame photometer analysis

Standard solutions of each element [Ca. Na, and K] were prepared by dilution of stock solutions by different glass pipettes and numbered 100 ml volumetric flasks were used .Test solution was given in 100 ml flask fill it up to the mark with distilled water .

The instrument was warmed up for 5 to 10 minutes ,then it was feed by distilled water .the element was selected by turning the selector .The distilled water, standard solutions , and samples were aspirated respectively.

2.4.3 Micro kjeldhal method

2.4.3.1 Digestion

0.2 G of samples were weighed and placed in small digestion flask [50 ml].About 0.4 gram catalyst mixture [96% anhydrous sodium sulfate and 3.5 % copper sulfate] was added, 3.5 ml of approximately 98% sulfuric acid was added. The contents of the flask were then heated on an electrical heater for 2 hours still the color changed to blue /green. The tubes were then removed from digester and allowed to cool.

2.4.3.2 Distillation

The digested samples were transferred to the distillation unit and 20 ml of sodium hydroxide [40%] were added. The ammonia was received in 100 ml conical flask containing 10 ml of 2% boric acid plus 3 drops of methyl red indicator, the distillation was continued until the volume reached 50 ml.

2.4.3.3 Titration

The content of the flask were titrated against 0.02 N hydrochloric acid.

The titration reading was recorded, and the crude protein was calculated.

2.4.4 Fibers analysis

2 grams of samples were treated successively with boiling solution of sulfuric acid and potassium hydroxide [0.26 N, and 0.23 N, respectively]. The residue was then separated by filtration, washed and transferred into a crucible then placed into an oven adjusted to 105 c for 18 to 24 hours. Then the crucible with the sample was weighed and ached in a muffle furnace at 500c and weighed, the crude fiber was calculated.

2.4.5 Ash analysis

2 grams of samples were placed in a clean dry pre weighed crucible, and then the crucible with its content ignited in a muffle furnace at about 550c for 3 hours until light gray ash was obtained .The crucible was removed from the furnace to a desiccators to cool and then weighed, the crucible was reignited in the furnace and allowed to cooling until a constant weight was obtained. Ash content was calculated.

2.4.6 Fat analysis

An empty clean and dry flask was weighed, about 2 grams of sample were weighed and placed in a clean extraction thimble and covered with cotton wool. The thimble was placed in an extractor.

Extraction was carried out for 8 hours with petroleum ether. The heat was regulated to obtain at least 15 siphoning per hour. The residual ether was dried by evaporation, the flask was placed in an oven at 105 c till it dried completely and then cooled in desiccators and weighed.

The fat content was calculated.

2.4.7 Statistical analysis

All the data are expressed as means ± SD of three independent analysis which was carried out in triplicates. ANOVA and statistical analysis was conducted using SPSS version 12.0.

Chapter 3

Chapter 3

Results and discussion

Table [3.1] concentration of inorganic elements in the different samples.

Elements	Test method	Unit	Wheat	Tomato	Kabkaby	Fatarita
Ca	FBH	Ppm	<0.10	120	60	<0.10
Na			40	120	60	440
K			40	4160	2000	440
Cd	AAS		<0.02	<0.02	<0.02	2.60
Cu			<0.03	5	16.18	<0.03
Fe			37.20	481.20	31.40	29
Mg			1214	1932	1280	1750
Mn			31.20	23.60	17.80	11.80
Ni			<0.10	<0.10	<0.10	<0.10
Zn			46	42.60	62.80	50

Table 3.1 shows concentrations of some inorganic metals, which are essential for so many biological roles in human body. Calcium [Ca], sodium [Na], potassium [K] measured by flame photometer, but the others measured by atomic absorption spectrometer.

We may easily observed that all the species showed high concentrations of magnesium [1932_1214] and potassium [4160_40] and Significant concentration Of sodium [440-40] , zinc [62_42] , iron [481.2_29] and manganese [31.20_11.80]. And low concentration of nickel [<0.10].

Tomato showed high concentration of potassium [4160], magnesium [1932] and iron [481.2] but at some time showed low concentrations of copper [5], cadmium [<0.02] and nickel [0.10].

Sorghum shows the highest concentration of cd [2.60] while the other species shows low concentrations.

Table [3.2] percentage of protein and fiber of all species.

Sample	Protein %	Fibers %
Sorghum	13.55	2.79
Wheat	12.81	1.82
Tomato	16.72	18.77
Chickpeas	18.47	10.44

Table 3.2 shows all species shows significant protein percentage [18.47_ 12.81], chickpeas showed the highest percentage [18.47], wheat showed the lowest one.

Tomato shows the highest fiber percentage [18.77] then. Chickpeas [10.44] and wheat showed the lowest percentage.

Table 3.3 the percentage of Ash.

Sample	Results %
Sorghum	1.995
Wheat	1.395
Tomato	4.3
Chickpeas	8.5

Table 3.3 shows Chickpeas shows highest percentages [8.57] then tomato [4.3] sorghum and wheat shows low concentrations, [1.995 and 1.395 respectively].

Table 3.4 the percentage of fat.

Samples	Fat %
Tomato	1.22
Chickpeas	10.40
Sorghum	2.36
Wheat	1.75

Table 3.4 shows Chickpeas shows highest concentration of fat percentage [10.40]. Tomato shows lowest concentration.

Conclusion

All the species were found to contain sufficient concentrations of inorganic elements sodium [Na], manganese [Mn], and zinc [Zn].

All species shows high concentration of magnesium [Mg]. Tomato showed very high concentrations of potassium [K], and cupper [Cu]. Chickpeas shows high concentrations of potassium [K], and manganese [Mn]. Sorghum shows high concentration of cadmium [Cd].

Wheat showed low concentrations of most of elements. All the species contained sufficient percentage of protein.

Tomato showed high percentage of fibers. Wheat showed low percentage of fibers. Chickpeas shows highest concentration of fat.

Recommendation

More studies may be needed for each species by analyzing more samples.

Tomato and chickpeas may need further analytical investigations as rich sources of many essential minerals.

Further studies of total chemical analysis may be required for determination of the other food constituents in these species such as sugars and vitamins contents.

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