



ELEMENTAL CONCENTRATION OF PACKAGED MEALS (BAKED AND EXTRUDED GOODS MADE USING COMPOSITE CEREAL-PULSE FLOUR) PROCURED AT DEBRE TABOR MARKETPLACES IN ETHIOPIA

G. Mekuannent Alemye*

Department of Nuclear physics, Andhra University, Visakhapatnam 530003, Andhra Pradesh, India *Corresponding Author

A.D.P. Rao

Department of Nuclear physics, Andhra University, Visakhapatnam 530003, Andhra Pradesh, India

P.V. Lakshmi Narayana

Department of Nuclear physics, Andhra University, Visakhapatnam 530003, Andhra Pradesh, India

ABSTRACT

The elemental analysis of packed food items which is collected in Debre Tabor markets, Ethiopia namely Pasta, Macaroni, cookies, biscuit, wheat bread, white teff injera, Red teff injera, barley so, barleycorn and maize bread samples were carried out using EDX spectrometer. An X-ray beam was used to excite each sample and spectra were recorded with a high-resolution Si(Li) detector. The data analysis was carried out by software. Trace elements P, K, Na, Cl, Mg, Ca, Fe, Al and Zn were estimated, and elemental concentrations were determined. To get the exact results of the present study the analysis repeats three times.

KEYWORDS : EDX, Packed food, Elemental composition, ppm, Essential elements, major elements

INTRODUCTION

Cereals are common food crops of the world. They provide food calories and proteins to humans. They are staple foods for most of the population. Cereals and derived products are among the major dietary sources of essential elements for humans[1]. The development of baked and extruded products prepared with cereal-pulse composite flour can dramatically improve the protein quality of the final product as the composition of amino acids in their proteins is complementary each other. The cereals have been found to be deficient in one or more essential amino acids like lysine and threonine; on the other side there is a lack of methionine in pulse protein[2].

Packed foods: Cereals and derived products are among the major dietary sources of essential elements for humans[1]. Wheat is considered a good source of protein, minerals, B-group vitamins and dietary fiber, although the environmental conditions can affect the nutritional composition of wheat grains with its essential coating of bran, vitamins and minerals; it is an excellent health-building food. Wheat flour is used to prepare bread, produce biscuits, confectionary products, noodles and vital wheat gluten or seitan. Wheat germ and wheat bran can be a good source of dietary fiber helping in the prevention and treatment of some digestive disorders. The antioxidant activity and phytochemical content were studied in milled grain of eleven varieties which included a range of red and white wheat and durum wheat. In Ethiopia, barley is used in many different recipes and deep rooted in the culture of people's diets[4]. In the highlands, it has been used for the preparation of various types of traditional foods such as kolo (roasted barley, corn), dabo (bread), beso (barley so), Genfo (porridge), chuko, tihlo, shorba (soup), kinche, and injera, with injera being the most widely consumed traditional dish in Ethiopia[5].

Pasta: Pasta was reportedly brought to Europe from China around the 13th century, according to historical accounts. Germany is claimed to have been the first country in Europe to produce pasta on a commercial scale in the fifteenth century. It is evident that references to pasta prepared from durum wheat flour date back to the Near East, primarily in Greek, Persian, and later Arabic countries[6]. Pasta is made by combining milled wheat, water, eggs and occasionally other substances. These materials are usually put to a continuous, high-capacity auger extruder, which can be outfitted with a variety of colors to decide the product's form. After that, it's dried and packed for sale[7]. Pasta is regarded as one of the world's oldest foods

and a highly adaptable dish, both nutritionally and gastronomically. It's also high in complex carbs, proteins, B vitamins, and iron while being low in sodium, amino acids, and total fat[8][9].

Macaroni: Dry pasta known as macaroni is fashioned like little tubes. Short lengths of elbow macaroni, which is often made from durum wheat, are also known as straight macaroni. As the pasta tube exits the machine, opposite sides are extruded at various speeds to produce the curved shape[10]. Durum wheat semolina, which is typically used to make pasta products, offers lesser quality nutrients like protein, fiber, and minerals when compared to other cereals and legumes. The findings demonstrated that when the proportion of teff and chickpea flour grew, the macaroni's protein, fiber, fat, iron, and zinc contents significantly increased[11].

Barley so: Barley-so commonly called Beso in Amharic is a drink of lightly roasted barley flour with honey or sugar. Beso is basically prepared from the roasted barley flour. Beso can also be prepared by mixing the flour with cold water and sugar, and served immediately in a cup or glass. According to most Ethiopians, beso cures gastritis[5].

Barley corn: Kolo, or barley corn, is Ethiopia's most popular roasted whole barley grain. The bran from the grain is separated during the manufacture of kolo utilizing two dehulling steps: fitega and shiksheka. The whole grains of barley are steeped in hot water for a few hours before being rubbed in a mortar with pestle (i.e., the fitega process). The grain is extensively roasted over iron/clay pans after the bran is removed from the grain by subsequent blowing. Finally, the roasted grain is dehulled a second time by lightly pounding it with a mortar and pestle (the shiksheka procedure) or rubbing it by hand to remove any remaining hulls. Kolo is a popular local snack that can be eaten alone or with peanuts, field peas, faba beans, sunflower seeds, and chickpeas[5].

Biscuits: A biscuit is a tiny baked good mostly comprised of flour, sugar, and fat. The biscuit differs from other baked goods like bread and cakes because it has less moisture. It typically has a moisture content of less than 4%, giving it a lengthy shelf life of up to six months[12]. The most popular processed food items worldwide are bakery goods. Given that they are created from straightforward, inexpensive, and widely accessible raw materials, biscuits comprise the largest

category of snack foods among bakery items. They are extensively consumed because they have a very palatable taste and a long shelf life due to their low water activity. Unfortunately, biscuits are also high-energy, easily digestible foods because they are typically composed from wheat flour and fat. If they are consumed frequently, especially in excess, they may have a deleterious effect on health[13].

Wheat bread: All social classes in human civilization consume bread. Its high caloric content and low cholesterol levels, as well as its high acceptance and the convenience of its eating, may all contribute to its enduring popularity. Potassium bromate, one of the ingredient, serves as a maturing agent by enhancing the loaf's volume and dough processing qualities. Although bromate has been shown to be a useful component in some other items, it has been discovered that the bromate added to bread during the baking process is to blame for illnesses like cancer and kidney failure[14].

Wheat cookies: Cookies, known in the United Kingdom as a type of biscuits but more generally referred to as "cookies" in USA is regarded as confection-food with low moisture content. It has been shown that the whole grain is a concentrated source of essential nutritional components such as vitamins, minerals, protein, fat and fiber while the refined grain is mostly starch. Wheat therefore, is perhaps the most popular energy grain for the production of confectionary products, because of the unique properties of its protein (gluten) which combines strength and elasticity required to produce bread, cookies, cakes and pastries such as spaghetti, macaroni and noodles of desirable texture and flavor[15]. Normally, wheat short-dough cookies are considered to be foods with low nutritional value, as their recipes have high fat and sugar content. The consumption of this type of cereal-based product is case of health disorders and diseases such as obesity, diabetes, and tooth decay. Therefore, any attempts to increase the nutritional value of cookie products are welcome. One way to achieve this goal is to use different composite flours[16].

Teff bread or Injera: "Injera" is an Amharic word for Ethiopian

bread that resembles pan cake and is typically prepared with teff. After several fermentations, injera is made from teff flour, water, and starter. Because of the fermenting process, the best acceptable (sensory) injera should have a lot of eyes, be softer, thin, rotable, and have a sour taste. Injera is a traditional ethnic staple meal eaten throughout Ethiopia and Eritrea. In this sense, Ethiopians have unique ideas and attitudes regarding foods; injera plays an important and prominent position in Ethiopian society. Ethiopians always celebrate national and religious festivals, as well as family events such as weddings, birthdays, and funerals. Injera makes up the majority of the cuisine for lunch and dinner in all settings[17].

Materials and Methods

Sample collection and preparation

Ten different packaged food samples were collected in Debre Tabor city markets. An agate mortar was used to powder the samples. After being powdered, the samples were run through a 100-mesh screen to obtain a fine, uniform powder. To get rid of any moisture, the powder form of the samples was dried at 45°C until the weight became uniform. In the last phase, each sample was weighed to determine a small representative mass between 0.25 and 0.300 g, which was then heat sealed in a polyethylene sheet for inspection.

Experimental studies and Method of Validation

At Mangalore University in Karnataka, experiments were conducted to determine the chemical makeup of Packed food materials using an EDX analyzer (CARL ZE155, OXFORD instruments EDX, USA) spectrometer. Analyzing certified reference materials derived from Apple leaves (NIST1515) verifies the EDX method's accuracy and truthfulness.

RESULTS AND DISCUSSION

According to this study, the concentration of 9 elements were determined quantitatively in ten packed food items of different kinds. As indicated in table 1 and figure 1 a significant amount of the macronutrients P, K, Na, Cl, Mg and Ca and also the micronutrients Fe and Zn were acquired from these sources.

Table 1: Elemental concentration of Ethiopian packed food items (ppm)

packed foods	P	K	Na	Cl	Mg	Ca	Fe	Al	Zn
Pasta	3266.67±151.67	633.3±1305.118	1233.3±208.16	300±100	833.67±152.752	766.67±159.02	146.67±50.33	BDL	33.33±57.73
Macaroni	2433.667±416.33	600±200	1533.333±513.16	383.3333±76.376	1033.3±57.52	566.667±158.37	133.3333±57.735	BDL	BDL
Barley so	1933.333±152.75	4333.33±208.16	466.667±57.73	3133.333±57.735	1300±300	866.667±57.735	66.667±57.735	BDL	33.333±57.73
Barley Corn	6933.333±1266.2	4733.333±907.37	300±100	1166.667±251.66	766.6667±251.66	433.333±152.75	233.333±57.735	66.667±57.7	33.3333±57.73
Biscuits	9366.667±550.75	1166.667±57.735	4500±600	2433.333±152.75	2500±100	233.333±57.735	166.667±57.735	333.333±57.73	66.667±57.73
Wheat Bread	3833.333±305.50	866.667±57.735	4066.667±57.735	3900±100	1433.333±251.66	333.333±57.735	133.333±57.735	366.667±57.73	100±0
Wheat cookie	10700±2206.8	1733.333±251.66	5533.333±568.62	2866.667±152.75	1833.333±115.47	533.333±152.75	166.667±57.735	333.333±152.7	66.667±57.73
white teff Injera	2366.667±230.94	4600±458.25	2566.667±152.75	366.667±57.735	2266.667±208.16	1666.667±57.735	133.333±57.735	100±0	66.667±57.73
Maiz Bread	6933.33±208.17	3233.333±152.75	1166.667±208.16	2866.667±152.75	1000±100	166.667±57.735	133.333±57.735	166.667±57.73	BDL
Red teff Injera	3200±351.19	6033.33±57.735	3133.333±152.75	266.667±115.47	2433.33±57.735	1933.333±57.735	200±100	100±0	166.667±115.4
Maximum	10700±2206.8	6033.33±57.735	5533.333±568.62	3900±100	2500±100	1933.333±57.735	200±100	366.667±57.73	166.667±115.4
Minimum	2366.667±230.94	600±200	300±100	266.667±115.47	766.667±251.66	166.667±57.735	66.667±57.735	66.667±57.7	33.333±57.73
Average	5396.7	2793.3	2450	1768.3	1540	746.67	151.33	146.7	56.67

Ppm = parts per million and BDL = below detection limit

Phosphorus (P): Phosphorus causes muscles to contract and aids in the development and maintenance of bones, teeth, and nerves. Children with phosphorus deficiency experience growth restriction and bone problems. Rich sources of phosphorus include dairy products, meats, poultry, beans, nuts, and seeds. The value of phosphorus in this work ranged from 2366.667 ± 230.92 to 10700.667 ± 2206.8 , from this value the phosphorus content in macaroni is in good agreement with the reported value of noodle elemental content by N. Naumova et al.[18].

Potassium (K): Potassium is essential for nerve impulse conduction, muscular contraction, and fluid equilibrium. It protects against stroke risk and promotes brain health. Edema (swelling), brain damage, and irregular heartbeats are all effects of low potassium. Potassium is abundant in bananas, sweet potatoes, avocados, beets, and dates.

Sodium (Na): Sodium conducts nerve impulses, aids in muscular contraction, and regulates the body's fluid balance. Table salt is the main dietary source of sodium. But salt should only be consumed in moderation. The level of sodium in this study was ranged from 300 ± 100 ppm in barley corn to 5533.333 ± 568.62 ppm in wheat cookies, which was in good accord with the reported value of Yemeni wheat bread's elemental composition of 581 ppm to 5556 ppm [19].

Chlorine (Cl): In conjunction with sodium, chloride keeps the body's proper fluid balance. It is utilised to create hydrochloric acid, or stomach acid, for digestion and to maintain the body's electrical balance. Chloride is abundant in table salt, tomatoes, celery, lettuce, and other foods.

Magnesium (Mg): Magnesium functions as a cofactor in a number of enzyme processes and is necessary for the production of glutathione, an antioxidant, and DNA. Whole grains, legumes, nuts, seeds, and green leafy vegetables all help to restore dietary magnesium. The concentration of magnesium in this work was ranged from 766.6667 ± 251.66 to 2500 ± 100 , this is in good agreement with the reported value of elemental analysis of bread by A. Winiarska-Mieczan and M. Kwiecie [20].

Calcium (Ca): Calcium strengthens bones and teeth and aids in the regulation of metabolism, muscle contraction, blood coagulation, nerve transmission, and cell communication. Calcium deficiency makes bone brittle and prone to fracture. Good sources of dietary calcium include milk and dairy products, cashews, dates, broccoli, parsley, and greens. The level of Mg, K and Ca in wheat products (cookies, biscuit and bread) was in good agreement with the reported values of the study's Durum and bread wheat flours by M. Ciudad-Mulero, M. C et al.[21].

Iron (Fe): Hemoglobin, which transports oxygen in the blood, is made from iron. Cell death and cellular hypoxia (reduced oxygenation) can result from iron shortage. Iron is abundant in green leafy vegetables and meats like beef, poultry, and pork. The concentration of iron in this study was ranged from 66.667 ± 57.735 to 200 ± 100 ppm, specifically iron concentration in injera was 133.333 ± 57.735 and 200 ± 100 ppm for white and red teff injera's respectively which is below the previously reported value of 342 ppm by T. Leykun et al.[22].

Zinc (Zn): Zinc is a crucial component for the synthesis of several enzymes and hormones. In this study, Zn concentrations in packaged foods ranged from 33.333 ± 57.73 to 166.667 ± 115.4 ppm, however it was below the detection limit in macaroni. Which is in good agreement with the level of zinc in Ethiopian barley food products studied by Z. Tilahun et al.[23] 3.85 to 175 ppm. This mineral supports wound healing,

immunity, and cell division. The immune system suffers when zinc levels are low. Major sources of zinc include oysters, red meat, chicken, beans, nuts, and whole grains.

All nine elements have favourable associations in samples 1 and 2, as depicted in the figure below. Fe and the other components of sample 3 interact negatively (barley so). Compared to the remaining six elements, sample 6's Cl and Al concentrations were higher. P showed a declining value in sample 8. Cl had a rising value at nine. P, Cl, and Al had decreasing values at sample 10 (red teff injera), whereas the other 6 elements had increasing values.

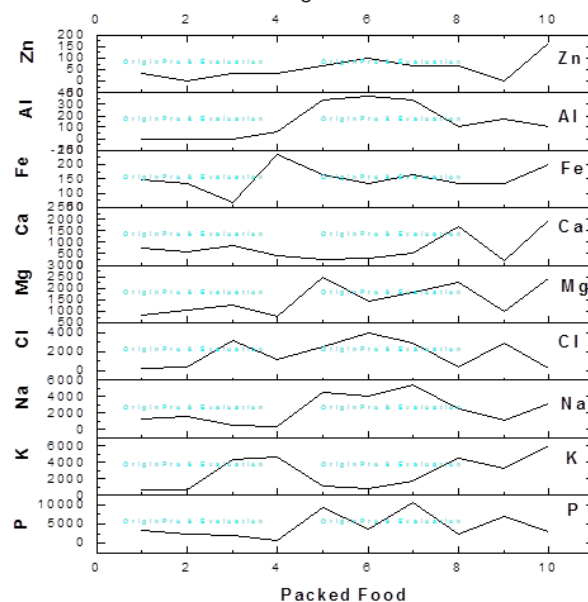


Figure 1: Elemental concentrations in Ethiopian packed foods

The correlations in table 2 display the coefficients after evaluation for all the elements that were observed. Correlations could point to a lack of metabolic control, a common source, or a common absorption mechanism. As shown in table 2 below the highest positive correlation determined between Aluminium and sodium ($r = 0.85$) and the second highest value was between magnesium and zinc ($r = 0.0708$).

Table 2: correlation relation between elements found in packed food items

	Mg	K	Ca	P	Fe	Al	Cl	Na	Zn
Mg	1	0.250	0.511	0.138	0.113	0.451	-0.040	0.693	0.708
K		1	0.651	-0.141	0.231	-0.334	-0.238	-0.317	0.366
Ca			1	-0.552	0.064	-0.381	-0.599	-0.010	0.606
P				1	0.268	0.603	0.534	0.439	-0.107
Fe					1	0.155	-0.373	0.162	0.344
Al						1	0.656	0.850	0.358
Cl							1	0.316	-0.058
Na								1	0.552
Zn									1

CONCLUSION

The study focuses on the elemental analysis of a few packaged meals that were bought from marketplaces in Debre Tabor, Ethiopia, and were consumed by the locals as breakfast and snacks. Energy Dispersive X-ray Spectroscopy was used to identify and quantify these ten different food items' elemental contents. The results showed that such packaged foods include significant amounts of trace elements as potassium, magnesium, calcium, iron, zinc, sodium, phosphorus, chlorine and aluminum. The environmental factors, the kinds of raw materials utilised to prepare these packed foods, or the geographic region where the food material grows all have an impact on the elemental

concentration of these food materials.

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