Elemental Concentration in Morinda

[1] Hla Hla Win, [2] Zaw Win, [3] Soe Soe Oo
[1]Engineering Physics Department, Myanmar Aerospace Engineering University
[2]Engineering Physics Department, Technological University (Mandalay)
[3]Engineering Physics Department, Technological University (Yamethin)
hlahlagreenwin2012@gmail.com

Abstract— Morinda citrifolia (*Ye - Yo*) has been used widely as a complementary and alternative therapy in many countries owing to its potent antioxidant activity and proven health benefits. It was investigated by using the Energy Dispersive X-ray Fluorescence (EDXRF) detection technique. In Morinda leaves, calcium was the largest concentrated element, and potassium and sulphur were the second largest elements. Manganese, iron, strontium, copper, silver, zinc and bromine were trace elements. In Morinda fruit, potassium was also the largest concentrated element, and phosphorous, calcium and sulphur were the second largest elements. Iron, manganese, copper, titanium, zinc and strontium were found as trace elements. In Morinda bark, potassium and calcium were the largest concentrated elements, and Sulphur and iron were the second largest elements. Other elements such as manganese, titanium, copper, silver and zinc were trace elements. The uses of Morinda and its elements were discussed.

Keywords— Balance, Concentration, Energy Dispersive X-ray Fluorescence, EDX-7000, Morinda, Pharmacologically active

INTRODUCTION

Morinda citrifolia (*Ye – Yo*) is a fruit-bearing tree in the coffee family, Rubiaceae. Its native range extends across Southeast Asia and Australasia, and the species is now cultivated throughout the tropics and widely naturalized. Among some 100 names for the fruit across different regions are the more common English names of great morinda, Indian mulberry, noni, beach mulberry, and cheese fruit. The strong-smelling fruit has been eaten as a famine food or staple food among some cultures, and has been used in traditional medicine. In the consumer market, it has been introduced as a supplement in various formats, such as capsules, skin products, and juices.

Morinda citrifolia grows in shady forests, as well as on open rocky or sandy shores. It reaches maturity in about 18 months, then yields between 4 kg and 8 kg, (8.8 lb and 17.6 lb), of fruit every month throughout the year. It is tolerant of saline soils, drought conditions, and secondary soils. It is therefore found in a wide variety of habitats: volcanic terrains, lava-strewn coasts, and clearings or limestone outcrops, as well as in coralline atolls. It can grow up to 9 m (30 ft) tall, and has large, simple, dark green, shiny and deeply veined leaves.

The plant bears flowers and fruits all year round. The fruit is a multiple fruit that has a pungent odour when ripening, and is hence also known as cheese fruit or even vomit fruit. It is oval in shape and reaches (10 – 18) centimetres, (3.9 – 7.1) in, size. At first green, the fruit turns yellow then almost white as it ripens. It contains many seeds. Morinda citrifolia is especially attractive to weaver ants, which make nests from the leaves of the tree. These ants protect the plant from some plant-parasitic insects. The smell of the fruit also attracts fruit bats, which aid in dispersing the seeds. A type of fruit fly, *Drosophila sechellia*, feeds exclusively on these fruits.

A variety of beverages (juice drinks), powders (from dried ripe or unripe fruits), cosmetic products (lotions, soaps), oil (from seeds), leaf powders (for encapsulation or pills) have been introduced into the consumer market. Noni is sometimes called a "starvation fruit", implying it was used by indigenous peoples as emergency food during times of famine. Despite its strong smell and bitter taste, the fruit was nevertheless eaten as a famine food, and in some Pacific Islands, even as a staple food, either raw or cooked. Southeast Asians and Australian Aborigines consume the fruit raw with salt or cook it with curry. The seeds are edible when roasted. In Thai cuisine, the leaves are used as a green vegetable and are the main ingredient cooked with coconut milk. The fruit is added as a salad ingredient to some versions of somtam.

Green fruit, leaves, and root or rhizomes might have been used in Polynesian cultures as a general tonic, in addition to its traditional place in Polynesian culture as a famine food. Although Morinda is considered to have biological properties in traditional medicine, there is no confirmed evidence of clinical efficacy for any intended use. In 2018, a Hawaiian manufacturer of noni food and skincare products was issued an FDA warning letter for marketing unapproved drugs and making false health claims in violation of the US Food, Drug and Cosmetic Act.

Among Austronesian peoples, noni was traditionally used primarily for the production of dyes. It was carried into the Pacific Islands as canoe plants by Austronesian voyagers. Morinda bark produces a brownish-purplish dye that may be used for making batik. In Hawaii, yellowish dye is extracted from its roots to dye cloth. *Morinda citrifolia* fruit powder contains carbohydrates and dietary fibre in moderate amounts. These macronutrients evidently reside in the fruit pulp, as *M. citrifolia* juice has sparse nutrient content. The fruit contains a number of phytochemicals, including lignans, oligo- and polysaccharides, flavonoids, iridoids, fatty acids, scopoletin, catechin, beta-sitosterol, damnacanthal, and alkaloids.

In this research, Morinda citrifolia leaves, fruits and barks were collected from Myanmar Aerospace Engineering University (MAEU), Meiktila Township, Mandalay Region in Myanmar. They were dried and analysed by Shimadzu EDX-7000 Spectrometer located at Taungoo University, Bago Region in Myanmar. Finally, the elemental concentration in each sample were presented.

I. FUNDAMENTAL OF MATERIAL CHARACTERIZATION

X-rays, Roentgen rays, are electromagnetic radiations having wavelengths roughly within the range from (0.05 to 100) Å. At the short-wavelength end, they overlap with gamma rays, and at the long-wavelength end they approach ultraviolet radiation. X-rays were discovered in 1895 by Wilhelm Conrad Roentgen at the University of Warzbur, Bavaria.

When a beam of X-ray photons interacts with matter, the different interactions occur. The intensity of incident

X-ray beam is attenuated due to these interactions. Two basic processes in the XRF analysis are the photoelectric effect and X-ray scattering. The sub-interactions included in the photoelectric effect are the characteristic X-ray emission, the photoelectron ejection and the Auger electron ejection. Also, both coherent scattering and incoherent scattering can occur. These interactions are strongly influenced by the spectral distribution of the incident X-ray beam and the sample composition. Detailed information on the interactions can be found elsewhere.

In the photoelectric interaction, a photoelectron is emitted when the incident photon energy E is greater than the binding energy ϕ of the electron in the atom. The atom becomes unstable due to the removal of a bound electron and undergoes a rearrangement to reach the normal state. The transition of an electron from an outer shell to inner shell emits energy as X-ray photons. These X-ray photons can either escape from the atom or be absorbed to eject an outer shell electron (Auger electron).

When a charged particle (e.g. electron, proton, etc.,) or photon is incident an electron of the inner shell in an atom, if its energy is larger than the binding energy of that atom, the inner shell electron is ejected from that shell and it becomes a vacancy. This vacancy is immediately filled by electrons falling into them from outer shells. The energy given up by the electrons in changing shells is released as X-rays and the energy of these X-rays is characteristic energies of the electron shells and hence of the electron shells and hence of the atoms themselves. These X-rays are called characteristic X-rays.

Characteristic X-ray lines are emitted from each chemical element when excited by higher energy radiation, by which is fast above the absorption edge of the element interest. Each element emits its characteristic spectra and for each transition series K, L and M, there is a simple relationship between the energy of the characteristic X-ray line and atomic number. By measuring the energy and intensity of these characteristic lines one can recognize what element and how much are present in a sample. This X-ray fluorescence spectrometry is utilized for routine quantitative and qualitative analysis. Sensitive available for most elements reach the low parts per million ranges and the method is equally applicable at high or low concentration levels.

The production of characteristic X-ray involves of the orbital electrons of atoms in the target material between allowed orbits, or energy states, associated with ionization of the inner atomic shells. When an electron is ejected from the K shell by electron bombardment or by the absorption of a photon, the atom becomes ionized and the ion is left in high-energy state. The excess energy of the ion has over the normal state of the atom is equal to the energy (the binding energy) required to remove the K electron to a state of rest outside the atom. If this energy vacancy is filled by an electron coming from an L level, the transition is accompanied by the emission of an X-ray line known as K_α line. This process leaves a vacancy in the L shell. On the other hand, if the atom contains sufficient electrons, the K shell vacancy might be filled by an electron coming from an M level that is accompanied by the emission of the K_β line. The L or M state ions then remains may also give rise to emission if the electron vacancies are filled by electrons falling from further orbits.

In recent years, the “fundamental” approaches have been developed to deal with the matrix effects in XRF analysis. The fundamental parameters method can be applied mostly to relatively simple situations. Hai Fe has developed a quantitative procedure which can be used on a personal computer for EDXRF that can handle nearly any sample from and matrix and provide accurate results even if only a limited number of standards are available.

The X-ray fluorescence spectrometer consists of three main parts of the excitation source, the specimen presentation apparatus and the X-ray spectrometer. The function of the excitation source is to excite the characteristic X-ray in the specimen via the X-ray fluorescence process. The specimen presentation apparatus holds specimen in a precisely defined position during analysis and provides for introduction and removal of the specimen from the excitation position. The X-ray spectrometer is responsible for separating and counting the X-ray of various wavelengths or energies emitted by the specimen. The term X-ray spectrometer denotes the collection of components used to disperse, detect, count and display the spectrum of X-ray photons emitted by the specimen. When referring to the entire instrument, including excitation source, sample preparation apparatus, and X-ray spectrometer, the term of X-ray fluorescence spectrometer will be used.

For the excitation of characteristic X-ray, X-ray tube and radioactive sources are used. Commonly X-ray tube is used not only in primary energy dispersive system but also in secondary target energy dispersive spectrometer. In the X-ray tube, a filament with adjustable current control is heated to generate free electrons. The electrons are accelerated to the anode (Rh or W) where they generate the X-rays. If the X-rays have enough energy, an atom in the sample may absorb energy and emit a characteristic X-ray. The X-ray leaves the sample and travels to the detector. In giving bias to X-ray tube; tube voltage must be set higher than the highest absorption edge energy. The range of tube voltage is (4 to 50) kV with the increment of 1 V and tube current is (0.01 to 0.99) μA with the increment of 0.01 μA. Sometime, filter is used between the X-ray tube and the sample to reduce background in energy region, to estimate X-ray tube characteristic lines, which overlap with an element of interest and to transmit X-rays of sufficient energy for the excitation.

Computerized data handling has become on established part of analytical practice. Mainly, there are two main steps in the analytical process of using step, computer can control the instrument and process signal and can transform raw-data into meaningful results such as concentrations. Next one is the interpretation relevant to the problem under investigation. Moreover, it could be possible to remove errors in measuring.

In present research work, Morinda citrifolia leaves, fruits and barks were analyzed by the energy dispersive X-ray fluorescence (EDXRF): Shimadzu EDX-7000 system. The fundamental parameter (FP balance) method was used to determine the concentration of elements that contained in the samples. The FP method has been an important analysis method. Based on this, the Shimadzu EDX-7000 is provided with high performance FP software as standard.

II. Sample Preparation

Morinda citrifolia leaves, fruits and barks were dried at room temperature. The dried samples were crushed and ground in order to get fine powder by using grinding machine. They were ground fine enough so as to meet the conditions for homogeneous dense materials, and to ensure reproducibility in measurements. And then, each powder was poured into a sample cell in which the bottom of it is covered with film (mylar). The diameter of the sample cell is 31.6 mm.

Sample preparation is important in the EDXRF analysis because it is required to get homogeneous fine powder for best results. Generally, biological samples are heterogeneous and so making sample to be dried, ground and homogenized. To obtain reliable results in X-rays emission spectrometry, sample preparation is a very important process prior to actual experiment.

Sample preparation needs to be done carefully not to contaminate from grinding devices. We should take care of the grinding process in order to minimize the particle size effect. The guiding principles for specimen preparation techniques are reproducibility, accuracy, simplicity, low cost and rapid of preparation.

Specimen preparation is crucial to the relationship between spectral line intensity and the element concentration. Factors such as surface roughness, particle shape, particle size, homogeneity, particle distribution, and mineralization can affect this relationship.

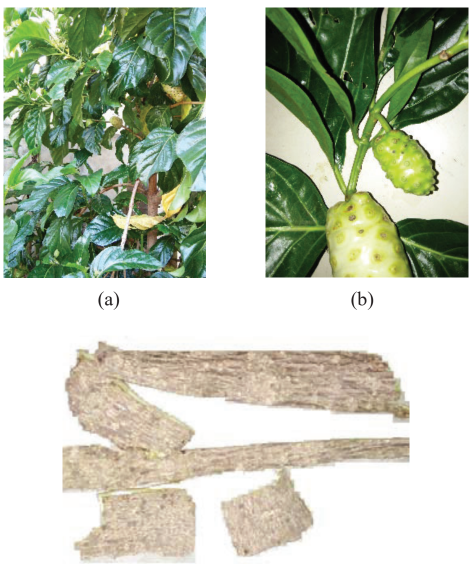

Figure 1. Morinda citrifolia (a) tree, (b) leaves and fruits and (c) barks

(a) (b)

Figure 2. Sample preparation for Morinda citrifolia (a) leaves and (b) fruits

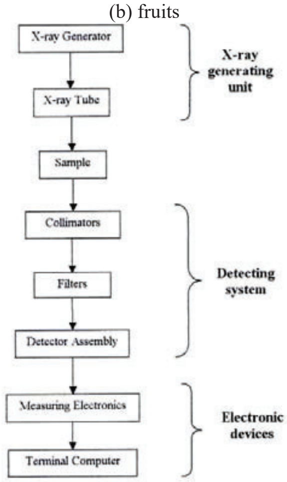

Figure 3. Schematic diagram of a sequential EDXRF Analysis

III. Results and Discussion

The EDXRF analysis gave qualitative and quantitative results. The energy dispersive has been superior resolution and had high counting rates. The measuring time was 100 s in air. It was found that calcium was the largest concentrated element, and potassium and sulphur were the second largest elements in Morinda leaves. Manganese, iron, strontium, copper, silver, zinc and bromine were trace elements. In Morinda fruit, potassium was also the largest concentrated element, and phosphorous, calcium and sulphur were the second largest elements. Iron, manganese, copper, titanium, zinc and strontium were found as trace elements. In Morinda bark, potassium and calcium were the largest concentrated elements, and Sulphur and iron were the second largest elements. Other elements such as manganese, titanium, copper, silver and zinc were trace elements. The concentrations of elements contained in these samples were described in Fig. 5, Fig. 6, Fig. 7, and Table 1, Table 2 and Table 3.

Figure 4. Photograph of the Shimadzu EDX-7000 Spectrometer at Material Science Lab, Taungoo University

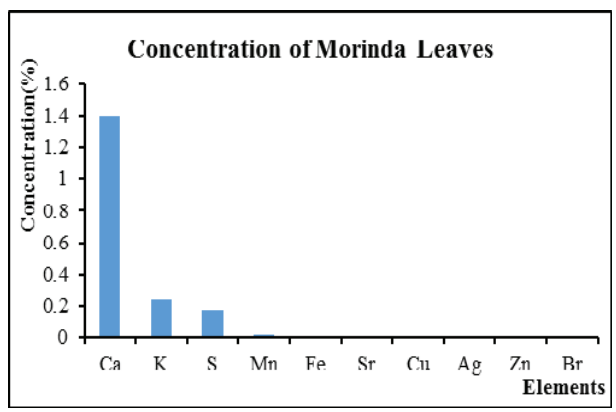

Figure 5. Elemental concentration of Morinda leaves

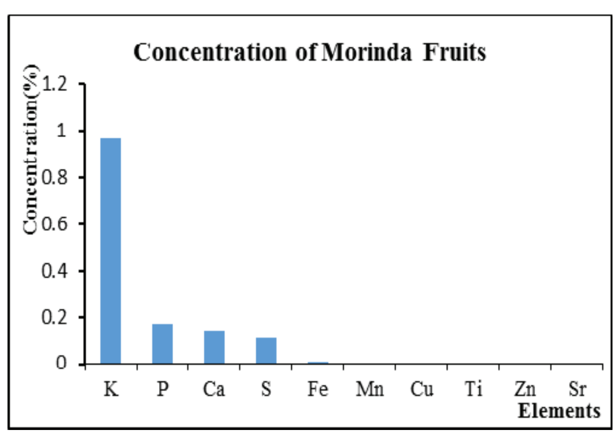

Figure 6. Elemental concentration of Morinda fruits

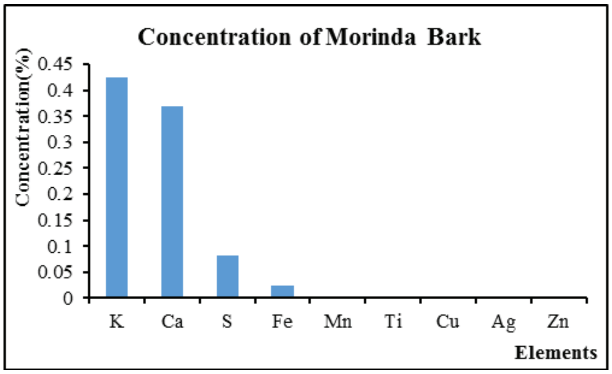

Figure 7. Elemental concentration of Morinda barks

TABLE I. ELEMENTAL CONCENTRATION OF MORINDA LEAVES

Element	Concentration (%)
Ca	1.398
K	0.244
S	0.174
Mn	0.018
Fe	0.011
Sr	0.006
Cu	0.002
Ag	0.002
Zn	0.001
Br	0.001

TABLE II. ELEMENTAL CONCENTRATION OF MORINDA FRUITS

Element	Concentration (%)
K	0.969
P	0.17
Ca	0.145
S	0.114
Fe	0.008
Mn	0.002
Cu	0.002
Ti	0.002
Zn	0.001
Sr	0.001

TABLE II. ELEMENTAL CONCENTRATION OF MORINDA BARKS

Element	Concentration (%)
K	0.425
Ca	0.368
S	0.081
Fe	0.024
Mn	0.003
Ti	0.003
Cu	0.002
Ag	0.001
Zn	0.001

Calcium is found in bones and teeth. Ironically, calcium's most important role is in bodily functions, such as muscle contraction and protein regulation. **Potassium** helps regulate the heartbeat and is vital for electrical signaling in nerves. **Sulfur** is found in two amino acids that are important for giving proteins their shape.

Manganese is essential for certain enzymes, in particular those that protect mitochondria — the place where usable energy is generated inside cells — from dangerous oxidants. **Iron** is a key element in the metabolism of almost all living organisms. It is also found in hemoglobin, which is the oxygen carrier in red blood cells.

The omission of **Strontium** caused an impairment of the calcification of the bones and teeth and a higher incidence of carious teeth. ^{90}Sr is one of the most abundant and potentially hazardous radioactive byproducts of nuclear fission and plants are more efficient than animals in the absorption of strontium.

Copper is important as an electron donor in various biological reactions. Without enough copper, iron won't work properly in the body. The **silver** ion is bioactive and in sufficient concentration readily kills bacteria *in vitro*. Silver ions interfere with enzymes in the bacteria that transport nutrients, form structures, and synthesise cell walls; these ions also bond with the bacteria's genetic material. Silver and silver nanoparticles are used as an antimicrobial in a variety of industrial, healthcare, and domestic application.

Zinc is an essential trace element for all forms of life. Several proteins contain structures called "zinc fingers help to regulate genes. Zinc deficiency has been known to lead to dwarfism in developing countries.

Bromine increases the growth rate of chicks and mice. It does not prevent the occurrence of goiter, and it is rapidly replaced by iodine when the latter is restored to the diet. More than one third of the iodine content in the thyroid was replaced by bromine.

Phosphorous is found predominantly in bone but also in the molecule ATP, which provides energy in cells for driving chemical reactions. **Titanium** is so reactive that a titanium oxide skin forms spontaneously in contact with air, without the presence of water.

IV. CONCLUSION

Morinda citrifolia leaves, fruits and barks were investigated by using the Energy Dispersive X-ray Fluorescence (EDXRF) detection technique. In this research, elements contained in Morinda samples were observed and their corresponding benefits were discussed. Morinda citrifolia is pharmacologically active and is used in different forms of cancer, viz. colon, esophageal, breast, colorectal cancers; cardiovascular diseases, diabetes, arthritis, hypertension.

ACKNOWLEDGMENT

We would like to thank Rector and Pro-Rectors, Myanmar Aerospace Engineering University, Meiktila, Mandalay region for their kind permission to accept this research work. Thanks are also due to reviewers from MAEU. We also thank our colleagues for their valuable advice and collaboration on this research.

REFERENCES

[1] A. N. Chopra, S. L. Nayar and I. C. Chorpa, "Glossary of Indian Medicinal Plants," New Delhi: Council of Scientific and Industrial Research, 1956.

[2] B. K. Agarwal, "An Introduction to X-ray Spectroscopy: An Introduction," Berlin: Springer - Verlag, 1979.

[3] EDX-700 Manual, Tokyo: Shimadzu Co., 2002.

[4] EDX-7000 and 8000 Catalogue, Tokyo: Shimadzu Co., 2013.

[5] H. Semat and J. R. Albright, "Introduction to Atomic and Nuclear Physics," London: Chapman and Hall, 1973.

[6] K. Deberlin and R. G. Helmer, "Gamma and X-ray Spectroscopy with Semiconductor Detectors," New York: North - Holland, 1998.

[7] K. O. Soetan , C. O. Olaiya and O. E. Oyewole, "The importance of mineral elements for humans, domestic animals and plants: A review," African Journal of Food Science, vol. 4, no. 5, 2010.

[8] Mohammad Ali, Mruthunjaya Kenganora and Santhepete Nanjundaiah Manjula, "Health Benefits of Morinda citrifolia

(Noni): A Review," Pharmacognosy Journal, vol. 8, no. 4, pp. 321-334, July 2016.
[9] Morinda citrifolia, https://en.wikipedia.org/wiki/Morinda, August 2019.
[10] R. E. V. Grieken and A. Markowicz, "Hand Book of X-Ray Spectroscopy," London: Dekker, 1993.
[11] S. Norton, "Quantitative determination of mast cells fragmentation by compound 48/80," Ed. J. Pharmacol., vol. 2, 1964.