

**Analysis of Metal Content in Turmeric Powder Available in the
Sri Lankan Market**

By

Melani Nisansala Withanage

Thesis submitted in partial fulfillment requirement for the award of

the degree of

Master of Science

In

Food Science and Technology

Of the Faculty of Applied Sciences

University of Sri Jayawardenepura

Gangodawila, Nugegoda,

Sri Lanka.

2015

DECLARATION

The work described in this thesis was carried out by me as a project under the supervision of Prof. Arthur Bamunuarachchi, Dr. Indira Wickramasinghe and Mr. R.M.G.B. Rajanayake and a report on this has not been submitted in whole or in part to any University or any other institution for another degree.

M.N. Withanage

M.N. Withanage

08/12/2015

Date

We Prof. A. Bamunuarachchi, Dr. Indira Wickramasinghe and Mr. R.M.G.B. Rajanayake jointly here by certify that the above statement in the preceding page made by the candidate is true and this thesis is suitable for submission to the university for the purpose of evaluation.



Supervisor

Prof. A. Bamunuarachchi

Emeritus Professor,

University of Sri Jayawardenepura,

Consultant Food and Herbal

Product Technologist,

Sri Lanka.



Supervisor

Dr. I. Wickramasinghe

Senior lecturer,

Department of Food Science and

Technology,

Faculty of Applied Science,

University of Sri Jayawardenepura,

Sri Lanka.



Supervisor

Mr. R.M.G.B. Rajanayake

City Analyst Colombo,

City Analyst's Laboratory,

Colombo Municipal Council,

Colombo 07,

Sri Lanka.

TABLE OF CONTENTS

Content	Page
TABLES OF CONTENT.....	i-v
LIST OF TABLES	vi
LIST OF FIGURES	vii
ACKNOWLEDGEMENT.....	viii
ABBREVIATIONS	ix
ABSTRACT.....	x-xi
CHAPTER 1: INTRODUCTION.....	1
CHAPTER 2: LITERATURE REVIEW.....	4
2.1 The Turmeric Plant.....	4
2.1.1 Historical background.....	4
2.1.2 Product and uses.....	5
2.1.3 Major growing areas.....	5
2.1.4 Varieties	5
2.1.5 Soil and climatic needs	5
2.1.5.1 Soil.....	5
2.1.5.2 Climate.....	6
2.2 Crop Management Techniques.....	6
2.2.1 Mulching.....	6
2.2.2 Fertilizer application.....	6
2.2.3 Weeding	7

2.3 Crop Protection.....	7
2.3.1 Diseases	7
2.3.2 Pests.....	7
2.4 Harvesting.....	8
2.5 Processing.....	8
2.5.1 Production of dried turmeric rhizome.....	8
2.5.2 Production process of turmeric powder	9
2.5.2.1 Purchasing of dried turmeric rhizome.....	10
2.5.2.2 Assembling, sorting and grading.....	10
2.5.2.3 Cleaning.....	11
2.5.2.4 Polishing.....	11
2.5.2.5 Powder process.....	11
2.5.2.6 Screening.....	12
2.5.2.7 Powder storage and packing.....	12
2.6 Chemical Constituents of Turmeric.....	13
2.7 Uses of Turmeric.....	14
2.7.1 Turmeric as a spice.....	14
2.7.2 Turmeric as a medicine.....	15
2.7.3 Turmeric as a cosmetic.....	15
2.7.4 Turmeric as a colorant.....	15
2.8 Export Market of Turmeric.....	16
2.9 Metals.....	16
2.9.1 Macro metals.....	17

2.9.1.1 Sodium.....	17
2.9.1.2 Magnesium.....	18
2.9.1.3 Potassium.....	18
2.9.1.4 Calcium.....	19
2.9.2 Micro metals.....	19
2.9.2.1 Iron.....	19
2.9.2.2 Manganese.....	20
2.9.2.3 Copper.....	21
2.9.2.4 Zinc.....	22
2.9.2.5 Chromium.....	22
2.9.3 Toxic heavy metals.....	23
2.9.3.1 Nickel.....	23
2.9.3.2 Lead.....	24
2.9.3.3 Cadmium.....	25
2.10 Recommended Dietary Intake of Minerals.....	26
2.11 The Principle of Digestion.....	27
2.11.1 Wet digestion.....	28
2.11.1.1 Advantages of wet digestion.....	28
2.11.1.2 Disadvantages of wet digestion.....	28
2.11.2 Dry ashing.....	29

2.11.2.1 Advantages of dry ashing.....	30
2.11.2.2 Disadvantages of dry ashing.....	29
2.12 The Principle of Metal Analysis Methods.....	29
2.12.1 The principle of Atomic Absorption Spectrometry.....	30
2.12.1.1 Flame atomization.....	31
2.12.1.2 Graphite furnace.....	31
2.12.2 X-Ray Fluorescence Spectrometry.....	31
CHAPTER 3: MATERIALS AND METHODS.....	33
3.1 Sample Selection.....	33
3.2 Sample Preparation.....	33
3.3 Atomic Absorption Spectrometric (AAS) analysis.....	33
3.3.1 Materials.....	34
3.3.2 Equipment/Apparatus.....	34
3.3.3 Reagents.....	35
3.3.4 Principle.....	37
3.3.5 Procedure.....	37
3.3.5.1 Removing Moisture.....	37
3.3.5.2 Digestion.....	37
3.3.6 Determination.....	38
3.3.7 Calculation.....	38

3.4 X-Ray Fluorescence Spectrometric (XRF) analysis.....	39
3.4.1 Materials.....	39
3.4.2 Equipment/apparatus.....	39
3.4.3 Procedure.....	39
3.4.3.1 Removing Moisture.....	39
3.4.3.2 Digestion.....	40
3.4.3.3 Pellet Preparation.....	40
3.4.4 Determination.....	40
3.4.5 Calculation.....	41
3.5 Statistical Analysis.....	41
CHAPTER 4: RESULTS AND DISCUSSION.....	42
4.1 Studies with turmeric.....	42
4.1.1 Estimation of macro metals.....	42
4.1.2 Estimation of micro metals.....	49
4.1.3 Estimation of toxic heavy metals.....	57
CHATER 5: CONCLUSION.....	62
REFEENCES.....	64
APPENDICES.....	I-XXX I

LIST OF TABLES

	Page
Table 2.1	Chemical composition of turmeric..... 14
Table 2.2	Metals in food17
Table 2.3	Recommended daily intake of minerals.....26
Table 2.4	Maximum limits for metals in turmeric powder and turmeric whole26
Table 2.5	Maximum limits for copper and lead in turmeric powder.....27
Table 2.6	Maximum limits for micro and heavy metals in spices..... 27
Table 3.1	Operating parameters of elements for flame AAS.....35
Table 3.2	Operating parameters of elements for graphite furnace AAS.....35
Table 3.3	Working standard solutions in flame AAS..... 36
Table 3.4	Working standard solutions in graphite furnace AAS.....36
Table 3.5	Operating parameters of XRF..... 39
Table 3.6	Characteristic fluorescence energy value of elements.....41
Table 4.1	Macro metal content in turmeric powder by AAS.....43
Table 4.2	Average macro metal content in different turmeric brands by AAS.....43
Table 4.3	Macro metal content in different turmeric brands by XRF.....47
Table 4.4	Micro metal content in turmeric powder by AAS.....49
Table 4.5	Average micro metal content in different turmeric brands by AAS.....50
Table 4.6	Micro metal content in different turmeric brands by XRF.....54
Table 4.7	Toxic heavy metal content in turmeric powder by AAS.....57
Table 4.8	Average toxic heavy metal content in different turmeric brands by AAS 57
Table 4.9	Toxic heavy metal content in different turmeric brands by XRF.....60

LIST OF FIGURES

		Page
Figure 2.1	The turmeric plant.....	4
Figure 2.2	Turmeric fingers.....	10
Figure 2.3	Turmeric sorting and cleaning.....	10
Figure 2.4	Manual cleaning.....	11
Figure 2.5	Polishing.....	11
Figure 2.6	Polished fingers.....	11
Figure 2.7	Grinding.....	12
Figure 2.8	Screening process.....	12
Figure 2.9	Powder storage.....	13
Figure 2.10	Packing.....	13
Figure 2.11	Keto-form of curcumin.....	13
Figure 2.12	Enol form of curcumin	13
Figure 4.1	Potassium content in turmeric by flame AAS.....	46
Figure 4.2	Na, Mg and Ca in turmeric by flame AAS.....	46
Figure 4.3	Potassium content in turmeric by XRF.....	47
Figure 4.4	Calcium content in turmeric by XRF.....	48
Figure 4.5	Iron content in turmeric by flame AAS.....	53
Figure 4.6	Mn, Cu and Zn contents in turmeric by flame AAS.....	53
Figure 4.7	Cr content in turmeric by GFAAS.....	54
Figure 4.8	Iron content in turmeric by XRF.....	55
Figure 4.9	Mn, Cu and Zn content in turmeric by XRF.....	55
Figure 4.10	Ni, Pb and Cd contents in turmeric by GFAAS.....	60

ACKNOWLEDGEMENT

First and foremost I offer my sincere gratitude to my supervisors emeritus professor Arthur Bamunuarachchi University of Sri Jayawardenepura, Dr. Indira Wickramasinghe, Senior Lecturer of Department of Food Science and Technology, University of Sri Jayawardenepura and Mr. R.M.G.B. Rajanayake, City Analyst Colombo, Colombo Municipal Council for their valuable advice, encouragement and guidance through this study. And also for reading the manuscript and sparing their valuable time in bringing this study to a successful completion. Apart from that I also like to remind the opportunity given by Mr. R.M.G.B. Rajanayake to use the sophisticated laboratory equipment in City analyst's laboratory, Colombo.

I wish to express my sincere thanks to Dr. Jagath Wansapala, senior lecturer, Department of Food Science and Technology and coordinator of food technology programme, University of Sri Jayawardenepura. I wish to thank Mr. P. Dias, Senior lecturer of Department of statistics, University of Sri Jayawardenepura for the support given me for the interpretation of statistical results of the research.

I wish to thank Mr. V.A. Waduge, Director-Life Science Division, Atomic Energy Board for the supporting to the analysis by XRF.

I extend my thanks to the staff of the City Analyst's laboratory for their assistance and support.

Last but not least my heartfelt gratitude goes out to my family and friends.

ABBREVIATIONS

WHO	-	World Health Organization
AOAC	-	Association Of Analytical Communities
AAS	-	Atomic Absorption Spectrometry
GFAAS	-	Graphite Furnace Atomic Absorption Spectrometry
XRF	-	X-Ray Fluorescence
ANOVA	-	Analysis of variances
DW	-	Dry Weight
DL	-	Detection Limit
ppm	-	parts per million
ppb	-	parts per billion

Analysis of Metal Content in Turmeric Powder Available in the Sri

Lankan Market

Melani Nisansala Withanage

ABSTRACT

Turmeric powder is a bright yellow coloured powder made by grinding of dried mature turmeric rhizomes. Turmeric is an important condiment used mainly for culinary preparations and also as a dye with varied uses in cosmetic industries and for medicinal properties. Sometimes turmeric may be contaminated with micro and toxic heavy metals excessively. Heavy metal contamination in the food chain is mainly caused by environmental pollution. Micro metals composition of turmeric are very important because of their essentiality or the toxic nature. In the processing of turmeric powder from the dried rhizome these metals content may be varied.

Turmeric is available as branded and unbranded powders. Therefore this study was carried out to assess the levels of macro, micro and toxic heavy metals in some of those widely used branded and unbranded turmeric powders available in the Sri Lankan market. Three batches from five different brands and an unbranded turmeric powder were subjected to the analysis. A pure turmeric rhizome was used as the control. AOAC Official method of 975.03 was carried out to determine these metal content using flame and graphite furnace atomic absorption spectrometry. The macro metals sodium (Na), magnesium (Mg), potassium (K), calcium (Ca) and micro metals namely iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) were analyzed by flame AAS.

The other micro metal chromium (Cr) and toxic heavy metals namely nickel (Ni), lead (Pb) and cadmium (Cd) were analyzed by graphite furnace AAS. The metals potassium, calcium, iron, manganese, copper, zinc, chromium, nickel and lead were also analyzed by X-Ray Fluorescence spectrometry (XRF). The results were statistically analyzed using analysis of variance (ANOVA). Tuckey's pair wise comparison, Dunnet's comparison, the equal variance test and one sample t test was applied to analyse the results. Paired t test was used to compare the results obtained by AAS and XRF for the metal analysis in turmeric.

According to the results, potassium was the most abundant macro metal in turmeric and the values ranged from 36155.8 to 42788.8 $\mu\text{g/g}$ in different brands. There were increment of sodium and iron content in turmeric during the grinding process. In the case of iron the pure rhizome contained 205.6 $\mu\text{g/g}$ of iron while branded and unbranded turmeric powders ranged from 222.1 to 463.0 $\mu\text{g/g}$. Except iron the other micro metals were present in very low level in turmeric. Iron content only in unbranded turmeric powder was exceeded the maximum limit and the value was 461.7 $\mu\text{g/g}$. Cadmium content exceeded the maximum limit in some brands as detected in brand B (423.3 $\mu\text{g/g}$) and brand C (788.0 $\mu\text{g/g}$). Lead was not detected in most of branded turmeric powders. According to the statistical analysis, only iron and cadmium contents in some brands were significantly exceeded the maximum limit recommended by World Health Organization (WHO). There were significant differences among all the brands and unbranded turmeric powder in majority of metal contents. The variation among batches in same brand for the all metals was not significant. It was statistically proved that the both AAS and XRF methods give the similar results for the metal content.

CHAPTER 1

INTRODUCTION

Spices are generally used to enhance the colour, flavor and the other organoleptic properties which increase the acceptability of food. Therefore they are used as diet components. They are dried plant parts such as rhizomes, barks, leaves, fruits, seeds or other part of spicy crops. Most of these are fragrant, aromatic and pungent plants.

Turmeric is a well known spice which is added to foods in cooking mainly as a coloring agent. It is produced from the dried rhizome of *Curcuma longa* L which belongs to ginger family. It is a flowering plant which has white flowers and the height of the plant is about 40 inches. Turmeric is widely distributed in tropical and subtropical regions especially in South and Southeast Asian countries, Africa and America. In Sri Lanka turmeric is cultivated in nearly every part of the island except in areas of very high elevations. Turmeric is cultivated under coconut as an inter-crop commercially. The harvested form is the rhizome and after several processing steps a yellow colour powder is obtained which is called turmeric. The yellow colour is given to the turmeric by curcumin. Turmeric can be used as a herbal medicine as rhizome and also used in religious activities. In addition turmeric oil and curcumin are produced from the turmeric rhizome.

Dried turmeric has pungent flavor and they contain carbohydrates and the other organic compounds with various functional groups. These may be contaminated with trace and heavy metals excessively. Regular usage of these contaminated turmeric result in accumulation of these metals in human organs and may results in serious health effects.