Determination of Some Selected Major, Minor (Trace) and Ultratrace Metals in Some Selected Cereals Commonly Used in Arba Minch, Ethiopia

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Abstract

Cereals are the main source of food in many countries. Iron, Magnesium, Copper and Chromium metals were determined. Cereal samples was digested using HCl and HNO_3 and the metals were determined using atomic absorption spectroscopy (AAS) and results indicates that the amount of metals in cereals is as follows wheat>Barely>maize> bean in average whereas in specific amounts, the amount of metal, Fe, Mg, Cu and Cr in wheat (18.28 $\pm$ 0.032, 18.55 $\pm$ 0.005, 18.01$\pm$ 0.034 and ND), in barely (17.75 $\pm$ 0.037, 17.35 $\pm$ 0.015, 17.02$\pm$ 0.045 and ND),in maize (16.35 $\pm$ 0.065, 13.12 $\pm$ 0.025, 7.05 $\pm$ 0.027 and ND), in bean (14.72 $\pm$ 0.062, 14.36 $\pm$ 0.054, 6.02 $\pm$ 0.014 and ND) respective, chromium did not detected in all cereals and the % recovery of the instrument for all metals is in between 90-102 %.Generally the amount of trace metals that was obtained in this research was in the acceptable range.

Keywords : *Atomic absorption spectroscopy, Cereals, Major metals, Minor metals, Trace metals and Ultratrace metals*

I. INTRODUCTION

Food safety is vital for the survival of all living organisms involved in the food chain [1]. World cereal production is high. In terms of quantity and area, wheat is by far the most popular cereal grown in the world, making up nearly half of the total. Of the remaining 50%, about one-third is maize and one-third is barley. Other cereals grown in smaller quantities include triticale, rye, oats, and spelt. Nearly two-thirds of world's cereal crop is used for animal feed, with around one-third for human consumption. Only 3% is used for biofuels. Cereal grains have been a primary source of nourishment for humans for thousands of years. Cereal group provide significant amounts of most nutrients and form an important part of a balanced diet in many countries. Cereals are the major staple food crop, contributing most of the human daily calorie intake in many cultures, as well as relevant quantities of minerals[2].Wheat, barley, rye and maize are basic food for human and animals. Their content in macro and micro elements depends on plant needs as well as amounts available from the soil. This study should deliver preconditions for the setup (number of replicates, fertilization practices) and interpretation of future projects of more detailed investigations, as well as establish baseline levels to recognize future contaminations [3].In most developing countries like Ethiopia, the quest for rapid economic growth through industrialization and modern agriculture have resulted in a concomitant inflow of several contaminants (such as heavy metals) into the environment. Advancement in technology has challenged the integrity of the environment with discharge of effluents containing heavy metals. Although, heavy metals occur as natural constituents of the earth crust, they are mostly considered persistent environmental contaminants since they cannot be degraded or destroyed. Hence, they can enter the body system through food, air, and water. These bio-accumulations could be over a period of time due to their long half-lives, the potential for accumulation in different organ of body leads to unwanted side effects. Lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), copper (Cu) and many other heavy metals are potentially toxic to humans and are widely dispersed in the environment. In general, heavy metal contaminations threaten agriculture and other food sources for human population. It also leads to poor vegetation growth and lower plant resistance against forest pests. It is well known that copper toxicity induces iron deficiency, lipid peroxidation and destruction of membranes [1].

The mineral and trace element contents of plants are known to be affected by the cultivar of plant, soil conditions, and weather conditions during the growing season, use of fertilisers and the state of plant maturity at harvest [2].Minerals may be broadly classified as macro (major) or micro (trace) elements. The third category is the ultra-trace elements. The macro-minerals include calcium, phosphorus, sodium and chloride, while the micro-elements include iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium and sulfur. The macro-minerals are required in amounts greater than 100 mg/day and the micro-minerals are required in amounts less than 100 mg/day. The ultra-trace elements include boron, silicon, arsenic and nickel which have been found in animals and are believed to be essential for these animals. Evidence for requirements and essentialness of others like cadmium, lead, tin, lithium and vanadium is weak [4].Different descriptions have been defined for the metals currently known as heavy metals which have deleterious effects on human health. A heavy metal is essentially defined as a metal of relatively high density (above 5 g/cm^3). In medicinal concept is used for metals with toxic properties regardless of their atomic weights. Although more than sixty elements were identified as heavy metals, the most frequently encountered and the most pronounced heavy metals are Hg, Mn, Fe, Co, Ni, Cu, Zn, Cd, As, Sn, Pb, Ag and Se. Heavy metals are accumulated particularly in certain organs, ultimately reaching up to toxic levels. Some of them, for instance zinc, selenium and copper are essential for maintaining metabolic activities, however may elicit toxic effects at high concentrations. Elements which are required in minor quantities for physiology of organism are referred to as trace elements. In this regard, Fe, Cu, Se, Zn, Ni and Mn are recognized as trace elements which are needed by the organism for maintaining vital activities [5].

In recent years, determination of metal contaminations in sea foods such as fish, cereals has been important for marine organisms and human health. Essential metals such as iron, copper and zinc play important roles in biological systems, whereas, non-essential metals such as Chromium, lead and cadmium are toxic, even in traces. The essential metals can also produce toxic effects when the metal intake is excessively elevated. Cr, Cd and Pb have cancerogenic properties and Cu is associated with anemia [6].Copper is an essential trace metal, vitally important for both physical and mental development in human, usually found in many food types particularly vegetarian foods such as nuts, seeds and grains. It is important for energy production in cells and is required for women's fertility in relation to estrogen metabolism amongst others. However, Cu accumulates easily in the body, hence, chronic low level intakes of heavy metals have damaging effects on human beings and other animals, since there is no good mechanism for their elimination. Conditions associated with increased copper body burden are arthritis, fatigue, insomnia, scoliosis, osteoporosis, heart disease, cancer, migraine, heart seizures, gum diseases, skin and hair problems. Reported also are mental and emotional disorders such as depression mood swings, fears, anxiety, panic attacks, violence and memory loss [7].A number of trace elements protect the cell from oxidative cell damage as these minerals are the cofactor of antioxidant enzymes. Zinc, copper and manganese are necessary for superoxide dismutases in both cytosol and mitochondria. Iron is a component of catalase, a heme protein, which catalyzes the decomposition of hydrogen peroxide [8].

II. MATERIALS and METHODS

A. Sample collection

Selected samples which are highly consumed in Ethiopia were analyzed. Cereals including Wheat (*Triticum aestivum*), Barely (*Hordeum Vulgare*), maize (*Zea mays*) and Bean (*Phaseolus Vulgaris*) where purchased from Arba Minch town market. Cereal samples were treated before digestion and ground using coffee grinder then kept for analysis. The experiment was carried out at Arba Minch University, Chemistry department Laboratory.

B. Sample preparation

The freshly collected samples were washed with deionized water to eliminate visible dirt and removed the water quickly with a blotting paper. Then the samples were ground into small pieces using coffee grinder, homogenized and accurate amounts were weighed as required for different analysis. Four samples from each cereal were selected for measurement. Four samples from each type of cerealwere selected for the measurement of metal content. Each value represents the average from four replications and the outcomes expressed as mean values ± standard deviations (SD). All the results were expressed as milligram (mg)per 1 kg of the sample.For dry digestion cereals were ground and 2.0 g of each cereal was placed into a crucible. The crucible were placed into a muffle furnace with a programmable heating: grain samples were dried for 1 h at 105 °C; then temperature was increased (20 °C at every 2 Hr) until constant weight were obtained. After that the crucible was removed from the muffle furnace and cooled down, and 1–3 ml of water was added to the residue in the crucible. This procedure was repeated until light gray or white ash was obtained. Then 6 M HCl was added and evaporated. The residue was re-dissolved in 25 ml 0.1 M HNO_3 and this solution obtained was used for element determination.

C. Determination of heavy metals

Iron, Magnesium, Copper, Chromium were determined by Atomic Absorption Spectrometric method.

D. Statistical analysis

Statistical analyses were carried out by using Statistical Package for Social Science (SPSS) for Windows version 8.0. The results obtained in the present study are reported as mean values (obtained from the four replications) ± standard deviation (SD). The significance differences between mean values were analyzed by Duncan multiple range test at a significance level of $p < 0.05$. Recovery (R) was done by spiking all cereals with 0.5 g of standard metals and calculated as follows;

$$R\ \% = \frac{Absorbance\ of\ spiked\ solution - Absorbance\ of\ unspiked\ solution}{absorbance\ of\ unspiked\ solution} * 100$$

Absorbance of all metals was measured at wave length given in table below which is an indication of the maximum absorbance value obtained in a given range of ultraviolet and visible electromagnetic radiation range.

Table 1.wave length for metals

Metals	Wave length (λ) in nm
Fe	248.3
Mg	285.2
Cu	324.7
Cr	357.9

Table 2.the value of minerals in selected cereals

Mineral content							
Samples				Fe (mg/kg)	Mg(mg/kg)	Cu(mg/kg)	Cr(mg/kg)
Local name	English name	Scientific name	n				
Snide	Wheat	Triticum aestivum	4	18.28 ± 0.032	18.55 ± 0.005	18.01 ± 0.034	ND
Bekolo	Maize	Zea mays	4	16.35 ± 0.065	13.12 ± 0.025	7.05 ± 0.021	ND
Gebse	Barely	Hordeum Vulgare	4	17.75 ± 0.037	17.35 ± 0.015	17.02 ± 0.045	ND
Bakela	Bean	Phaseolus vulgaris	4	14.72 ± 0.062	14.36 ± 0.054	6.02 ± 0.014	ND

NB; ND indicates Not Detected
All the results are expressed mean ± standard deviation at 95 % confidence level ($p < 0.05$) value.

III. RESULTS and DISCUSSIONS

Atomic absorption spectroscopy determination of the concentration of Fe, Mg, Cu and Cr in cereals; wheat, barely, maize and bean are shown in figures (1-4) below. The highest concentration of Fe, Mg and Cu was found in wheat (18.28 ± 0.32, 18.55 ± 0.05 and 18.01 ± 0.34 mg/kg respectively). However with regards to mean concentration Fe in cereals, wheat (18.28 ± 0.32 mg/kg), maize (16.35 ± 0.65 mg/kg), barely (17.75 ± 0.37 mg/kg) and Bean (14.72 ± 0.62 mg/kg). Magnesium in cereals, wheat (18.55 ± 0.05mg/kg),maize (13.12 ± 0.25mg/kg), barely (17.35 ± 0.15mg/kg), and bean (14.36 ± 0.54mg/kg) and Cu in cereals, wheat (18.01 ± 0.34 mg/kg),maize (7.05 ± 0.21mg/kg), barely (17.02 ± 0.45 mg/kg) and bean (6.02 ± 0.14mg/kg) whereas Chromium was not detected in all cereals. Almost all the concentrations of the metals are in the recommended level when compared to literatures done in this metals and cereals.Recovery of the instrument for every metal was tested by adding 0.5 gram standard metal for each sample and it was calculated using the above expression, finally the recovery of all metals was in between 90-102 %, which is in the acceptable range of recovery for instruments performance.

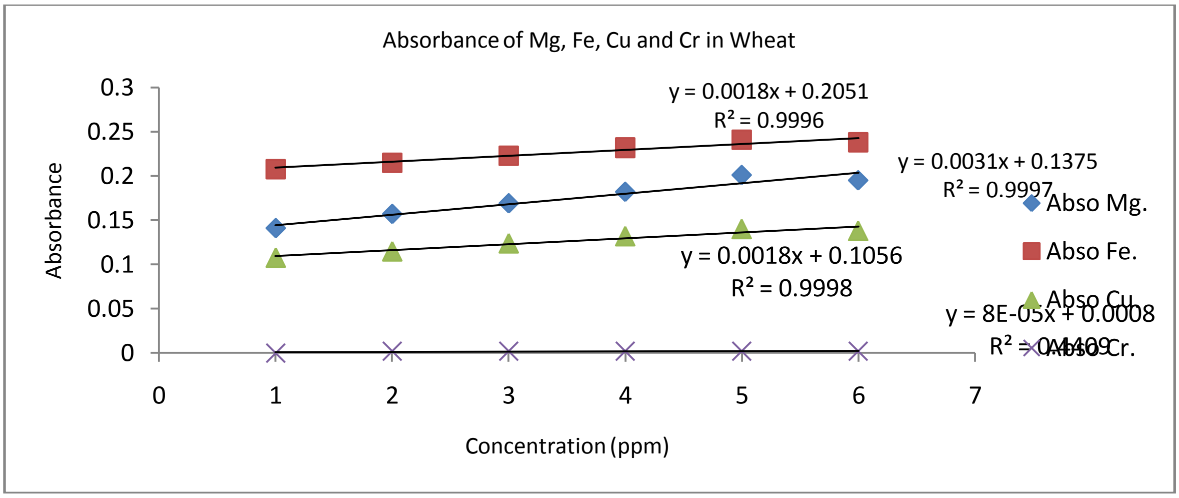

Figure 1. calibration curve of metals in wheat

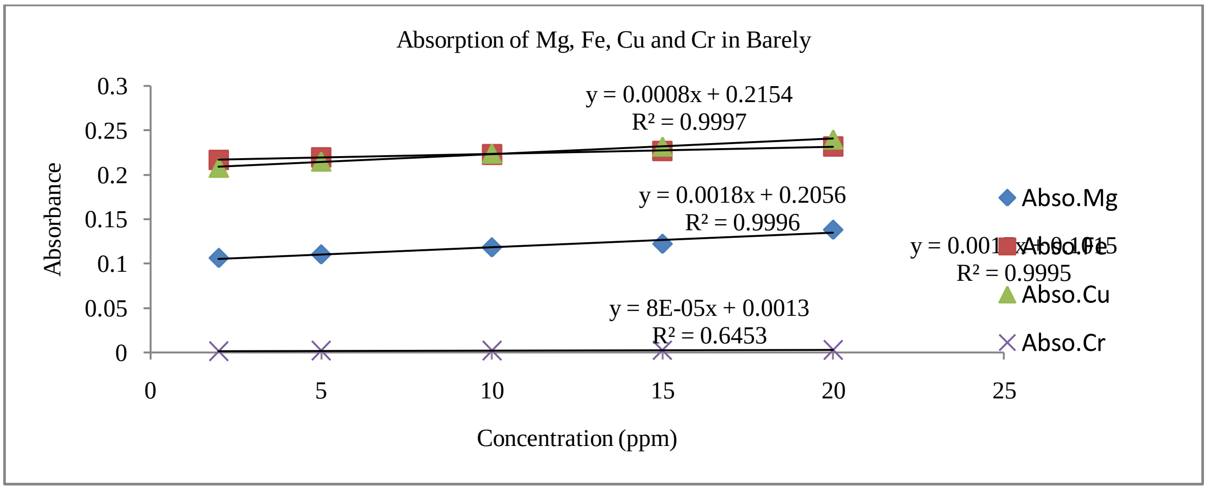

Figure 2.calibration curve of metals in barely

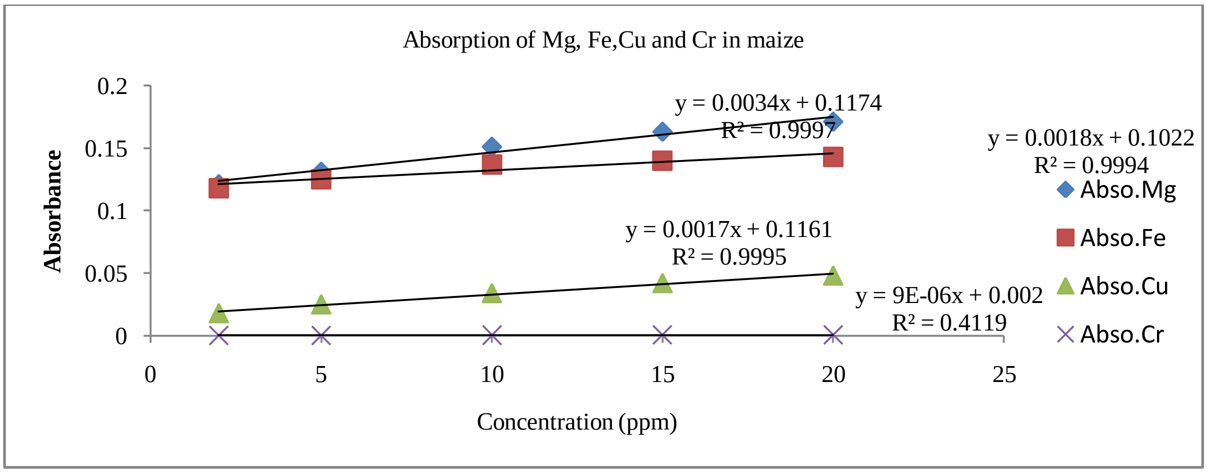

Figure 3.calibration curve of metals in maize

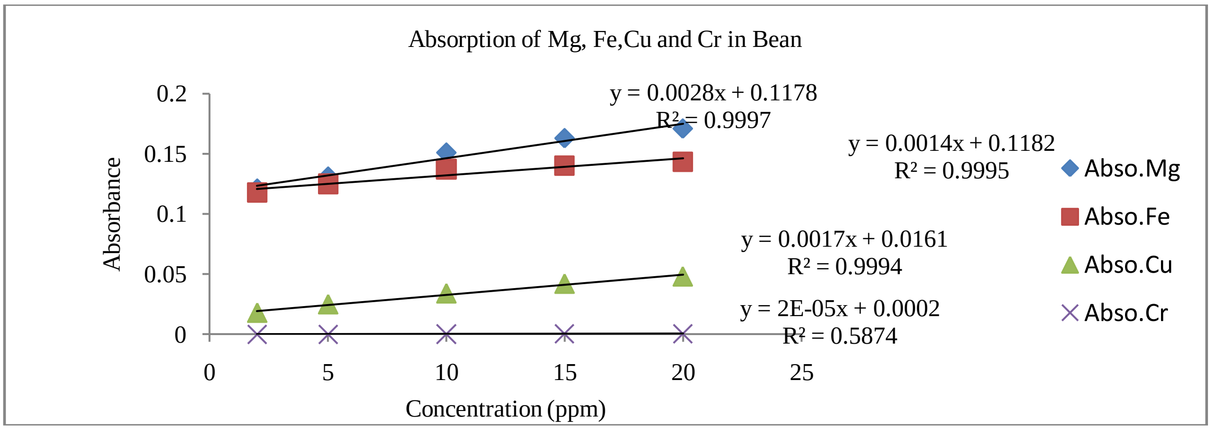

Figure 4.calibration curve of metals in bean

IV. CONCLUSION

The aim of the present study was to investigate the levels of certainheavy metals and trace elements that may be found in some commonly used cereals. It is considered that the findings of the study will be a contribution to assess whether or not the cerealvarieties sold in Ethiopian markets pose a risk for public health in terms of heavy metal content and also it is assumed that demonstration of trace element composition of cereals will elucidate the nutritional value of these products. Moreover, it is anticipated that the findings will serve as a tool for estimating the permissible limit of elements in cereals, which are yet neither nationally nor internationally established.

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