Elementary Analysis on the Differences between Some Samples of Rice and Wheat Powders by EDXRF Technique

Khin Sint Sint Kyaw
University of Computer Studies, Thaton
sint999@gmail.com

Abstract

This research work presents a study of the classification of elements contained in some rice and wheat samples by using the energy dispersive X-rays fluorescence spectrometer with X-rays analysis software. The measurements were done at University Research Centre (URC), Yangon University with EDXRF facilities (EDX 700 instrument).In this research; qualitative and quantitative analysis of the rice and wheat samples were investigated. Three groups of rice samples are obtained from the various townships of Ayeyarwady division and three classes of wheat samples are obtained from local market. This study aimed to describe the application of an EDXRF (Energy dispersive X-ray fluorescence) method to determine the element concentration percentages of P, K, Ca, Fe, Mn, and Zn in wheat and rice samples. This paper also presented the properties of the contained elements and the effects of those elements on human beings. It is also observed that rice and wheat are essential nutrients for human beings.

Keywords: *XRF analysis, EDXRF, qualitative, quantitative, rice and wheat samples.*

1. Introduction

X-ray fluorescence analysis (XRF) has previously been used in quantitative and qualitative elemental analysis of a wide range of organic and inorganic samples. The basis for the technique is that all elements emit secondary (fluorescent) X-rays of characteristic energy when exposed to X-rays of appropriate higher energy, with energy and intensity of emitted X-rays used to determine elemental composition. In general, the heavier the element being analyzed, the higher the energy of X-rays required to elicit fluorescence, the higher the energy of fluorescence, and the easier it is to detect fluorescence. The lightest elements found in biological samples (e.g. H, B, C, N, O) are not generally detectable by XRF, while elements such as Na, Mg, P, S, Cl, K, Ca are detectable, but only at high concentrations or with highly specialized conditions, and heavier elements such as the trace metals Mn, Fe, Cu and Zn or toxic heavy metals are readily analyzed, even at trace levels.

The X-ray fluorescence analysis (XRF) technique is nondestructive and can be used for various applications like solid, powder, liquid and wafer. Therefore XRF is used for research and development (R & D) and quality control in a wide range of applications, including; universities, research institutions, electronic industries and the metal industries. The general organization of this paper is described as follows: In section 1, X-ray fluorescence analysis is briefly introduced. Section 2 is the overview of Energy Dispersive X-ray Fluorescence Analysis. Section 3 provides experimental procedure of wheat and rice samples. Then measurable quantities results are illustrated and thoroughly explained in section 4.At the end; section 5 concludes the work of this paper.

2. Energy Dispersive X-ray Fluorescence Analysis

There are essentially two methods of X-ray fluorescence analysis. They are Wavelength Dispersive X Ray Fluorescence method (WDXRF) and Energy Dispersive X Ray Fluorescence (EDXRF) method. EDXRF is designed to analyze groups of elements simultaneously. This type of XRF instrumentation separates the characteristic x-rays of different elements into a complete fluorescence energy spectrum which is then processed for qualitative or quantitative analysis [1]. The main advantages of energy-dispersive X-ray fluorescence (EDXRF) analysis are its multi- element capability and its nondestructive nature, combined with the need for only simple sample preparation without time-consuming sample destruction, and which only requires personnel with minimum manual skills. This is undoubtedly the cheapest and the simplest analysis technique among the instrumental analytical techniques.

2.1. Instrumentation in EDXRF System

An EDXRF system consists of several basic functional components. These components are an X-ray excitation source, sample chamber, Si (Li)

detector, preamplifier, main amplifier and multi-channel pulse analyzer. The performances of an EDXRF system differ upon the electronics and the enhancements from computer. The excitation sources of different types are used in an EDXRF system. The excitation sources produced the X-ray beam that is used to X-ray fluorescence in the sample target. The block diagram of EDXRF system is described in figure 1.

In this system, a Si (Li) detector normally consists of a protective window, a gold contact layer, a Si dead layer and the Si (Li) active crystal. When an X-ray photon from the sample is collected in the Si (Li) detector diode, electron-hole pairs are generated and are swept to the terminal of the detector by the high voltage applied across it. The number of the electron-hole pair is proportional to the energy of the photon. The pairs are accumulated by a capacitor and a pulse is generated with voltage height proportional to the number of pairs. The pulse is sent to a feedback preamplifier and then to the main amplifier. The amplifier pulse is then processed by a multi-channel analyzer (MCA) within which it is transformed into a digital signal by an analog to digital converter (ADC). The output of the ADC becomes the address of a channel in the memory unit where an add-one operation is performed. The detection procedure mentioned above continues and a spectrum is then formed as counts (intensity) versus channel and is displayed on PC monitor.

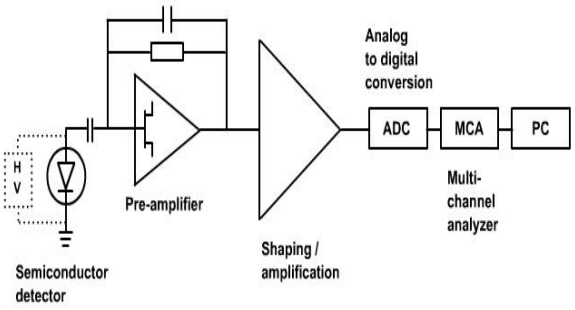

Figure 1. Block diagram of electronic set- up of EDXRF system

2.2. Shimadzu's EDX-700 Energy Dispersive X-Ray Fluorescence Spectrometer

A very high-performance, general-purpose instrument, Shimadzu's EDX-700 Energy Dispersive X-Ray Fluorescence Spectrometer provides rapid, non-destructive elemental identification and quantification of solid, liquid, and powder samples with no sample preparation. The Shimadzu's EDX-700 offers an array of features to deliver enhanced performance and operation. This machine include an automatic opening/closing door, a large sample chamber that can accommodate samples up to 300 mm wide and 150 mm high, and five types of filters for high-sensitivity analysis. Its measurement range is Na (11) to U (92), while the X-ray tube is Rh target with a voltage of 5 to 50 kV and a current of 1 to 1000 μ A. Analysis can be performed in air, Helium (optional), or Vacuum (optional). The detection unit is a Si (Li) detector with a resolution of (155 e V (Mn K α, 1500 cps). X-ray spectra were acquired on a PC base MCA [2].

3. Introduction of Wheat and Rice Grains

Each grain is different in its nutritional value. Rice has many B-complex vitamins, minerals like magnesium in larger percentage, proteins, dietary fibers and carbohydrates. On the other hand, whole wheat contains good amount of proteins, sodium, vitamin-B6, calcium, carbohydrates and more dietary fibers. Rice and wheat are the most important food sources of human beings. Especially, rice is the staple food of a large majority of the people in Asia and wheat, in Europe. In Myanmar, rice is the staple food for citizens. Probably 92 percent or more of the world rice crop is produced and consumed in monsoon Asia. Wheat is also grown in all temperate countries and in most of the subtropical countries of the world as well as high elevations in some tropical countries. There are so many different types of rice all over the world. They are Arborio rice, Basmati tice, Black rice, Jasmine rice, Brown rice, Red cargo rice, Parboiled rice, Sticky rice, Sushi rice, Valencia rice, Long grain white rice, Wild rice and Calrose rice [3]. Most of rice in Myanmar can be classified into three groups. They are Kaukyn. Kauklat and Kaukgyi. Under the official grain standards, wheat is divided into six classes primarily on the basis of colour, kernel texture and variety characters. They are Hard red spring, Hard red winter, Soft red winter, Hard white, Soft white and Durum [4].

3.1. Sample Collection and Preparation

In this research, three kinds of rice samples were taken; Baygerlay from Phyapon township, Kaukgyi from Maubin township and Ngakyauk from Nyaungdone township in Ayeyarwady division. Three wheat samples were taken; red rocket high quality wheat flour (Donepyan) from Diamond Star Flour Mill, OK high quality wheat flour (OK) and another low quality wheat flour from U Kyu Family grains & Manufacturing Co., LTD. The amount of sample material required for an accurate quantitative analysis can be less than a few milligrams with conventional excitation. For EDXRF analysis of processed foods and beverages, sample are typically homogenized and

pressed into pellets. So the samples were made dry, powdered and pressed into pellets in 12 tons by hydraulic press. The pellets were weighted with scientific balance. The diameter of each pellet is 2.5 cm. The photographs of research samples are mentioned in figure 2.

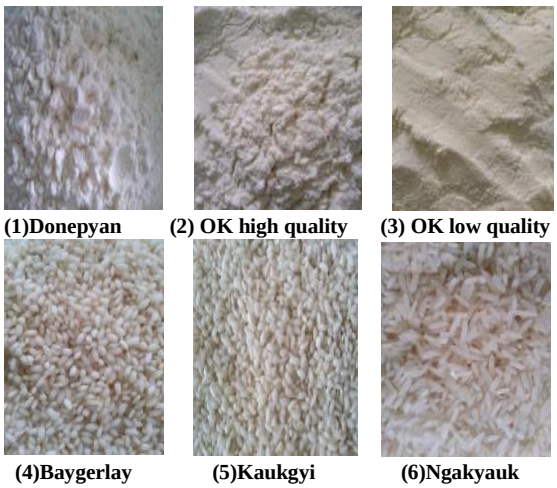

Figure 2. Wheat and rice samples photos

4. Results and Discussion

4.1 Analysis of the Results from X ray Spectra

The analyzed results of wheat samples are shown below in table 1 and rice samples are also shown below in table 2. From the results, it is obvious that the element potassium (K) and iron (Fe) were mainly found in both samples. Other elements such as calcium (Ca), manganese (Mn) and zinc (Zn) were found only in two samples (i) code no. 3, wheat sample (OK low quality) and (ii) code no. 5, rice sample (Kaukgyi).

In the results of wheat samples table 1, it is found that code no. 1, red rocket high quality wheat flour (Donepyan) from Diamond Star Flour Mill presents the most potassium (K) among these wheat samples and code no. 2, the high quality 'OK' wheat flour from U Kyu Family grains & Manufacturing Co., LTD also presents the most iron (Fe) among them. But unexpectedly, code no. 3, the low quality 'OK' wheat flour from U Kyu factory has more other three elements manganese (Mn), Zinc (Zn) and calcium (Ca) than potassium (K) and iron (Fe).

Similarly the results of rice samples from table 2 were observed that code no. 4, Baygerlay from Phyapon township is the most potassium (K) in all three rice samples and code no. 6, Ngakyauk from Nyaungdone township is the most iron (Fe) in these samples. But the element, calcium (Ca) was found only in code no.5, Kaukgyi from Maubin township in addition to potassium (K) and iron (Fe). Then according to measurable data, the comparison of contained elements in three wheat samples is illustrated graphically with the bar chart in figure 3. And the comparison of contained elements in three rice samples is also described in figure 4.

Sample code no.	Element concentration%				
	K	Fe	Mn	Zn	Ca
1	75.928	24.072	-	-	-
2	71.102	28.898	-	-	-
3	56.891	10.283	7.512	7.129	18.184

Table 1. Results for three wheat samples

Table 2. Results for three rice samples

Sample code no.	Element concentration%		
	K	Fe	Ca
4	72.458	27.542	-
5	45.375	25.262	29.363
6	63.457	36.543	-

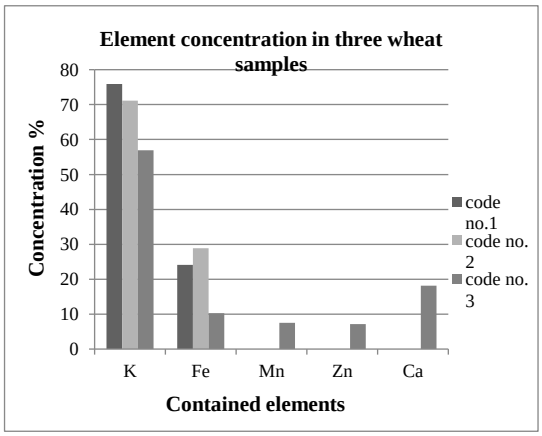

Figure 3. Comparison of element concentration in three wheat samples

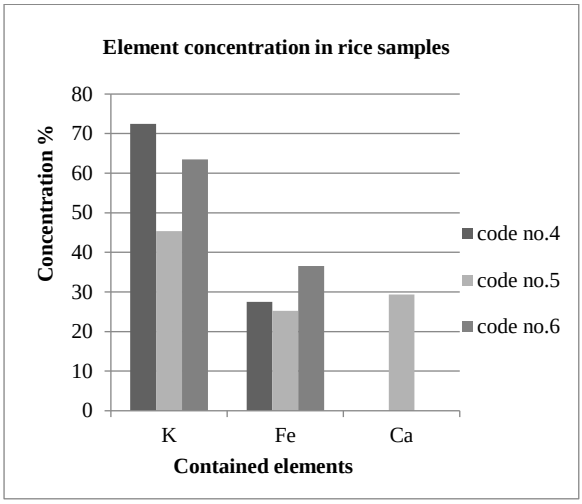

Figure 4. Comparison of element concentration in three rice samples

4.2 Discussion on Mineral and Medical Issues

From the mineral point of view, human beings need to take minerals as nourishment for their health. Minerals are inorganic elements that are necessary for the body to build tissues, regulate body fluids or assist in various body functions. They can combine with other elements in the body but maintain their chemical identity. Based on the amounts needed in the body, they are categorized as macro minerals and micro minerals. Macro minerals are needed in the diet in amounts greater than 100mg per day. Micro minerals are needed in the diet in amounts of 100mg or less per day. Calcium (Ca), Phosphorus (P), Magnesium (Mg), Sodium (Na), Potassium (K), Chlorine (Cl) and Sulphur (S) are the major (or) macro-minerals and Iron (Fe), Copper (Cu), Manganese (Mn), Zinc (Zn), Chromium (Cr),Silicon (Si), Iodine (I) etc. are the minor (or) micro-minerals for human beings [6]. From the finding results of this paper, analyzed samples contain Calcium (Ca) and Potassium (K) as macro-minerals and Manganese (Mn), Zinc (Zn) and Iron (Fe) are as micro-minerals.

From the medical point of view, Potassium (K) and Calcium (Ca) are very important for human body. Potassium (K) is required about 2 mg to 3 mg and also Calcium (Ca) is required about 0.5 g to 1g per day. Besides Iron (Fe) is required about 12 mg to 15 mg, as the daily requirement [7]. Among the toxic elements such as Zinc (Zn), Chromium (Cr), Arsenic (As), Zinc (Zn) is included. However Zinc (Zn) has a very little disadvantage and plays an important role for human body.

5. Conclusion

Rice and wheat grains are the principle food crops of all population around the world. They contain a lot of minerals and owe to their unique nutritional values. According to the results, the wheat and rice samples possess both macro-minerals and micro-minerals for human body but do not possess toxins for the body. The elements such as Potassium (K), Iron (Fe), Calcium (Ca), Manganese (Mn) and Zinc (Zn) which are occurred in all samples are required for the body as essential or basic nutrients. These elements have to be provided to the body because they cannot be synthesized by the body at a rate sufficient to meet its need. It can be also said that all investigated samples were within legal limits and show no health risk.

The optimum mineral requirements for human beings are Potassium (K) and Iron (Fe). Especially the results of Potassium (K) and Iron (Fe) were more present than other elements in all sample types. Thus, experimental results were agreeable. Moreover, the rice and wheat samples contain numerous other components such as proteins, fats, carbohydrate, vitamins, minerals etc. Among these components, it can be described that the mineral part by EDXRF technique in 100% in accuracy. By the comparison of wheat to rice samples, the only one of the wheat sample has more elements than rice samples. Finally it can be concluded that by eating the wheat and rice as principle food, the same effect can acquire by human beings from the mineral point of view. And the author expects to confirm this conclusion will help further more research works.

Acknowledgments

The author wishes to acknowledge her deepest gratitude to Professor Dr Thet Tun Aung (Retired), Department of Physics, for enlightening the first glance of research. The author is also grateful to UJCIR, the editorial board for permitting the submission of this paper. The author would like to express her special thanks to all respectful teachers, her colleagues and her family for their supports, kindly advices and help in completing her research work.

References

[1] Revenko, Anatoly G., X-*Ray Spectrometry*, 2002, 31, 264-273.

[2] Energy Dispersive X-Ray Fluorescence Spectrometer (Shimadzu's EDX-700) catalogue at University Research Centre (URC), Yangon University

[3]Leonard,Warren H Leonard & John H martin, *Cereal crops* ,New York ,Macmillan,1963.

[4] https://www.rdasia.com.

[5]Min Yao, Dongyue Wang, and Min Zhao, "Element Analysis Based on Energy-Dispersive X-Ray Fluorescence", *Advances in Materials Science and Engineering*, Dec 2015, pp 1-7.

[6] Nicholas G. Paltridge, Paul J. Milham, J. Ivan Ortiz-Monasterio, Govindan Velu, Zarina Yasmin, Lachlan J. Palmer, Georgia E. Guild & James C. R. Stangoulis, "Energy-dispersive X-ray fluorescence spectrometry as a tool for zinc, iron and selenium analysis in whole grain wheat", *Plant and Soil* ,volume 361, 2012, pp. 261–269.

[7] Vitamin and mineral requirements in human nutrition: *report of a joint FAO/WHO expert consultation*, Bangkok, Thailand, 21–30 September 1998.