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Determination of Some Micronutrients In Traditional Sudanese Food

تحديد بعض المغذيات الصغرى في الأطعمة السودانية التقليدية

A Thesis Submitted in Partial Fulfillment of the Requirements for Master Degree in Chemistry

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كُلُوا وَ (اشْرَبُوا هَنِيئاً بِمَا كُنْتُمْ تَعْمَلُونَ)   المرسلات (ايه 43)

صدق الله العظيم

Dedication

To my

Parents,

Husband, children,

Brother and sisters.

Acknowledgement

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

My unlimited thanks go to my supervisor Dr. Omer Adam Mohamed Gibla for his continuous encouragement and help during his supervision of this work.

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Abstract

The aim of this study was to determine some micronutrients in traditional Sudanese food. Fifteen different samples were collected from Algazira and Khartoum states markets. The samples included aradeib, karkady, doum, tabaldy, guddaim, date (gondaila), Sorghum (tabat, fatarita and abahmed), Wheat, Millet, kabkaby, adasia, lubia and turmos. Minerals content of each sample were measured by inductively coupled plasma spectrometry (ICP, PQ 9000). All the analyzed species were found to be rich in, manganese (Mn) and iron (Fe). Lithium (Li) and Selenium (Se) showed low concentrations. The highest manganese concentration was shown by Turmos (1946 ppm), and the lowest concentration was in gondaila (5.184 ppm).The highest iron concentration was in tabaldy (790.5 ppm), and the lowest concentration was in gondaila(21.13ppm).The highest Silicon concentration was in karkady (168.2 ppm), and trace concentrations were shown by kabkaby, adasia and lubia. The highest zinc concentration was in turmos (48.49 ppm), and the lowest concentration was in doum (6.638 ppm). The highest copper concentration was in fatarita (14.14 ppm) and the lowest concentration was in doum (1.907 ppm). Highest Titanium concentration was in tabaldy (49.74 ppm) and doum (22.91 ppm). Most of the other species showed trace concentrations of titanium concentrations. The highest vanadium concentration was found in karkady (5.950ppm) and the lowest concentration was in gondaila (1.159 ppm).The highest molybdenum concentration was in lubia (12.89 ppm), and the lowest was in gondaila (0.0300 ppm). The highest nickel concentration was found in turmos (2.547 ppm) and adasia(2.529 ppm), whereas the lowest concentrations were found in tabat (0.1399ppm) and doum (0.1397 ppm). The highest cobalt concentration was in turmos (1.728 ppm), and trace concentrations were shown by gondaila, tabat and fatarita. The highest Selenium content was in turmos (1.998 ppm), whereas the most other species showed trace concentrations. The highest lithium concentration was in tabaldy (0.5594 ppm) and the lowest concentration was in gondaila (0.0300 ppm).

المستخلص

هدفت هذه الدراسة لتقديربعض المغذيات الصغرى في الأطعمة السودانية التقليدية. تم جمع خمسة عشر عينة من اسواق ولايتي الجزيرة والخرطوم. و قد شملت العينات العرديب , الكركدي , الدوم , التبلدي , القضيم , البلح(قنديله),وعينات ذره(طابت ,اب احمد , فتريته), الدخن , القمح , الكبكبي , العدسية , اللوبيا والترمس. تم قياس المحتوى المعدني لكل عينة بمطيافية بلازما الحث المزدوج (ICP,PQ900). كل الفصائل التى تم تحليلها كانت غنية بالمنجنيز والحديد وأظهر كل من الليثيوم و السيلينيوم تراكيز منخفضة. اعلى تركيز للمنجنيزوجد في الترمس(1946ppm) وادنى تركيز في القنديله (5.184ppm) . اعلى تركيز للحديد ظهر في التبلدي (790.5ppm) وادنى تركيز في القنديله (21.13ppm). أعلى تركيزللسيليكون كان في الكركدي (168.2ppm) وأظهر تراكيزأثرية في كل من الكبكبي ,العدسية واللوبيا. اعلى تركيز للزنك ظهر في الترمس (48.49ppm) وادنى تركيز في الدوم (6.638ppm). اعلى تركيز للنحاس ظهر في الفتريته (14.14ppm) وادنى تركيز في الدوم (1.907ppm). وجد أعلى تركيز للتيتانيوم في التبلدي (49.74ppm) و الدوم (22.91ppm).معظم الفصائل الاخرى اظهرت تراكيز أثرية للتيتانيوم. اعلى تركيز للفانيديوم كان في الكركدي (5.950ppm) وادنى تركيز في القنديله (1.159ppm). اعلى تركيز للموليبدينوم ظهر في اللوبيا (12.89ppm) وادنى تركيز في القنديله (0.0300ppm). اعلى تركيزللنيكل ظهر في الترمس (2.547ppm) والعدسية (2.529ppm) بينما كان اقل تركيز في عينة طابت (0.1399ppm) والدوم (0.1397ppm). اعلى تركيز للكوبالت ظهر في الترمس (1.728ppm) و أظهرت القنديله، طابت و الفتريته تراكيز أثرية. اعلى محتوى للسيلينيوم كان في الترمس (1.998ppm) بينما معظم العينات الاخرى اظهرت تراكيز أثرية. الليثيوم اظهر اعلى تركيز له في التبلدي (0.5594ppm) واقل تركيز في القنديلة (0.0300ppm).

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List of Abbreviations

Abbreviation	Term
DES	Dietary Energy Supply
GIT	Gastrointestinal Tract
RBC	Red Blood Cells
CNS	Central Nervous System
GSH-Px	Glutathione Peroxidase
SOD	Superoxide Dismutase
CAT	Catalase
RDA	Recommended Daily Amount
WHO	World Health Organization
TLV	Threshold Limit Value
FAO	Food and Agriculture Organization
UNU	United Nations University

CHAPTER ONE

INTRODOUTION

Chapter one

Introduction

1.1 Sudanese foods

Sudanese food is essentially composed of cereals, milk and its products, eggs, meats, fruits, and vegetables. According to Samar and Ingrid (2013) Cereal foods comprise about 49.8%of the total Dietary Energy Supply (DES) compared to the other food groups. The contribution of milk, eggs, and fish are about 16.9%, followed by sugars and sweets (10.1%), roots and tubers (1.0%). However, the contribution of fruits and vegetables to the (DES) is only about 3.5%. Fruits and vegetables provide good sources of micronutrients. Meat and fish represent other limited sources of micronutrients. Cereals food is the major contributor of both energy and protein and its availability is the most important factor to ensure food security in Sudan.

1.2 Trace Elements

The term trace elements refer to chemical elements present in a natural material at very small amounts. In analytical chemistry, a trace element is an element in a sample that has an average concentration of <100 parts per million measured in atomic count or <100 μg/g. In biochemistry, a trace element is a dietary mineral that is needed in very minute quantities for the proper growth, development, and physiology of the organism (Falah and Saja, 2017).

Trace elements have several important roles in human bodies, some are essential for enzymes reactions, where, they attract and facilitate conversion of substrate molecules to specific end products. Moreover, some of them donate or accept electrons in redox reactions, that are, of primary importance in generation and utilization of metabolic energy. Some of them have structural roles, and responsible for the stability of important biological molecules. Furthermore, some trace elements have important actions, throughout, biological processes, for example, iron (Fe) binds, transports, and releases oxygen in the body. Although trace elements are essential components of biological activities, excessive levels of these elements can be toxic for the body health and may lead to many fatal diseases, such as cancers (Falah and Saja, 2017).

1.2.1 Iron (Fe)

Iron is a component of Haemoglobin, myoglobin, the cytochromes, and in certain other enzymes. As a part of these haeme complexes and metalloenzymes ,it serves important functions in oxygen transport and cellular respiration as well as playing role in catalyzing the transformation of beta -carotene to vitamin-A. The human body of normal adult contains approximately 2-6 gm of iron, depending largely, on the body weight and circulating mass of hemoglobin. One half of two thirds of this total is found in hemoglobin. Iron is needed to make red blood cells (Abdelmoneim, 2001).

The amount of iron absorbed, normally, ranges from 3% to 6% of the amount ingested. It is more absorbed in (Fe^{+2}) form but most of dietary iron is (Fe^{+3}) form. The average diet in (USA) provides about 12-15 mg of food iron. For people who eat large amounts of meat, the amount may increase up to 20 mg or more. Therefore, the amount of iron absorbed depends very much, on the source of iron, whether from meat or vegetables, and presence of other substances such as vitamin-C from fruits and some Vegetables, Phytate from cereal products" and tannin from tea (Abdelmoneim, 2001).

Iron is absorbed from Castro-Intestinal Tract (GIT) mainly in duodenum. Ascorbic acid increases absorption by reducing (Fe^{+3}) to (Fe^{+2}), while, the pancearatic juice inhibits iron absorption. Phytic acid, found in cereal reacts with iron to form insoluble compounds in the intestine. In the normal human adult between 600 and 1500 mg of iron are stored in trace as ferritin hemosiderin in the liver, spleen, bone marrow and other tissues while most ferritin iron is in (Fe^{+3}) state (Abdelmoneim ,2001). Approximately 1 to 5 mg of iron is lost from the body each day in feces urine and sweat and twice this value is lost during menstruation. Iron deficiency is the most common nutritional problem in the world today, which lead to anemia. Iron deficiency in infancy and childhood, impair learning and the ability to resist diseases (Abdelmoneim, 2001).

1.2.2 Cobalt (Co)

Cobalt is a constituent of vitamin B12 and its metabolism is the same as for vitamin B12. In addition, cobalt is also a cofactor of enzymes involved in DNA biosynthesis and amino acid metabolism (Soetan et al, 2010). In cattle and sheep, bacteria in the rumen use metallic (Co) to synthesize vitamin B12 and are thus the ultimate source of the vitamin in human diets. Vitamin B12 plays a role in methylating choline and thamine. Thamine is required for the synthesis of DNA, which regulates cell division and growth. Cobalt is readily absorbed into bloodstream and excreted primarily in urine. Deficiency disease or symptoms is manifested in vitamin B12 deficiency. Cobalt deficiency in ruminants has been successfully alleviated by the use of cobalt oxide pellets, which remain in the reticulum or rumen fluid (Soetan et al, 2010). In humans, toxicity disease or symptoms include goitre, hypothyroidism and heart failure. In animals, excessive intake results in polycythaemia, apparently, due to the inhibition by cobalt of certain respiratory enzyme systems, for example, cytochromeoxidase and succinic dehydrogenase. Deficiencies of cobalt in ruminants cause anorexia, wasting of skeletal muscle, fatty livers, haemosiderosis of the spleen and anemia. Dietary sources of cobalt are the same as for vitamin B12, such as foods of animal origin or fermented foods, where, bacteria produces the vitamin. Organ meats liver, kidney, heart, and pancreas are the best source of vitamin B12 followed by clams, oysters, extra-lean beef, seafood, eggs, milk, yogurt, chicken and cheese (Soetan et al, 2010).

1.2.3 Copper (Cu)

Copper is a constituent of enzymes like cytochrom c oxidase, amine oxidase, catalase, peroxidase, ascorbic acid oxidase, plasma monoamine oxidase , erythrocuprin (ceruloplasmin), lactase, uricase, tyrosinase, cytosolic superoxide dismutase , and it plays a role in iron absorption (Soetan et al, 2010).Copper is an essential micro-nutrient necessary for the haematologic and neurologic systems. It is necessary for the growth and formation of bone and myelin sheaths in the nervous systems.It helps in the incorporation of iron in haemoglobin, assists in the absorption of iron from the gastrointestinal tract (GIT) and in the transfer of iron from tissues to the plasma (Soetan et al, 2010).It is transported by albumin; bound to ceruloplasmin. Ceruloplasmin has oxidase activity and, thereby, facilitates the incorporation of Fe^{+3} into transferrin. The copper-containing protein in red blood cells (RBC) is erythrocuperin, in liver, it is hepatocuperin and in brain, it is cerebrocuperin. In the monogastric animals, copper is absorbed, mainly, in the upper part of the small intestine, where the (pH) of the contents is still acidic. In general, Cu is poorly absorbed, and under normal conditions >90% of the ingested copper appears in the faeces. Most of the faecal copper is unabsorbed dietary copper, but some of it comes from the bile, which is the major pathway of Cu excretion. Biliary obstruction increases the excretion of copper, through, the kidney and intestinal wall (Soetan et al, 2010). Increased levels of copper are seen in acute infections and in chronic conditions such as cirrhosis, rheumatoid arthritis and in post-operative stages. Increased level is also found in malnutrition ,Clinical disorders associated with copper deficiencies include anemia , bone disorders, neonatal ataxia, depigmentation and abnormal growth of hair, fur or wool, impaired growth and reproductive performance, heart failure and gastrointestinal disturbances. The incidence of these disorders varies widely, among animal species. Copper deficiency has also been associated with cardiac hypertrophy and sudden cardiac failure. Carboxyl groups found on the cell walls of dead algal biomass are potentially responsible for copper binding. Toxicity disease or symptoms are rare and is secondary to Wilson's disease (Soetan et al, 2010).

In Wilson's disease, large amount of copper is deposited in liver, brain, etc. Total copper content in the plasma and ceruloplasmin-bound copper content decreases and there is an increased excretion of copper in urine. Sometimes, copper may be deposited in the renal tubules giving rise to renal tubular degeneration and this is manifested as glycosuria and aminoaciduria. Excess dietary copper causes an accumulation of copper in the liver, with a decrease, in blood haemoglobin concentration and packed cell volume. Liver function is, adversely, affected in copper poisoning (Soetan et al, 2010).

Jaundice results from erythrocyte haemolysis and this, may, lead to death unless treatment is started. In animals, sheep's are more susceptible, than cattle, to the toxic effects of copper. Deficiency diseases or symptom include anemia (hypochromic, microcytic). Sources include liver, whole grains, molasses, legumes, nuts, shell fish and other sea foods (Soetan et al, 2010).

1.2.4 Manganese (Mn)

Manganese is a cofactor of hydrolase, decarboxylase, and transferase enzymes It is involved in glycoprotein and proteoglycan synthesis and is a component of mitochondrial superoxide dismutase. Manganese is a co-factor in phosphohydrolases and phosphotransferases involved in the synthesis of proteoglycans in cartilage. It is a part of enzymes involved in urea formation, pyruvate metabolism and the galactotransferase of connective tissue biosynthesis (K. O. Soetan et al, 2010). Manganese activates several important enzyme systems, and in this capacity it is required for the synthesis of acid mucopolysaccharides, such as chondroitin sulphate, to form the matrices of bones and egg shells. Consequently skeletal deformities and defects in shell quality occur when the manganese intake is inadequate. The fact that (Mn) is concentrated in the mitochondria has led, to the suggestion that, in vivo, manganese is involved in the partial regulation of oxidative phosphorylation. Absorption of (Mn) is inhibited by, the presence of excessive amounts of calcium and phosphorus in the diet (Soetan et al, 2010).

The absorption and retention of manganese from foods, low in iron, such as milk, are relatively high. If milk is supplemented with iron, the percentage of manganese absorbed will be reduced. Increased absorption of manganese has been reported during pregnancy in sows and with coccidiosis infection in chickens (Soetan et al, 2010). Manganese deficiency has been demonstrated in several animal species including laboratory animals, pigs, poultry, and possibly in cattle. Its severity depends greatly on the degree and duration of the deficiency and on the maturity of the animal. Manganese deficiency presents with the following signs. In pigs, lameness, enlarged hock joints, and shortened legs, in cattle, leg deformities with over knuckling, in chicks, poults and ducklings, perosis or slipped tendon; and in chick embryos, nutritional chondrodystrophy. In laboratory animals, effects of deficiency include deformities of bone, poor growth, impaired reproduction, egg shell formation, and blood clotting. Some of these defects are related to the role of the manganese ion as the most effective activator of glycosyl transferase enzymes in the synthesis of mucopolysaccharides and glycoprotein's (Soetan et al, 2010). Other deficiency disease symptoms are ataxia and abnormal formation of otoliths in the inner hears. In other species, congenital defects in embryonic bone development result from (Mn) deficiency. Birds are much more susceptible to manganese deficiency, than, mammals because their requirements for this element are considerably higher, and this is attributable partly to relatively poor absorption from the intestine. Deficiency disease or symptoms is unknown in humans. Manganese overexposure may have, an adverse effect on central nervous system (CNS) function and mood (Soetan et al, 2010). Toxicity disease or symptoms by inhalation poisoning produces psychotic symptoms and Parkinsonism. Corn is extremely low in manganese (4-12ppm). So animals fed high-corn diets especially, if supplemented with animal by-products which are also low in manganese content, may receive inadequate amounts. The high requirement of poultry and the low levels of (Mn) in many ingredients of poultry diets make (Mn) supplementation highly, important sources include, whole grains, tea, legumes, nuts and seeds (Soetan et al , 2010).

1.2.5 Molybdenum (Mo)

Molybdenum is a component of several metalloenzymes , including xanthine oxidase, aldehyde oxidase, nitrate reductase, and hydrogenase. Xanthine oxidase and aldehyde oxidase play a role in iron utilization , as well as in cellular metabolism in electron transport. Xanthine oxidase is actively, involved in the uptake and release of iron from ferritin in the intestinal mucosa and in the release of iron from ferritin in the liver, placenta, and erythropoietic tissues to the ferrous form. It is readily absorbed from foods. Molybdenum is an important micronutrient, both in animal and plant nutrition. In plants, it plays a role in nitrogen fixation and nitrate assimilation through, nitrate reductase, which is, a key enzyme in the metabolic process in leguminous plants (Soetan et al, 2010).

Dietary molybdenum affects copper metabolism in man. High intake of molybdenum can apparently precipitate copper in cattle and sheep .The amount in the body is regulated by excretion in urine and bile. Molybdenum is a cofactor for enzymes necessary for the metabolism of sulphur-containing amino acids and nitrogen-containing compounds present in DNA and RNA, the production of uric acid, and the oxidation and detoxification of various other compounds. Low molybdenum intake is a predisposing cause of renal xanthine calculi. Deficiency diseases or symptoms are secondary to parenteral nutrition. It also causes gout. Sources include whole grains, dairy products, organ meats and legumes (Soetan et al, 2010).

1.2.6 Selenium (Se)

Selenium is a constituent of glutathione peroxidase ,It is a constituent element of the entire defence system ,that, protects the living organism from the harmful action of free radicals. Organic selenium is more thoroughly resorbed and more efficiently metabolized than its inorganic equivalent, which is poorly resorbed and acts more as, a prooxidant provoking glutathione oxidation and oxidative damage to the DNA (Soetan et al, 2010). Selenium is a synergistic antioxidant with vitamin E. It is activity appears to be closely related, to the antioxidative properties of alpha-tocopherol (vitamin E) and coenzyme Q (ubiquinone). It enhances the overall activity of the alpha- ketoglutarate oxidase system, probably by affecting the decarboxylation reaction. Organic and inorganic selenium compounds function in preventing certain disease conditions that, in the past have been associated with vitamin E deficiency. Selenium prevents liver necrosis in rats, white muscle disease in lambs, and exhudative diathesis in chicks. Selenium protects the organism from oxidative damage to cell membranes by destroying hydrogen peroxide (H_2O_2), whereas vitamin E protects against damage by, preventing the formation of the lipid hydroperoxides.The most important metabolic role of selenium is manifested in the activities of the selenoenzymes glutathione peroxidase (GSH-Px) and thioredoxin reductase. The activity of selenium as adequate supply of vitamin E and some enzymes like GSH-Px, superoxide dismutase (SOD), catalase (CAT) protect chicks from numerous diseases like encephalomalacia, exudative diathesis and muscular dystrophy (Soetan et al, 2010).The activity of SOD in the cells and in the extracellular fluid is very important, in the prevention of diseases closely associated with oxidative stress, for example, cardiovascular diseases, Alzheimer's disease, Parkinson's disease and many others.

Selenium deficiency results in white muscle disease, an illness that causes high mortality in young calves and lambs. The clinical signs are myopathy, that, affects both the heart and skeletal muscles, that frequently accompanied by abnormal calcification. White muscle disease is not a serious problem in areas, where, the soil is high in selenium. In the mild acute form, selenium deficiency interferes with the normal growth processes of sheep and cattle. Selenium deficiency also, disrupts the normal reproductive process, apparently affecting ovulation and fertilization, resulting in a higher incidence of embryonic mortality. Selenium deficiency has been associated with a high incidence of retained placenta, resulting in delayed onset of oestrus and impaired conception (Soetan et al, 2010). Selenium deficiency in growing chickens cause exudative diathesis, signs like unthriftiness, ruffled feathers appear early at the growing stage. Egg production and feed conversion are adversely affected. In plants, (Se) is incorporated primarily by replacement of sulfur in the amino acids cystine and methionine. Toxic levels in plants result in blind stagger in horses and in the sloughing of hair and hoofs in horses and cattle.

The animals become lame, and death in such cases is mainly caused by starvation resulting from movement impedement. In pigs, (Se) deficiency results in liver necrosis, hepatosis dietetica, resulting in high mortality.

Mulberry heart disease in swine has been attributed to Se deficiency and is complicated by other factors other than Se deficiency. In humans, toxic levels in some soils and megadose supplementation induces hair loss, dermatitis, and irritability (Soetan et al, 2010).Deficiency disease or symptoms are also secondary to parenteral nutrition, protein-energy malnutrition. There is a considerable variation in the availability of selenium in different feedstuffs. Even in the presence of adequate levels of vitamin E, poultry rations still require an adequate level of selenium in the feed but care should be taken to prevent selenium toxicity. Sources include fishmeal, sea foods, dried brewer's yeast, kidney, liver, eggs and grains.

1.2.7 Silicon (Si)

Silicon is one of the most abundant elements in plant and animal tissue. Silicon was confirmed as an essential element in 1972, when rats and chickens fed on a silicon depleted diet showed, reduced weight gains and pathological changes in the formation and structures of collagenous connective tissues and bones (Soetan et al, 2010). Silicon is an essential component of certain mucopolysaccharides, hyaluronic acid and chondroitin-4-sulfate, which are important constituents of connective tissue. It appears to function as a biological cross-linking agent contributing to the structure and resiliency of connective tissue. It plays a role in calcification of bone and in glycosaminogly can metabolism in cartilage and connective tissue (Soetan et al, 2010). Studies have shown that silicic acid, Si(OH)4, the form in which silicon exists in physiology, interacts with aqueous aluminium (Al) species to form hydroxyl aluminosilicates that can have low bio-availability and toxicity and it is also established that the gastrointestinal absorption of aluminium is greatly reduced in the presence of silicic acid and also that the intake of dietary silicic acid also influences the excretion of aluminium via the kidneys so that Si appears to be profoundly involved in aluminium homesostasis (Soetan et al, 2010).

There are also strong indications that silicic acid promotes copper utilization and the observed effects of silicon deficiency on collagen and osteogenesis may be due to low copper utilization. It is however uncertain whether reduced copper utilization is caused by aluminium, so that, it is enhanced by silicic acid via the latters interaction with aluminium. Silicon and its salt are poorly soluble in water and only trace amounts are present in tissues. Herbivorous animals consume relatively large quantities of silica (SiO_2) daily, and most of the insoluble silica passes unabsorbed through the alimentary tract, but appreciable amounts are absorbed and excreted in the urine. Although, the silica is eliminated without side-effects, in some animals a portion is deposited as granules in the bladder, kidney, or urethra to form uroliths or calculi and these can block urine passages, which can result in death. These calculi may be composed of various minerals, especially Mg, P and Si. Silicon is essential for the normal growth and skeletal development in rats and chicks (Soetan et al, 2010).Deficiency disease or symptoms implies impairment of normal growth. Silicosis due to long-term inhalation of silica dust arises from silicon toxicity. Sources include whole grain products and root vegetables.

1.2.8 Zinc (Zn)

Zinc is the second metal present in human body (about 2.5 g), after Fe (about 4g) but before copper (about 0.2 g). It is found throughout the entire body system, with half in the muscle tissue .The established recommended daily amount, for Zn is 8 mg/day for women and 11 mg/day for men. In fact, (Zn) is found in wheat, brown rice, oats, lentils, soybeans, dried peas, black-eyed peas, lima beans, walnuts, peanuts, cashews, Brazil nuts, many cheeses, any kind of liver and animal flesh such as beef, lamb, chicken, turkey, and various fish and seafood. It is also found in most vitamin mineral supplements as sulfate, citrate, or oxide and these are inexpensive and bioavailable sources (Falah and Saja, 2017).

Zinc is an essential trace element that functions as a cofactor for certain enzymes involved in metabolism and cell growth. It is found in nearly 300 specific enzymes it is involved in the metabolism of proteins, carbohydrates, lipids, and energy. It is vital for the healthy working of many body’s systems. It is particularly important for healthy skin and is essential for a healthy immune system and resistance to infections. It plays a crucial role in growth and cell division where it is required for protein and DNA synthesis, in insulin activity, in the metabolism of the ovaries and testes, and in liver function (Falah and Saja, 2017).

Zinc deficiency may occur due to insufficient dietary intake. It was reported that nearly two billion people in the developing world are deficient in zinc. It is deficiency is a serious problem in many developing countries. It ranked as the 5th leading risk factor in causing disease, especially diarrhea and pneumonia in children, which can lead to high mortality rates in underdeveloped regions. Other deficiency symptoms include stunted growth and impaired development of infants, children, and adolescents. Early zinc deficiency, also leads to impaired cognitive function, impaired immune function, behavioral problems, memory impairment, and problems with spatial learning and neuronal atrophy. Public health programs involving Zn supplementation and food fortification could help overcome these problems (Falah and Saja, 2017). In more severe cases, Zn deficiency causes hair loss, delayed sexual maturation, impotence, hypogonadism in males, and eye and skin lesions, weight loss, delayed healing of wounds, taste abnormalities, and mental lethargy can also occur.

The World Health Organization (WHO) advocates (Zn) supplementation for severe malnutrition and diarrhea. Zinc supplements help prevent disease and reduce mortality, especially among children with low birth weight or stunted growth (Falah and Saja, 2017).

1.2.9 Nickel (Ni)

Nickel is an essential ultra-trace nutrient in plants, animals, and humans. It has been reported that, nickel is essential for the active synthesis of urease in plant cells. In several species of higher plants such as, jack beans, soybeans, rice and tobacco,it is required for effective urea metabolism and urease synthesis . Although the biological function of nickel is still unclear in human body, it is found in highest concentrations in the nucleic acids, particularly RNA, and is thought to be somehow involved in protein structure or function. It has been speculated that nickel may play a role, as a cofactor, in the activation of certain enzymes related to the breakdown or utilization of glucose. Nickel may aid in prolactin production and thus be involved in human breast milk production (Falah and Saja, 2017).

There is no recommended daily amount (RDA) has been established for nickel. It has been reported that, the estimated daily intake of nickel from food and water worldwide is 80-130 μg/day. Nickel is contained in many foods such as, beans, chocolate, soybeans, lentils, split, green peas, oats, buckwheat, barley, and corn. Nuts, such as walnuts and hazelnuts, are best sources of nickel. Many vegetables and fruits, such as bananas and pears, have moderate amounts of nickel content (Falah and Saja, 2017).

It has been reported that humans may be exposed to nickel during breathing air, eating food, or smoking cigarettes. Skin contact with nickel-contaminated soil or water may also result in nickel exposure. In fact, small quantities of nickel are essential for the body, but when the uptake is, too high, it can be danger to human health. Some studies have shown that acute exposure of human body to nickel may cause several health problems such as liver, kidney, spleen, brain and tissue damage, vesicular eczema, lung, and nasal cancer. It has been observed that the exposure to nickel may result in the development of a dermatitis known as “nickel allergy”. The first symptom is usually itching, before skin eruption occurs (Falah and Saja, 2017).

Nickel is an important cause of contact allergy, partly due to its use in jewelry intended for pierced ears, Furthermore, it has been demonstrated that acute exposure to nickel carbonyl, a carcinogenic gas that results from the reaction of nickel with heated carbon monoxide, can cause symptoms such as frontal headaches, nausea, vomiting, or vertigo. Long-term nickel inhalation may cause serious health problems, including cancer. Nickel deficiency has not been shown to be a concern in humans, despite it may cause biochemical changes, such as reduced iron (Fe) resorption, that, leads to anemia. It can disturb the incorporation of calcium into skeleton and lead to parakeratosis-like damage, which finds expression in disturbed zinc metabolism. It has found that nickel deficiency particularly affects carbohydrate metabolism (Falah and Saja, 2017).

1.2.10 Vanadium (V)

Vanadium compounds have effect on glucose metabolism in vitro and also in lipid metabolism Vanadium also has a wide range of other biological activities like effects on ribonuclease, alkaline phosphatase, adenyl cyclase, NADH oxidase and phosphofructokinase. Vanadium has been shown to be nutritionally essential for both chicks and rats. It reduced growth of wing and tail feathers in chicks fed a diet containing less than 10mg vanadium per gram. Bone development was also abnormal. In rats, reduced growth and increased packed cell volume, as well as, increased iron in blood and bone were observed (Soetan et al, 2010).

Reproductive performance was also impaired in rats. However, rats fed purified diets low in vanadium responded to dietary vanadium supplementation with increased weight gain and with improved reproductive performance. A precise biochemical or physiological role for vanadium is yet to be determined, but it has long been suspected because of its effects on phospholipids oxidation and inhibition of cholesterol synthesis. It is necessary for normal feather development in chicks and for normal growth in chicks and rats, the required level appears to be very low, < 0.1 to 2 ppm. Essentiality of vanadium in man has been hypothesized but not demonstrated (Soetan et al, 2010).

1.2.11 Lithium (Li)

Lithium has no known function in human body (Edward et al, 1985). Attention has been given to this element because of its use in the treatment of manic depressive psychosis. It is distributed in all body fluids and tissues similar to sodium, but in lower concentrations. Lithium is prevalent in soils, with concentrations ranging from 8 to 40 ppm. Concentrations in plants are much lower, ranging from 20 ppb to 0.3ppm. The average daily intake of lithium from food and water is estimated to be 2 mg. The biochemical mechanism of lithium in the treatment of manic depression is still not clear, but doses of several thousand times the normal intake level are required (Edward et al, 1985).

This causes major changes in the electrolytic distribution in the brain. In cases where excessive doses were given, polyuria, ataria, hypothyroidism, and weight gain result. Epidemiological studies have suggested that lithium may protect against the development of cardiovascular disease. Lithium is believed to stimulate triglyceride metabolism with a concomitant increase in serum concentrations of free fatty acids (Edward et al, 1985).

1.2.12 Titanium (Ti)

Titanium is widely distributed in the earth's crust. It is the ninth commonest element. It has many uses, with an annual production of over 1-1/2 million tons. Titanium alloys include surgical implants, which resist corrosion by body fluids and ferrotitanium used in the steel industry. The dioxide (TiO_2) is extensively used as a white pigment in paint, paper and plastics. It is also used in food as a coloring agent, in cosmetics and in pharmaceuticals. Other titanium compounds are used as catalysts. Titanium concentrations in drinking water should range between 0.5 and 15ug/l.

Many vegetables and cereals contain high levels of titanium. The daily intake from dietary sources has been estimated between 0.3 and 2 mg of the element. Titanium dioxide has been classified as a nuisance particulate, with a threshold limit value

(TLV) of 10 mg/m3. Titanium is poorly absorbed from the gut, and no essential metabolic role has yet been ascribed to this element (George, 1981).

1.2.12.1 Mutagenic Effects of Titanium

Titanium nitrate, while not giving rise to cmitosis in root cells of Allium cepa, did however induce sticky chromosomes manifested mainly by the formation of anaphase bridges , Abnormal staining of the chromosomes at metaphase-anaphase was also seen (George, 1981).

1.2.12.2 Carcinogenic Effects of Titanium

Titanium (IV) oxide, together with iron (III) oxide did not produce transformation of Syrian hamster embryo cells in culture, even though concentrations as high as 20, ug/ml of medium were used.

Titanium oxalate or acetate given in drinking water at a rate of 5 mg /L to 150 mice of both sexes for their whole life span from weaning, Environmental Health Perspectives produced no increase in tumor frequency or other adverse effect compared with control animals, In a long-term feeding study performed by the National Cancer Institute, rats and mice given titanium dioxide under their standard bioassay protocol experienced no increase in cancer (George, 1981).

1.3 Minerals Contents of Some Sudanese Food

Amir et al, (2014) have analyzed chemical composition, protein fractions, mineral profile, tannin content, in vitro protein digestibility, and amino acids content of two Sudanese sorghum cultivar (namely feterita and dabar). Feterita cultivar showed significantly ($p<0.05$) high moisture, ash, protein, fiber, and fat while dabar cultivar was significantly higher ($P<0.05$) in carbohydrate contents. Feterita showed significantly ($p<0.05$) high globulin and glutelin contents while dabar showed significantly ($p<0.05$) high albumin and residual content. Prolamin (kafirins) represented a considerably greater fraction in both cultivars. Cupper, calcium, iron, phosphorus, potassium, and sodium were determined for the two cultivars. Results revealed that, feterita was significantly higher ($P<0.05$) in cupper, iron, and sodium while dabar was significantly higher ($P<0.05$) in phosphorus, calcium and potassium content. Tannin content in feterita was significantly ($P<0.05$) higher compared to dabar.

Table (1.1): Minerals contents of feterita and dabar sorghum cultivars (mg/100g).

Cultivars	Mineral				
	Cu	Ca	Fe	Na	K
Feterita	0.51	2.73	14.54	5.98	247.23
Dabar	0.40	3.33	11.32	4.83	307.51

Source: Amir et al, (2014)

Sanoussi et al, (2013) have measured and compared the chemical composition of calyces and seeds of three ecotypes of Roselle from Niger. Their results indicate that calcium (Ca), potassium (K), sodium (Na), magnesium (Mg) and protein contents in calyces are significantly different ($P<0.005$) among ecotypes. The highest concentrations of K, Na, Mg and protein in calyces were recorded for ecotype E7 (35.66, 3.40, 6.01 and 101 mg/100g) respectively. Ecotype E9 had the highest Ca content in calyces (34.41 mg/100g); while E3 and E7 had similar and lower contents. The protein content in calyces for E9 (52 mg/100g) was approximately halved compared to those of E3 and E7. For all ecotypes, the concentrations of Ca, K, Mn, Na and Fe in the calyces were higher compared to those in the seeds. In contrast, P content was higher in seeds. The highest K, Na, Mg and P concentrations in seeds were registered for E7 and the lowest ones for

E9. Ecotypes E3 and E9 recorded higher and similar Cu, Fe and Mn contents in calyces and in seeds compared to E7. The highest Zn concentrations in seeds were obtained for E3 and E7.

Table (1.2): Minerals content in calyces of three ecotypes of roselle from niger (µg/g).

element	Ecotype		
	E3	E7	E9
Cu	73±7.25[a]	49±1.06[b]	67±3.71[a]
Fe	302±36.59[a]	1580±50.40[b]	197±24.36[ab]
Mn	924±81.53[a]	11±54.25[b]	602±58.94[b]
Zn	37±4.24	42±7.65	43±2.29

Source: Sanoussi et al, (2013)

Gali Adamu et al, (2016) studied the pulp extracts of the indigenous wild fruit Tamarindus indica for their mineral, nutritional and Phyto-chemical compositions. The results of analysis showed ,that, the fruit pulp contain (9.15%) crude protein , (7.16%)crude fiber, (11.19%) moisture, (6.24%) total ash, (60.02%) total carbohydrate and (6.24%) total fat . The mineral analysis revealed the presence of Calcium (21.57 mg/100g), Iron (1.05 mg/100g), Magnesium (10.54 mg/100g), Manganese (0.13 mg/100g), Sodium (112.76 mg/100g) and Potassium (187.73 mg/100g) respectively. The phytoconstituents present included alkaloids, cardiac glycosides, flavonoids, phenols, saponins, steroids, tannins and terpenoids. These values show that the fruit pulp of Tamarindus indica is a rich source of micro and macro elements to the body.

Table (1.3): Minerals Composition of tamarindus fruit Pulp.

Mineral	Concentration (mg/100g)
Ca	21.57
Fe	1.05
Mg	10.54
Mn	0.13
Na	112.76
K	187.73

Source: Gali Adamu et al, (2016)

Magdi Osman, (2004) have analyzed baobab seed and pulp, for proximate composition, of mineral contents, and amino acid composition. The seeds oil and protein were evaluated for their fatty acid profile and protein solubility. The seed was found to be a good source of energy, protein, and fat. Both the kernel and the pulp contain substantial quantities of calcium, potassium, and magnesium. Amino acids determination revealed high glutamic and aspartic acid contents and the sulfur-containing amino acids as being the most limited amino acids. The fatty acid profile showed that oleic and linoleic were the major unsaturated fatty acids, whereas palmitic was the major saturated acid. Of the several solvents tested to solubilize the seed protein, 0.1 M NaOH was found to be the most effective. The protein was more soluble at alkaline than acidic pH, with the lowest solubility at pH 4.0. The seed and fruit pulp are excellent sources of potassium, calcium, and magnesium, but poor sources of iron, zinc, and copper.

Table (1.4): Minerals content of baobab seed and fruit pulp.

Mineral	concentration in mg/100g	
	seed	Fruit pulp
Potassium	910 ±20	1240±30
Sodium	28.3 ±2.2	27.9±0.10
Calcium	410±10	295±10
Magnesium	270±30	90±2
Iron	6.4±0.2	9.3±0.2
Copper	2.6±0.2	1.6±0.1
Zinc	5.2±0.00	1.8±0.00

Source: Magdi Osman,(2004)

Waleed Aboshora, (2014) Studied the physicochemical, nutritional and functional properties of epicarp, flesh and pitted samples of doum fruit (Hyphaene thebaica) were assessed. Results on carbohydrate content revealed that the flesh, pitted fruit and epicarp samples contained 72.50%, 65.61% and 44.17% respectively. Total fiber was highly concentrated in the epicarp accounting for more than 40%. It was further revealed that the fruit contained substantial amounts of essential minerals as follows: sodium 364.7 mg/100 g, calcium 284 mg/100 g and iron 12.18 mg/100 g in the epicarp while the following were contained in the flesh part of the fruit: potassium 2947.6 mg/100 g, magnesium 185.62 mg/100 g and phosphorus 154.6 mg/100 g. Vitamin content was determined by RP-HPLC and the results showed that doum fruit is a good source of vitamin B-complex which was found it at high portion in epicarp with the variance of 3.6 mg/100 g in niacin (B3) content to 13.6 mg/100 g in pyridoxine (B6) content. Monosaccharide content was determined by using HPAEC-PAD and the results showed that the flesh of the doum fruit is a good source of glucose and fructose. There was a significant difference in color parameters between samples. Bulk density results were 0.73, 0.75 and 0.95 mg/ml for epicarp, pitted fruit and flesh respectively. It can be concluded that the doum fruit contained essential nutrients and functional properties which can be exploited for various useful applications.

Elmuez Alsir, (2014) has analyzed chemical and nutritional properties of guddaim fruits were investigated. Proximate compositions, total energy, minerals, vitamins, sugar profile, amino acids and volatile compounds were determined. Content of carbohydrate was 66.59%, while moisture, crude fiber, ash, crude protein and crude fat were 11.72%, 9.41%, 4.12%, 7.68% and 0.48%, respectively. The calorific values of fat, protein, and carbohydrates were 0.043, 0.307, and 2.663 kcal/g; respectively. The content of potassium was the highest minerals (856.25 mg/100 g), while chromium was the lowest (0.063 mg/100 g). The main amino acids were threonine, valine, phenylalanine and leucine 1.99, 2.91, 2.77, 3.62 g/100 g, respectively, which were found to be higher than the level of Daily Recommended Allowance (DRA) of essential amino acids required for child and adult human suggested by FAO/WHO/UNU pattern. Thiaine, riboflavin, pyridoxine, ascorbic acid and folic acid were, 0.185, 0.205, 3.15, 0.415 and 0.765 mg/100 g, respectively. The highest content of sugar was glucose 115.734 mg/g. Volatile compounds were identified to be relatively smaller, that is ; acetic acid 61.04%; hydrazine –methyl 4.78%; 2,3-butanediol 4.06% and hexanoic acid 3.48%. The results following this study showed this fruit contained a lot of important nutrients and nutritional value, beneficial to human health. The sample was contained macro and micro-minerals. The zinc being higher than other minerals (856.25 and 2.107 mg/100 g), respectively, while manganese and copper were lowest (1.034 and 0.708 mg/100g), respectively, Iron and sodium were higher (8.22 and 22.135 mg/100 g), respectively and magnesium (135.625 mg/100 g) From this results, guddaim fruits was found to contain many important minerals which can be used in cereal and cereal product especially flour for bakery products to improve their nutritional properties.

Table (1.5): Mineral contents of guddaim fruits powder.

Minerals	content(mg/100g)
Copper (Cu)	0.708±0.02
Chromium (Cr)	0.063±0.01
Zink (Zn)	2.107±0.05
Manganese (Mn)	1.034±0.17
Potassium (K	856.25±1.76
Sodium (Na)	22.135±0.16
Magnesium (Mg)	135.625±0.53
Iron (Fe)	8.222±1.05

Source: Elmuez Alsir, (2014)

Afzal et al, (2015) studied the nutritional values of three different varieties (Trounja, Lagou, Gounda) of Tunisian dates available in Bangladeshi local markets. Moisture and total solids were (13.2-14.1%) and (85.9-86.8%), respectively. Ash and crude fibers contents were (2.13-2.18%) and (6.05-6.9%), respectively. The dates were rich in carbohydrate (51.8–55.0% dry weight), while they contained low concentrations of protein and lipid (2.0–2.2% and 0.12–0.72%, respectively). Dates represented little amounts of vitamin-A (0.7-1.2 mg%) and vitamin-C (0.7-0.9 mg%). High source of energy, as 100gm of date flesh can provide an average between (226.49-241.79) kcal. 11 minerals were determined from dates by Atomic Absorption Spectrophotometer. The predominant mineral was potassium (460-680 mg%). They contained low content of sodium (0.6-1.0 mg%). Rich source of calcium (51-60 mg%), phosphorus (52-60 mg%), magnesium (48-53 mg%) were found. Good source of iron (0.79-0.90 mg%), manganese (0.85-1.1 mg%), zinc (0.69-0.72 mg%), copper (0.32-0.36 mg%), chromium (0.36-0.42 mg%) and selenium (0.22-0.31 mg%) were found.

Table (1.6): Minerals content of three varieties of dates (mg/100g).

Minerals	Trunja	Lagou	Gounda
K	860	460	520
Ca	60	55	51
P	55	60	52
Mg	53	50	48
Fe	1.9	1.7	0.82
Cr	0.42	0.37	0.36
Cu	0.35	0.36	0.32
Mn	1.1	0.85	0.91
Zn	0.72	0.71	0.69
Se	0.22	0.31	0.25
Na	1	0.7	0.6

Source: Afzal et al, (2015)

Abdelmoneim, (2001) Studied some trace element in edible crops grown in jebel merra area. 19 samples of vegetables, cereal grains, species and fruits were collected from farms in Nyala, Derbat, Sunie and Gawa. With the exception of Nyala, the sampling farms were located on hill slopes using turus system as a means for water harvesting. Samples were analyzed for six trace elements, Fe, Mn, Zn, Cu, Co and Cr using Atomic Absorption Spectrpscopy. Categorically speaking, among the vegetables analyzed, okra has shown a high affinity in accumulating Fe (187.49 ppm), Mn (80.31 ppm), Cu (7.43 ppm) and Zn (12.74 ppm) comparative to other species. On the other hand, opposite trend was observed with sorghum as the poorest one with respect to its ability in concentrating Fe (55.57 ppm), Mn (4.19ppm), Zn (5.26 ppm) and Cu(1.26 ppm) relative to millet, wheat, lupins and broadbeans. With regard to spices covered in this investigation, garlic contains the lowest concentrations of all the elements analyzed and agree well with those found in onion the poorest of all the vegetables. Concentrations obtained were 108.78 ppm (Fe), 3.6 ppm (Mn), 4.6 ppm (Zn), 1.73 ppm(Cu) and 0.1 ppm (Cr) and 0.16 ppm (Co). On individual basis, the highest concentration of Mn was measured in lupins at 143.18 ppm. Cr content in all species was found to be less than 1 ppm, whereas for Co the same is true except in Guava , apple and fenugreek.

Table (1.7): Concentrations of some trace elements in grains grown in Jebel Merra area (ppm).

Location	**cereal**	Fe	Mn	Zn	**Cu**	**Cr**	**Co**
derbat	Lupins	160.00	143.18	9.39	3.38	0.18	0.52
derbat	Millet	134.43	8.40	4.53	2.14	0.21	0.08
sunie	Wheat	125.13	18.92	7.98	2.04	0.13	0.20
Derbat	sorghum	55.57	4.19	5.26	1.15	0.26	0.34

Source: Abdelmoneim, (2001)

CHAPTER TWO

Materials and methods

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Materials and methods

2.1 Materials

Fifteen different samples were collected from Algazira and Khartoum states markets, the samples included Tamarindus indica (aradeib), rosselle (karkady), Hyphaene (doum), Adansonia (tabaldy) ,Tinnas grewia (guddaim), Date (gondaila) , Sorghum (tabat), Sorghum (fatarita), Sorghum (ab ahmed), Triticum (Wheat), Pennisetum (Millet), Cicer arietinum (kabkaby), Bayrony (adasia), Vigna (lubia) Lupines (turmos).

2.2 Chemicals

Hydrogen peroxide (30%)

Nitric acid (65%)

2.3 Instruments

Microwave digestion system (milestone)

Inductively coupled plasma mass spectrometry (PQ 9000)

2.4 Methods of analysis

2.4.1 ICP analysis

0.5 g of powdered sample were, accurately, weighed in clean dry vessels, 8 ml of nitric acid (%65) and 2 ml of hydrogen peroxide (%30) were added to each sample, then placed in microwave digestion system at 200 ºC for 30 minutes to digest the sample. The digested sample solution was transferred to 50 ml volumetric flask and the volume was diluted with deionized water to the marke. The samples were processed by ICP-MS .The obtained results were tabulated below.

CHAPTR THREE

Results and discussion

Chapter Three

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Table (3.1): Concentrations of iron in the different samples.

Sample type	iron Concentration (ppm)	Sample type	iron Concentration (ppm)
Aradaib	42.48	ab ahmed	43.07
karkady	212.5	Wheat	54.45
doum	345.5	Millet	59.40
tabaldy	790.5	Kabkaby	282.7
guddaim	39.00	Adasia	23.39
gondaila	21.13	Lubia	29.05
tabat	34.73	Turmos	80.46
fatarita	34.24		

3.1 Iron contents.

Table (3.1) showed surprisingly, higher iron concentration in tabaldy (790.5 ppm), followed by doum (345.5 ppm) . The other two wild fruits or forest fruits showed iron concentrations as (42.48ppm) in aradaib and (39.00ppm) in goddaim. Sudanese normally expect higher iron concentrations in goddaim and gondaila. Gondaila as a type of date sample (tree product) showed relatively low iron concentration (21.3ppm) when compared to the above four species. For cereal samples which are classified as dura species in Sudanese culture, iron concentration, where almost identical (34.73 ppm) in tabat , (34.24ppm) in fatraita and (43.07ppm) in abahmed . Wheat and millet species also showed almost equal iron content, where iron concentration in wheat was found to be (54.453ppm) and in millet (59.40ppm). The agricultural domestic crops showed clear variations in there iron content. Kabkaby showed the highest iron concentration (282.7ppm) ,followed by karkady (212.5ppm) , turmos (80.46 ppm), lubia (29.05 ppm) and adasia (23.39 ppm). Generally we may say that all the analyzed species could be described as iron rich food materials or good sources of iron for human body.

Table (3.2): Concentrations of some micronutrients elements.

Sample type	Mn (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	Mo (ppm)
Aradaib	5.344	0.00200	0.3696	4.694	8.500	0.0300
karkady	180.1	0.3195	1.987	3.315	16.80	0.2097
doum	13.40	0.0599	0.1397	1.907	6.638	0.0699
tabaldy	21.64	0.2298	0.6394	5.025	8.861	0.0000
guddaim	9.088	0.0400	0.6599	6.529	10.41	0.2000
gondaila	5.184	<0.000198	0.7691	3.536	10.02	0.0300
tabat	14.71	<0.000198	0.1399	3.189	15.69	0.8097
fatarita	18.28	<0.000198	0.499	14.14	24.71	0.569
abahmed	14.17	0.0200	0.1499	2.119	21.31	0.7196
Wheat	35.31	0.020	0.4892	3.305	32.11	0.5092
Millet	11.73	0.1000	0.9100	6.510	27.11	0.6300
Kabkaby	22.53	0.0900	0.4599	8.768	34.67	3.809
Adasia	18.23	0.0100	2.529	13.79	30.99	6.539
Lubia	22.10	0.0999	0.9988	8.140	19.44	12.89
Turmos	1946	1.728	2.547	9.209	48.94	3.775

3.2 Micronutrients contents.

Table (3.2) showed considerable concentrations of some micro nutrients, which are essential for so many biological roles or functions in human body. We may easily observed, that, all the species showed significant concentrations of manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), nickel (Ni) and cobalt (Co). For the wild or forest fruits, tabaldy showed no detectable molybdenum content, but at the same time showed high manganese content. Turmos showed surprisingly higher manganese concentration (1946ppm), followed by karkady (180.1ppm) , and the lowest concentration was in gondaila (5.184ppm) . The highest zinc content was also shown by turmos (48.94ppm) followed by kabkaby (34.67ppm), and the lowest concentration was in doum (6.638ppm) . the highest copper concentration was shown by fatraita (14.14ppm) followed by adasia(13.79ppm), and the lowest concentration was in doum (1.907ppm). The highest molybdenum concentration was shown by lubia (12.89ppm) followed by adasia (6.539ppm), and the lowest was in gondaila (0.0300ppm) and zero concentration was in tabaldy. The highest nickel content was also shown by turmos (2.547ppm) followed by adasia (2.529ppm) , and the lowest concentrations were in tabat (0.1399ppm) and doum (0.1397 ppm). The highest cobalt content was shown by turmos (1.728ppm) followed by karkady (0.3195ppm), and the lowest was shown by gondaila, tabat, fatarita as (<0.000198ppm) for each. All the species under investigation were found to be rich in manganese, zinc, copper, molybdenum and nickel and but poor in cobalt.

Table (3.3): Concentrations of some trace minerals.

Sample type	Li(ppm)	Ti(ppm)	V(ppm)	Si(ppm)	Se(ppm)
aradaib	0.1199	2.727	2.078	82.28	<0.004993
karkady	0.2196	4.573	5.950	168.2	0.1797
doum	0.2695	22.91	2.835	62.37	<0.004993
tabaldy	0.5594	49.74	4.745	21.78	<0.004993
guddaim	0.1300	<0.000147	1.880	51.57	<0.004993
gondaila	0.0300	<0.000147	1.159	114.54	<0.004993
tabat	0.0800	<0.000147	1.949	103.4	0.1200
fatarita	0.040	0.0699	2.715	37.58	<0.004993
ab ahmed	0.0700	<0.000147	2.039	121.3	<0.004993
Wheat	0.1198	1.328	1.977	133.4	<0.004993
Millet	0.1500	<0.000147	2.260	75.68	0.2000
Kabkaby	0.0600	<0.000147	2.290	<0.01068	<0.004993
Adasia	0.1800	<0.000147	1.910	<0.01068	<0.004993
Lubia	0.0699	<0.000147	1.938	<0.01068	<0.004933
Turmos	0.100	2.607	3.176	15.62	1.998

3.3 Some trace minerals contents.

Table (3.3) showed that lithium concentrations were found to be low in all of the analyzed species. The highest concentrations were appear in tabaldy (0.5594ppm), doum (0.2695ppm), and karkady (0.2196ppm). The sorghum samples have low lithium content ,it was (0.0800ppm) in tabat (0.0700ppm) for abahmed and

(0.040ppm) in fatarita .Titanium showed noticeable concentration as (49.74ppm) in tabaldy , (22.91ppm) in doum , (4.573ppm) in karkady , (2.727ppm) in aradaib ,(2.607ppm) in turmos ,and (1.328ppm) in wheat where most other spacies showed concentrations less than (<0.000147ppm).All sample showed relatively low concentrations of vanadium. The highest vanadium contents was found in karkady (5.950ppm) ,tabaldy (4.745ppm) and turmos (3.176ppm). Silicon have moderately high concentrations in all species , except in the case of kabkaby ,adasia and lubia where the concentrations were (<0.01068ppm).Selenium concentrations were low in all samples except in the case of turmos (1.998ppm) ,millet (0.2000ppm) ,karkady (0.1797ppm) and tabat (0.1200ppm).

Conclusion:

All the species were found to contain sufficient concentrations of the essential micronutrients manganese, iron, zinc, copper, silicon and molybdenum. Turmos showed very high concentrations of manganese, iron and zinc. Lubia showed high concentrations of iron, manganese, zinc and molybdenum. Adasia showed high concentrations of zinc, iron, manganese, copper and molybdenum. Kabkaby showed high concentrations of iron, zinc and manganese. Wheat showed high concentrations of silicon, iron, manganese and zinc. Millet showed high concentrations of silicon, iron and zinc. Abahmed showed high concentrations of silicon, iron and zinc .Fatarita showed high concentrations of silicon , iron , zinc and copper. Tabat showed high concentrations of silicon, iron, zinc and manganese. Gondaila showed high concentrations of silicon, iron and zinc. Guddaim showed high concentrations silicon, iron and zinc. Tabaldy showed very high concentrations of iron, titanium and silicon. Doum showed very high concentrations of iron, silicon and titanium .Karkady showed high concentrations of iron, manganese, silicon and zinc. Aradaib showed high concentrations of silicon, iron and zinc.

Recommendations

More studies may be needed for each species by analyzing more samples from different sates of Sudan.

Tabaldy and turmos 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 proteins, carbohydrates, sugars, lipids and vitamins contents.

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