ELEMENTAL ANALYSIS OF PARTS OF CHILI

Myint Myint Maw[1] and Win Sin[2]

Abstract

Different parts of raw green and ripe red chilies have been analysed using EDX-7000 to study the elements contained in each parts and the change in concentrations of elements due to varying parts, such as seed, skin or stalk. The major elements found in each part are potassium, sulphur, copper and iron.

Keywords: Chili, EDXRF, Elemental Analysis

Introduction

Chili peppers are one of the very popular spices known for their medicinal and health benefiting properties. The chili is a fruit pod of the plant belonging to the nightshade family (Solanaceae), of the genus, **Capsicum**.

Chili peppers contain a substance called capsaicin, which gives peppers their characteristic pungency, producing mild to intense spice when eaten. Capsaicin is being studied as an effective treatment for sensory nerve fibre disorders, including pain associated with arthritis, psoriasis, and diabetic neuropathy.

Red chili peppers have been shown to reduce blood cholesterol, triglyceride levels, and platelet aggregation, while increasing the body's ability to dissolve fibrin, a substance integral to the formation of blood clots. Cultures where hot pepper is used liberally have a much lower rate of heart attack, stroke and pulmonary embolism.

Chili peppers contains Vitamin A, Vitamin C, Vitamin B6, Vitamin K1, Potassium and Copper. Chilli peppers are rich in various vitamins and minerals but usually eaten in small amounts - so they don't contribute significantly to our daily micronutrient intake.

We are interested in minerals contained in chili, the concentration of minerals in each part of fruit, and comparison to green and red ones. So we have chosen EDXRF method to embody the minerals contained in chili.

Theoretical Background

When a sample is irradiated with x-rays from an x-ray tube, the atoms in the sample generate unique x-rays that are emitted from the sample. Such x-rays are known as "fluorescent x-rays" and they have a unique wavelength and energy that is characteristic of each element that generates them. Consequently, qualitative analysis can be performed by investigating the wavelengths of the x-rays. As the fluorescent x-ray intensity is a function of the concentration, quantitative analysis is also possible by measuring the amount of x-rays at the wavelength specific to each element.

[1] Dr, Assistant Lecturer, Department of Physics, University of Yangon
[2] Dr, Associate Professor, Department of Physics, West University of Yangon

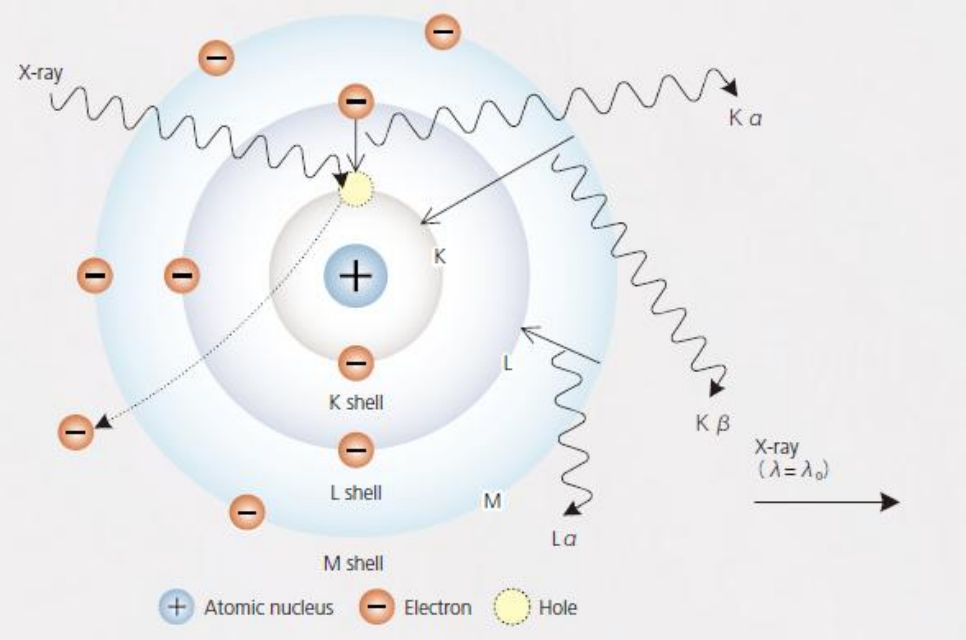


Figure 2.1 Electron Paths and Principle of X-ray Generation Expressed as a Bohr Model

Main Specifications of Shimadzu EDX-7000 Spectrometer

Measurement principle	X-ray fluorescence spectrometer
Measurement method	Energy dispersive
Target samples	Solids, liquids, powders
Measuring range	11 Na to 92 U

X-ray Generator (EDX-7000)

X-ray tube	Rhodium (Rh) target
Voltage	4 kV to 50 kV
Current	1μA to 1000 μA
Cooling method	air cooling (with a fan)
Irradiated area	10 mm diameter (standard)
Primary filters	Automatic selection from among 5 types of filter

Detector

Type	Silicon drift detector (SDD)

Sample Chamber

Measurement Atmosphere	Air, vacuum, helium
Sample replacement	12- sample turret
Sample observations	Semiconductor camera

Sample Collection and Preparation

Green and red chilies grown at home were collected. Stalk, seeds and skin were separated and placed in the cells covering with film. The cells were put into chamber and analysed.

Results and Discussions

The elemental concentrations of various parts of chili are shown in Table 1 and the respective graph is shown in Figure 1. Major elements found are potassium, sulfur and calcium. The minor elements found are copper, iron and zinc.

The elemental concentrations of various parts of green chili are shown in Table 2 and the respective graph is shown in Figure 2. Major elements found are potassium, sulfur and calcium. The minor elements found are copper, iron and zinc. Potassium is mostly found in stalk. Sulfur is mostly found in stalk and seed. Calcium is only found in stalk. Seeds contain more copper than stalk and skin. Iron is found in all parts.

The elemental concentrations of various parts of red chili are shown in Table 3 and the respective graph is shown in Figure 3. Major elements found are potassium, sulfur and calcium. The minor elements found are copper, iron and zinc. Potassium is mostly found in stalk. Sulfur is mostly found in stalk and seed. Calcium is found in all parts. Copper and Iron are found in all parts.

The comparisons of minerals contained in stalks of green and red chilies are shown in Figure 4. The stalk of Red chili contains more minerals than stalk of green chili.

The comparisons of minerals contained in seeds of green and red chilies are shown in Figure 5. Both contain nearly the same minerals. Calcium is only found in red chili seeds.

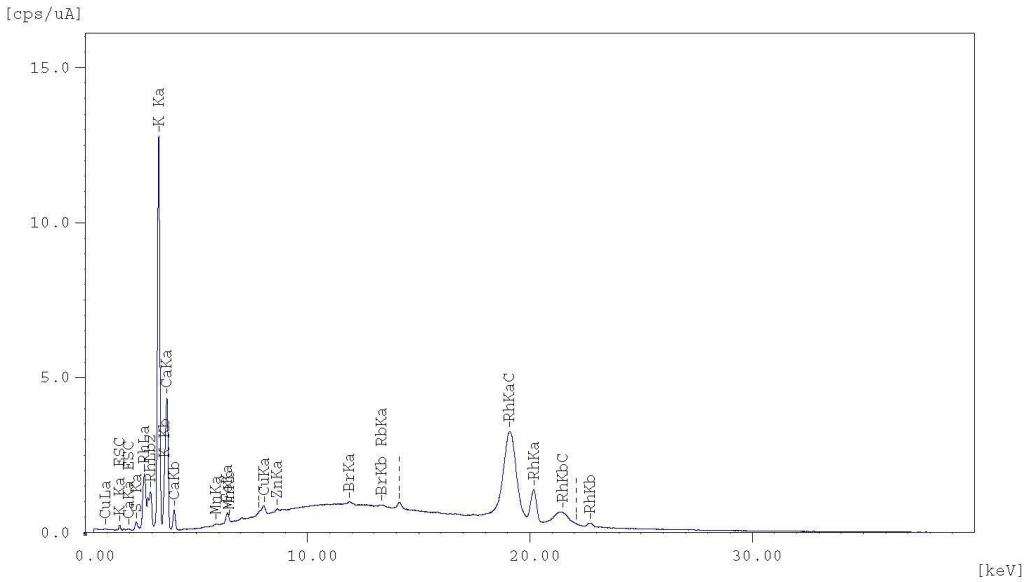
The comparisons of minerals contained in fruit-wall of green and red chilies are shown in Figure 6. The fruit-wall of red chili contains more minerals than that of green chili.

```
Sample   : Chilli_R_Bone
Operator: DRWLO
Comment  : with mylar film
Group    : FP balance 10mm
Date     : 2019-03-15 12:48:30
```

Measurement Condition

Instrument: EDX-7000	Atmosphere: Air	Collimator: 10(mm)	Sample Cup:Mylar

Analyte	TG kV	uA	FI	Acq.(keV)	Anal.(keV)	Time(sec)	DT(%)
Al-U	Rh 50	69-Auto	----	0 - 40	0.00-40.00	Live- 100	30



Qualitative Result

Element: Cu, K , Ca, S , Rh, Mn, Fe, Zn, Br, Rb

Quantitative Result

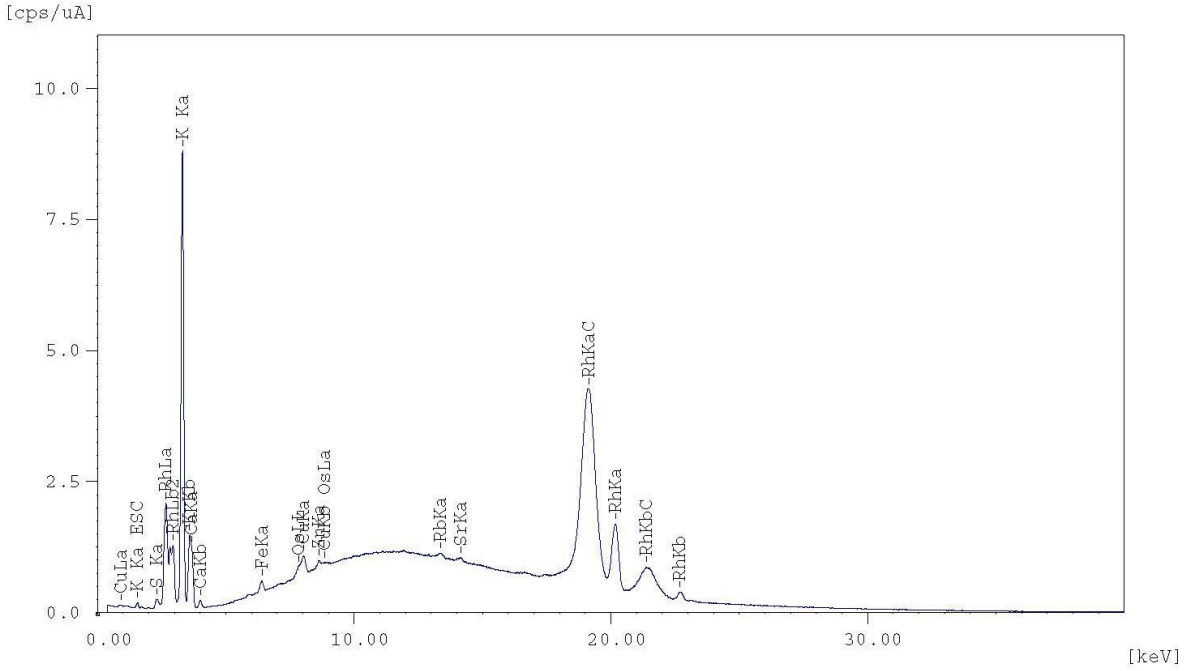
Analyte	Result	[3-sigma]	Proc.-Calc.	Line	Int.(cps/uA)
K	1.013 %	[0.004]	Quan-FP	K Ka	75.1816
Ca	0.198 %	[0.001]	Quan-FP	CaKa	24.0894
S	0.086 %	[0.003]	Quan-FP	S Ka	1.4851
Fe	0.002 %	[0.000]	Quan-FP	FeKa	2.4435
Cu	0.001 %	[0.000]	Quan-FP	CuKa	2.9934
Zn	0.000 %	[0.000]	Quan-FP	ZnKa	1.0496
Mn	0.000 %	[0.000]	Quan-FP	MnKa	0.3159
Br	0.000 %	[0.000]	Quan-FP	BrKa	1.1855
Rb	0.000 %	[0.000]	Quan-FP	RbKa	0.9106
CH	98.699 %	[------]	Balance	--------	--------

```
Sample   : Chilli_G_Bone
Operator: DRWLO
Comment  : with mylar film
Group    : FP balance 10mm
Date     : 2019-03-15 12:43:17
```

Measurement Condition

Instrument: EDX-7000	Atmosphere: Air	Collimator: 10(mm)	Sample Cup:Mylar

Analyte	TG kV	uA	FI	Acq.(keV)	Anal.(keV)	Time(sec)	DT(%)
Al-U	Rh 50	61-Auto	----	0 - 40	0.00-40.00	Live- 100	30



Qualitative Result

Element: Cu, K , S , Rh, Ca, Fe, Os, Zn, Rb, Sr

Quantitative Result

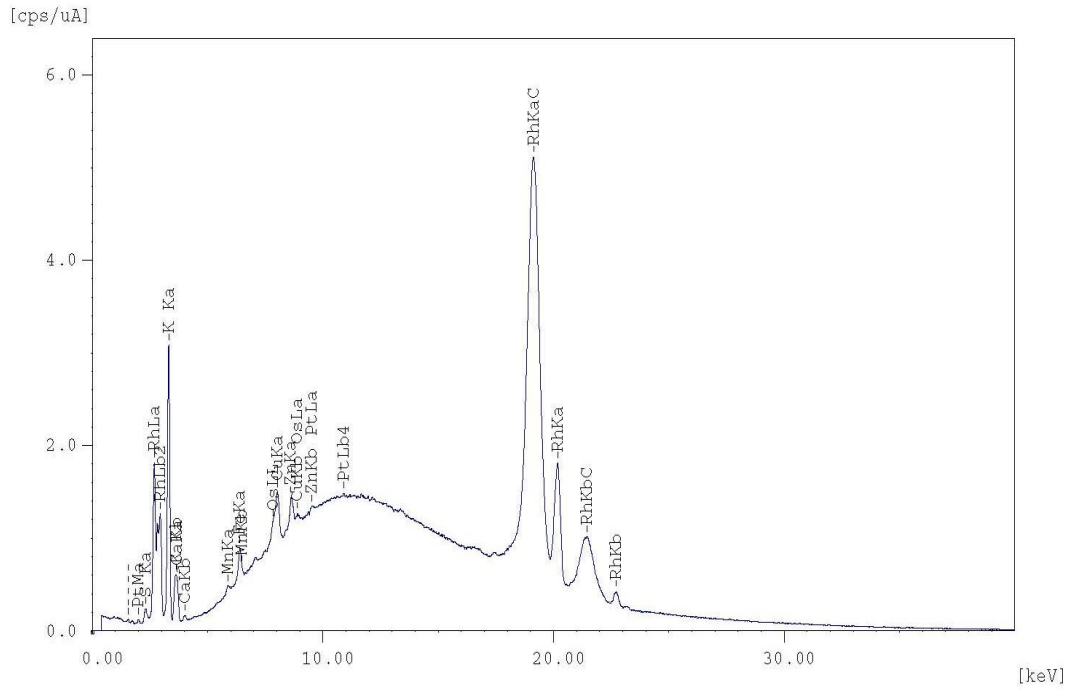
Analyte	Result	[3-sigma]	Proc.-Calc.	Line	Int.(cps/uA)
K	0.676 %	[0.004]	Quan-FP	K Ka	51.3476
S	0.063 %	[0.003]	Quan-FP	S Ka	1.1038
Ca	0.039 %	[0.000]	Quan-FP	CaKa	5.1626
Cu	0.001 %	[0.000]	Quan-FP	CuKa	3.3525
Fe	0.001 %	[0.000]	Quan-FP	FeKa	1.5709
Zn	0.000 %	[0.000]	Quan-FP	ZnKa	1.6310
Os	0.000 %	[0.000]	Quan-FP	OsLa	0.5811
Rb	0.000 %	[0.000]	Quan-FP	RbKa	1.2438
Sr	0.000 %	[0.000]	Quan-FP	SrKa	1.0075
CH	99.218 %	[------]	Balance	--------	--------

Sample : Chilli_R_Seed
Operator: DRWLO
Comment : with mylar film
Group : FP balance 10mm
Date : 2019-03-15 12:45:53

Measurement Condition

Instrument: EDX-7000	Atmosphere: Air	Collimator: 10(mm)	Sample Cup:Mylar

Analyte	TG kV	uA	FI	Acq.(keV)	Anal.(keV)	Time(sec)	DT(%)
Al-U	Rh 50	53-Auto	----	0 - 40	0.00-40.00	Live- 100	30



Qualitative Result

Element: Pt, S , Rh, K , Ca, Mn, Fe, Os, Cu, Zn

Quantitative Result

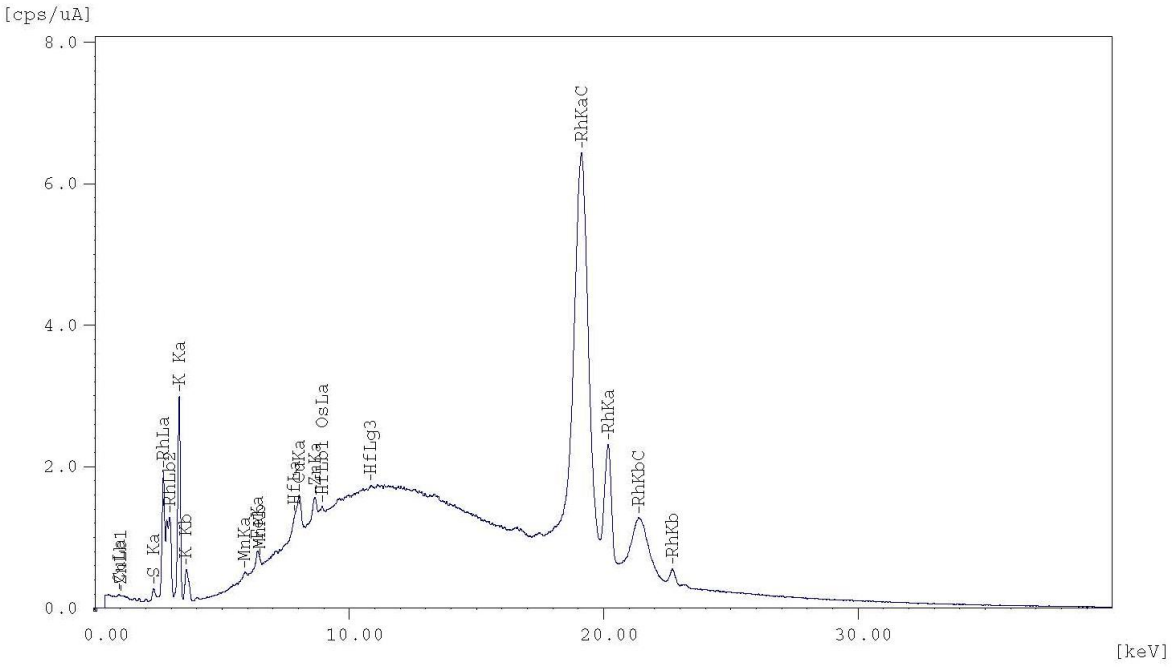
Analyte	Result	[3-sigma]	Proc.-Calc.	Line	Int.(cps/uA)
K	0.224 %	[0.002]	Quan-FP	K Ka	17.4608
S	0.052 %	[0.003]	Quan-FP	S Ka	0.9052
Ca	0.014 %	[0.001]	Quan-FP	CaKa	2.1021
Fe	0.002 %	[0.000]	Quan-FP	FeKa	2.6759
Cu	0.001 %	[0.000]	Quan-FP	CuKa	5.0654
Zn	0.001 %	[0.000]	Quan-FP	ZnKa	3.5531
Mn	0.001 %	[0.000]	Quan-FP	MnKa	0.6309
Os	0.000 %	[0.000]	Quan-FP	OsLa	0.6922
Pt	0.000 %	[0.000]	Quan-FP	PtLa	0.5159
CH	99.704 %	[------]	Balance	--------	--------

```
Sample   : Chilli_G_Seed
Operator: DRWLO
Comment : with mylar film
Group    : FP balance 10mm
Date     : 2019-03-15 12:40:41
```

Measurement Condition

Instrument: EDX-7000	Atmosphere: Air	Collimator: 10(mm)	Sample Cup:Mylar

Analyte	TG kV	uA	FI	Acq.(keV)	Anal.(keV)	Time(sec)	DT(%)
Al-U	Rh 50	44-Auto	----	0 - 40	0.00-40.00	Live- 100	30



Qualitative Result

Element: Cu, Zn, S , Rh, K , Mn, Fe, Hf, Os

Quantitative Result

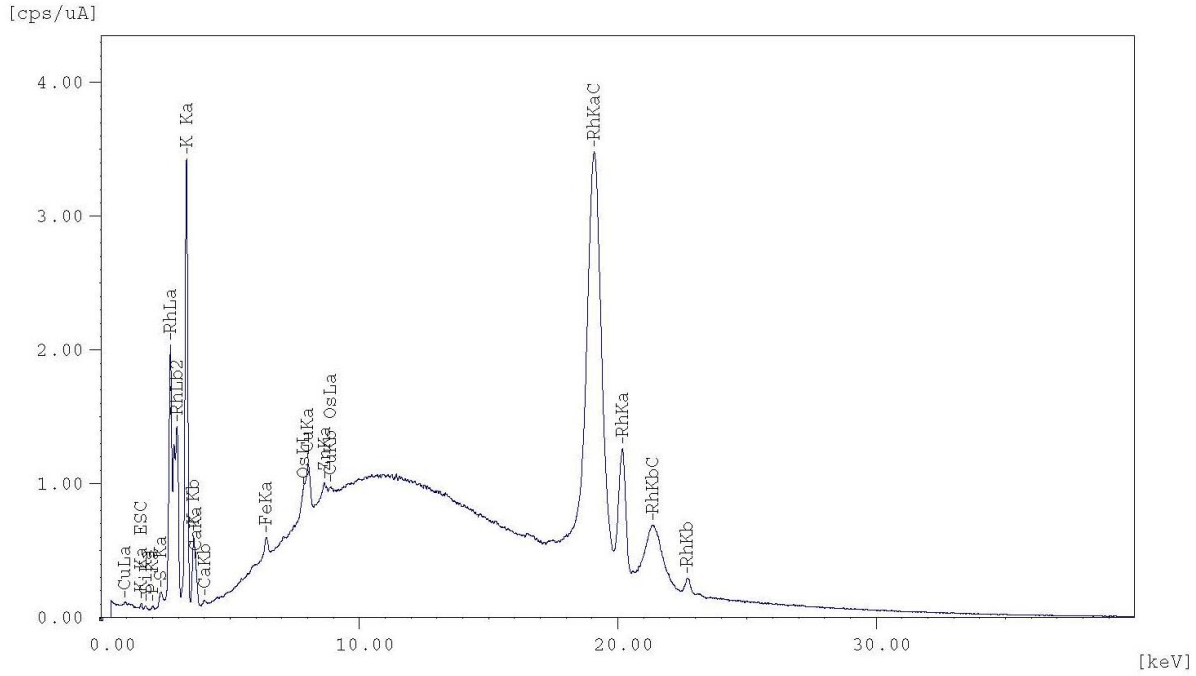
Analyte	Result	[3-sigma]	Proc.-Calc.	Line	Int.(cps/uA)
K	0.219 %	[0.002]	Quan-FP	K Ka	16.9864
S	0.063 %	[0.004]	Quan-FP	S Ka	1.0936
Hf	0.003 %	[0.000]	Quan-FP	HfLa	2.8399
Cu	0.002 %	[0.000]	Quan-FP	CuKa	5.2118
Fe	0.001 %	[0.000]	Quan-FP	FeKa	1.9560
Zn	0.001 %	[0.000]	Quan-FP	ZnKa	3.5360
Mn	0.001 %	[0.000]	Quan-FP	MnKa	0.6297
Os	0.000 %	[0.000]	Quan-FP	OsLa	0.3127
CH	99.712 %	[------]	Balance	--------	--------

```
Sample   : Chilli_R_Shell
Operator: DRWLO
Comment : with mylar film
Group    : FP balance 10mm
Date     : 2019-03-15 13:00:56
```

Measurement Condition

Instrument: EDX-7000	Atmosphere: Air	Collimator: 10(mm)	Sample Cup:Mylar

Analyte	TG kV	uA	FI	Acq.(keV)	Anal.(keV)	Time(sec)	DT(%)
Al-U	Rh 50	71-Auto	----	0 - 40	0.00-40.00	Live- 100	30



Qualitative Result

Element: Cu, K , Si, P , S , Rh, Ca, Fe, Os, Zn

Quantitative Result

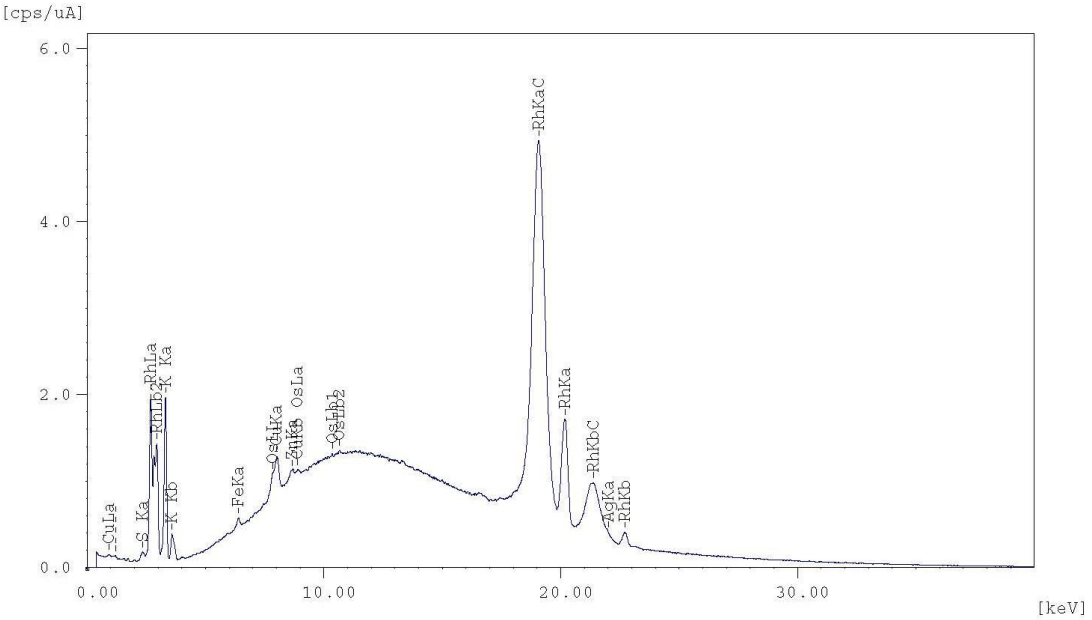
Analyte	Result	[3-sigma]	Proc.-Calc.	Line	Int.(cps/uA)
K	0.256 %	[0.002]	Quan-FP	K Ka	19.6584
Si	0.095 %	[0.026]	Quan-FP	SiKa	0.1088
S	0.042 %	[0.003]	Quan-FP	S Ka	0.7297
P	0.025 %	[0.006]	Quan-FP	P Ka	0.1207
Ca	0.008 %	[0.001]	Quan-FP	CaKa	1.1951
Cu	0.001 %	[0.000]	Quan-FP	CuKa	3.4240
Fe	0.001 %	[0.000]	Quan-FP	FeKa	1.2965
Zn	0.000 %	[0.000]	Quan-FP	ZnKa	1.7208
Os	0.000 %	[0.000]	Quan-FP	OsLa	0.6493
CH	99.571 %	[------]	Balance	--------	--------

Sample : Chilli_G_Shell
Operator: DRWLO
Comment : with mylar film
Group : FP balance 10mm
Date : 2019-03-15 12:38:04

Measurement Condition

Instrument: EDX-7000	Atmosphere: Air	Collimator: 10(mm)	Sample Cup:Mylar

Analyte	TG kV	uA	FI	Acq.(keV)	Anal.(keV)	Time(sec)	DT(%)
Al-U	Rh 50	58-Auto	----	0 - 40	0.00-40.00	Live- 100	31



Qualitative Result

Element: Cu, S , Rh, K , Fe, Os, Zn, Ag

Quantitative Result

Analyte	Result	[3-sigma]	Proc.-Calc.	Line	Int.(cps/uA)
K	0.140 %	[0.002]	Quan-FP	K Ka	10.9472
S	0.039 %	[0.003]	Quan-FP	S Ka	0.6794
Cu	0.001 %	[0.000]	Quan-FP	CuKa	3.9761
Ag	0.001 %	[0.000]	Quan-FP	AgKa	1.3351
Fe	0.001 %	[0.000]	Quan-FP	FeKa	0.8829
Zn	0.000 %	[0.000]	Quan-FP	ZnKa	1.7980
Os	0.000 %	[0.000]	Quan-FP	OsLa	0.7262
CH	99.818 %	[------]	Balance	--------	--------

Table 1 Elemental Concentration (W%) of parts of green and red chilies

Element	Green Chili			Red Chili		
	Stalk	**Seeds**	**fruit-wall**	**Stalk**	**Seeds**	**fruit-wall**
K	0.676	0.219	0.140	1.013	0.224	0.256
S	0.063	0.063	0.039	0.086	0.052	0.042
Ca	0.039	0.000	0.000	0.198	0.014	0.008
Cu	0.001	0.002	0.001	0.001	0.001	0.001
Fe	0.001	0.001	0.001	0.002	0.002	0.001
Zn	0.000	0.001	0.000	0.000	0.001	0.000
Hf	0.000	0.003	0.000	0.000	0.000	0.000
Mn	0.000	0.001	0.000	0.000	0.001	0.000
Ag	0.000	0.000	0.001	0.000	0.000	0.000
Si	0.000	0.000	0.000	0.000	0.000	0.095
P	0.000	0.000	0.000	0.000	0.000	0.025

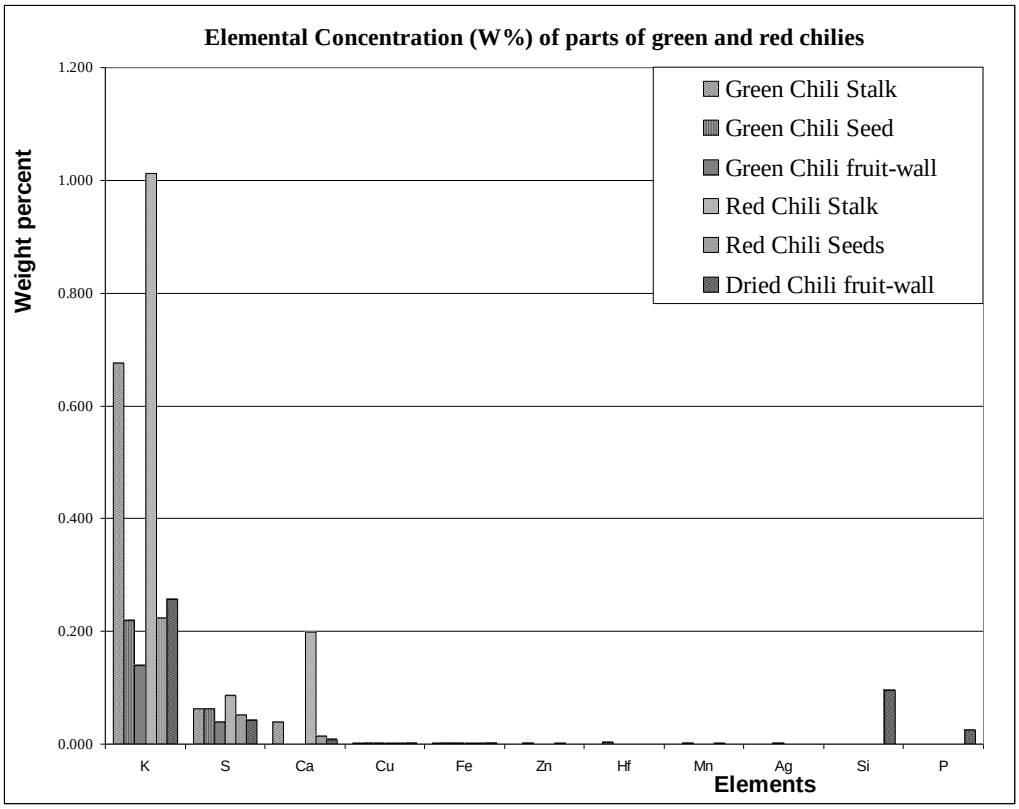


Figure 1 Elemental Concentration (W%) of parts of green and red chilies

Table 2 Elemental Concentration (W%) of parts of green chili

Element	Stalk	Seeds	fruit-wall
K	0.676	0.219	0.140
S	0.063	0.063	0.039
Ca	0.039	0.000	0.000
Cu	0.001	0.002	0.001
Fe	0.001	0.001	0.001
Zn	0.000	0.001	0.000
Hf	0.000	0.003	0.000
Mn	0.000	0.001	0.000
Ag	0.000	0.000	0.001

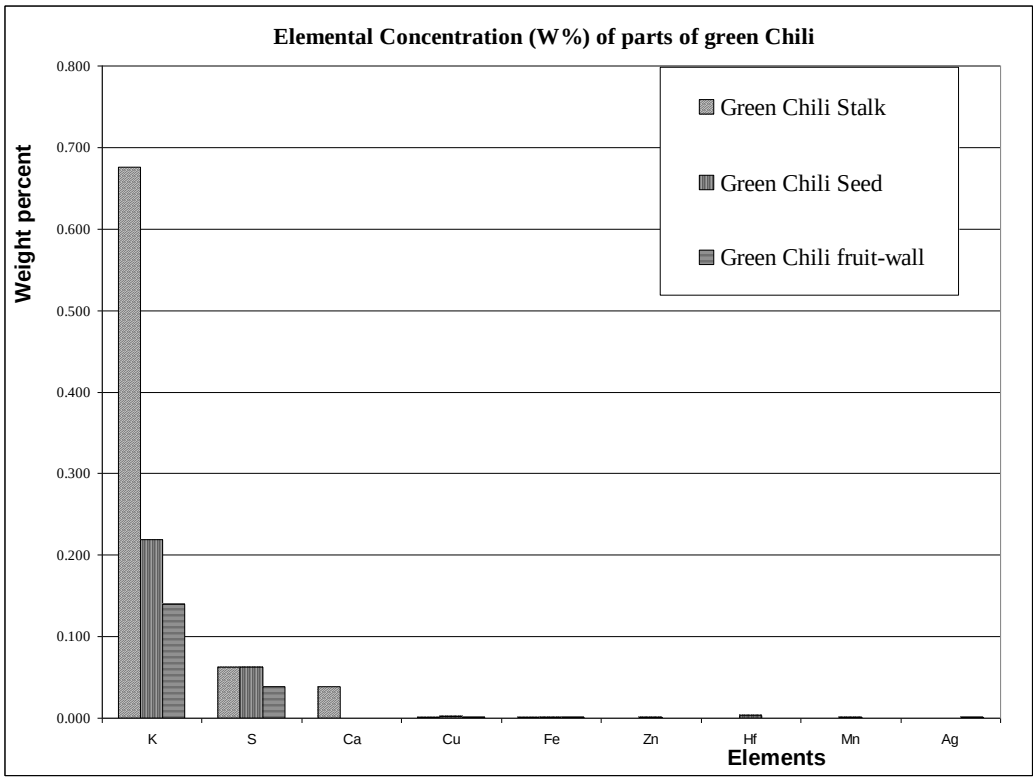


Figure 2 Elemental Concentration (W%) of parts of green chili

Table 3 Elemental Concentration (W%) of parts of red chili

Element	Stalk	Seeds	fruit-wall
K	1.013	0.224	0.256
S	0.086	0.052	0.042
Ca	0.198	0.014	0.008
Cu	0.001	0.001	0.001
Fe	0.002	0.002	0.001
Zn	0.000	0.001	0.000
Mn	0.000	0.001	0.000
Si	0.000	0.000	0.095
P	0.000	0.000	0.025

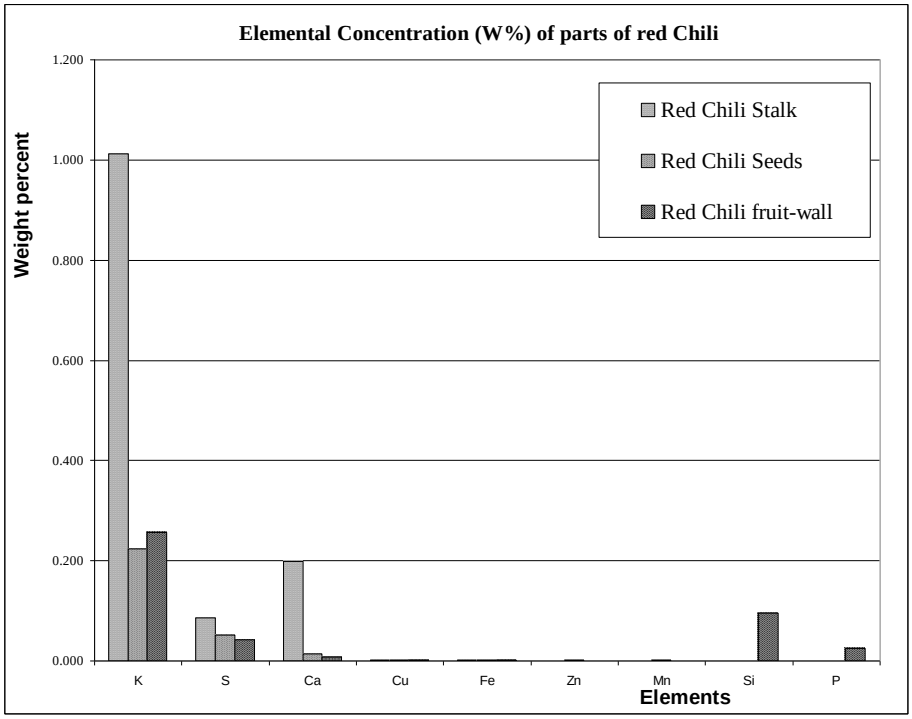


Figure 3 Elemental Concentration (W%) of parts of red chili

Table 4 Comparison of Elemental Concentration (W%) of stalks of green and red chilies

Element	Green Chili Stalk	Red Chili Stalk
K	0.676	1.013
S	0.063	0.086
Ca	0.039	0.198
Cu	0.001	0.001
Fe	0.001	0.002

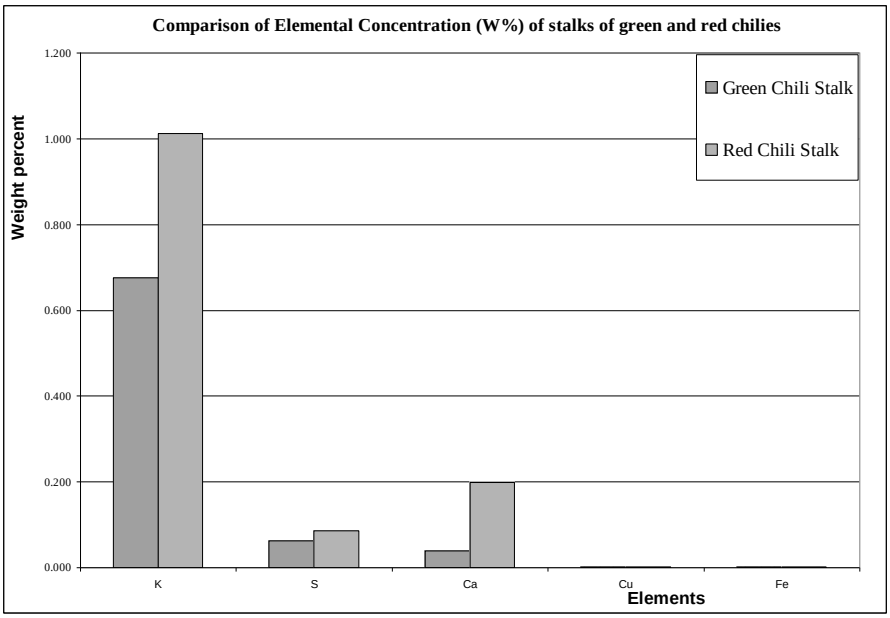


Figure 4 Comparison of Elemental Concentration (W%) of stalks of green and red chilies

Table 5 Comparison of Elemental Concentration (W%) of seeds of green and red chilies

Element	Green Chili Seeds	Red Chili Seeds
K	0.219	0.224
S	0.063	0.052
Ca	0.000	0.014
Cu	0.002	0.001
Fe	0.001	0.002
Zn	0.001	0.001
Hf	0.003	0.000
Mn	0.001	0.001

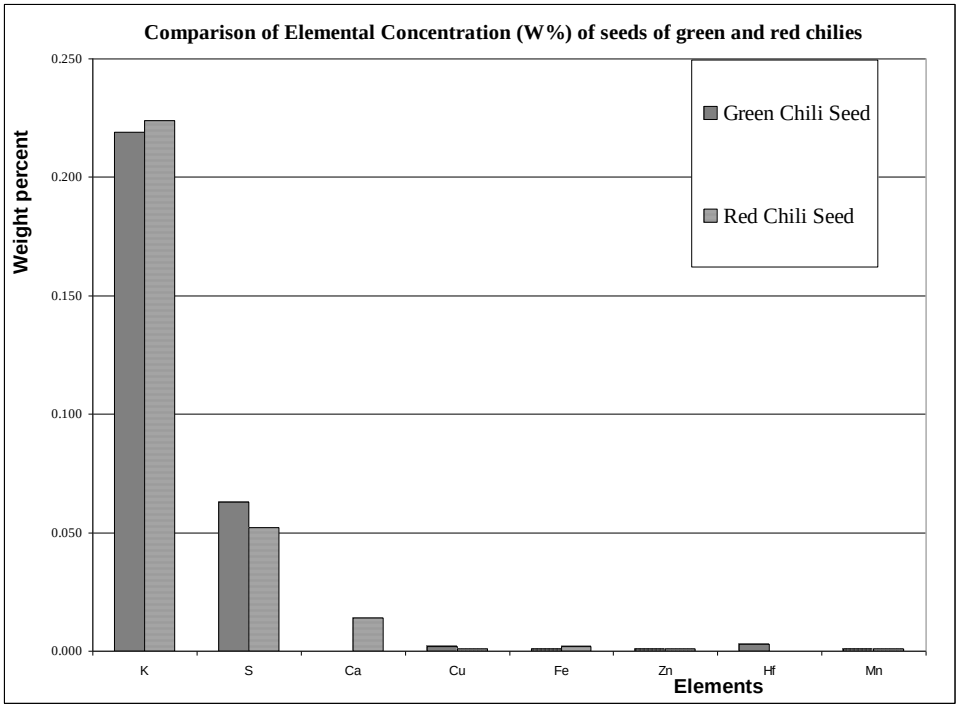


Figure 5 Comparison of Elemental Concentration (W%) of seeds of green and red chilies

Table 6 Comparison of Elemental Concentration (W%) of fruit-walls of green and red chilies

Element	Green Chili fruit-wall	Red Chili fruit-wall
K	0.140	0.256
S	0.039	0.042
Ca	0.000	0.008
Cu	0.001	0.001
Fe	0.001	0.001
Ag	0.001	0.000
Si	0.000	0.095
P	0.000	0.025

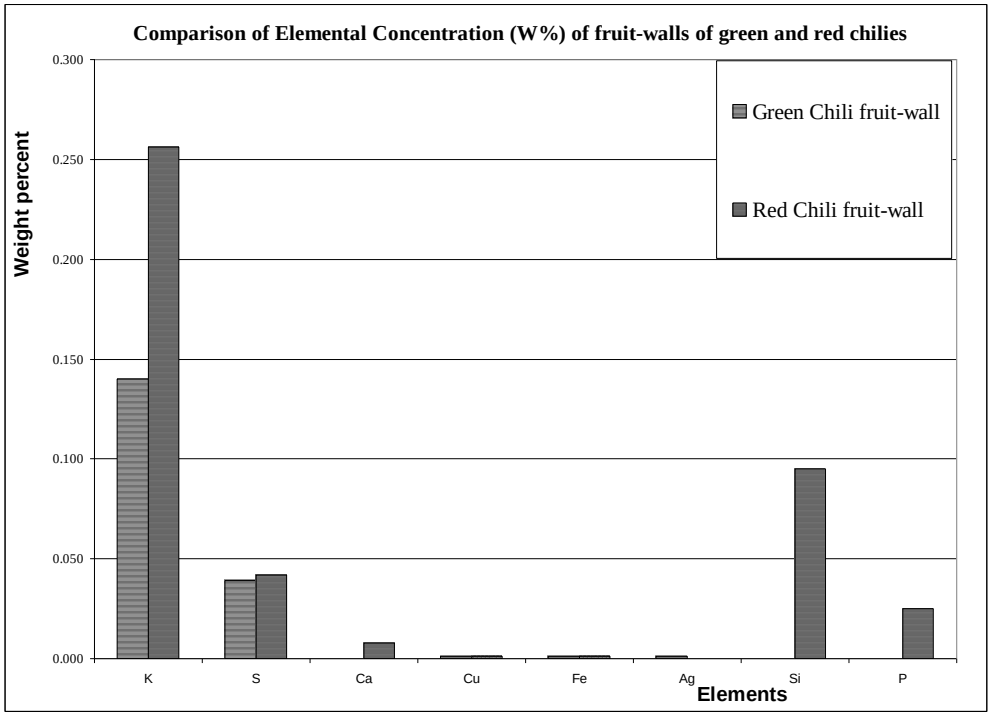


Figure 6 Comparison of Elemental Concentration (W%) of fruit-walls of green and red chilies

Conclusion

Potassium lowers blood pressure, protects against loss of muscle mass, preserves bone mineral density, and reduces the formation of kidney stones.

Sulfur makes up vital amino acids used to create protein for cells, tissues, hormones, enzymes, and antibodies. Sulfur is needed for insulin production.

Calcium can build and maintain strong bones. Our heart, muscles and nerves also need calcium to function properly.

Copper is essential for infant growth, bone strength, red and white blood cell maturation, iron transport, cholesterol and glucose metabolism, heart muscle contraction and brain development.

From our study, chili is found to contain essential macrominerals. It is surprisingly found that the chili stalks which we throw away contain more valuable minerals. Red chili, not dried chili, is better than green chili.

Acknowledgements

I would like to thank Professor Dr Khin Khin Win, Head of Department of Physics, University of Yangon for her kind permission to carry out this research.

I would like to express my sincere thanks to Dr Myo Lwin, Professor, Department of Physics, Dr Ye Chan, Professor and Head, Universities' Resarch Centre, Dr Aye Aye Thant, Professsor, Department of Physics, Dr Yin Maung Maung, Professor, Department of Physics and Dr Than Zaw Oo, Professor, Universities' Resarch Centre, University of Yangon for their suggestion to carry out this work.

References

Cesareo R (2000) "X-Ray Physics: Interaction with Matter, Production, Detection" (Bologna: La Rivista del Nuovo Cimento)

Chevallier, A. (1996). The encyclopedia of medicinal plants. London: Dorling Kindersely Limited.

Donal E Leydon (1999) "Fundamentals of X-Ray Spectrometry as Applied to Energy Dispersive Techniques", Spectrace Instruments Technical Paper

Jekins RE (1999) "X-Ray Fluorescence Spectrometry" (New York: Wiley- Interscience)

Peter N. Brouwer, (2003) Theory of XRF 1st ed PANalytical B.V The Netherlands.

Rene E, Van Grieken, Andrzej (1993) " Handbook of X ray Spectrometry Methods and Techniques" (New York : Marcle Dekker)

Tertain R & Classie F (1982) "Principles of Quantitative X ray Fluorescence Analysis" (London: Heyden)