Assessment, Evaluation and Validation of Analytical Method for determination of Elemental Impurities in *Semecarpus anacardium* Seed by ICP-OES

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Abstract — **Since ancient times, majority of people in India have used herbal remedies for the treatment, management, and prevention of many diseases. The use of plant-based medicines as supplements or medications is spreading among the global population. These therapeutic plants can be hazardous or insufficient in nutrients for use by humans and animals. They do this by absorbing trace elements and metals that are present in the soil solutions in ionic, complexed, or chelated forms. In addition to being widely accessible, these medications are also reasonably priced when compared to allopathic treatments. A number of incidents involving heavy metals in herbal medicine have surfaced recently. Regulators have therefore begun to keep an eye on and regulate the quality of herbal medications. The goal of this study is to assess, evaluate, and provide a validated method for determining the content of elemental impurities present in *Semecarpus anacardium* Seeds. An accurate, precise, reproducible and eco friendly Inductively Coupled Plasma Optical Emission Spectroscopic (ICP – OES) method was developed and validated for the estimation of Calcium, Potassium, Magnesium and Iron in *Semecarpus anacardium* Seed. The method has been developed and validated using RF power of 1450 W, auxiliary gas of 0.2 L/min, and nebuliser flow of 0.7 L/min and plasma view at axial mode for all elements of interest. The wavelength was monitored for Iron, Magnesium, Calcium and Potassium at 239.562 nm, 285.213 nm, 317.933 and 766.490 nm respectively. The method has been validated in terms of specificity, precision, linearity, accuracy, limit of quantification as per ICH Q2 (R2) Guideline and acceptance criteria for this validation has been obtained from Elemental Impurities-Procedure USP Chapter <233>.The obtained limit of quantification, repeatability, and measurement uncertainty were satisfactory. Linearity results obtained 0.999 and with other statistical data such as slope, y-intercept and Styx at acceptable limit. Recovery estimation with approved reference materials confirmed the method's accuracy. Accuracy of method ranging from 70.23% to 133.37%.**

Keywords—Semecarpus anacardium, **inductively coupled plasma optical emission spectroscopy (ICP-OES), Elemental Impurities, Method Development and Validation, Medicinal plants; multi-elemental analysis, ICH Guideline, USP Chapter <232& 233>.**

I. INTRODUCTION

The earliest archaeological evidence on the relationship between humans and plants dates back 1.2 million years. Recently, chemical analysis of human dental calculus belonging to ancient times has demonstrated that 70–80% of daily calorie was provided from plant products. Like human being, plants also need certain level of micro and macro-elements (Ca, Cl, N, Na, P, K, Mg, etc.) and trace elements (B, Fe, Cu, Mn, Zn, etc.) for their structure, growth, and metabolic activities in maintaining a proper life. About 80% of the world's population benefits from medicinal plants against diseases and more than 80,000 plant species are used for medicinal purposes [1]. Certain mineral elements are classified as micronutrients because they are anticipated to be present in plants in trace amounts, while others are considered trace elements because they are often needed for certain metabolic functions within the human body. Numerous mineral elements that are present in plants are vital for human nutrition and have been extensively documented in the literature to have varying degrees of metabolic processes, from cell defence and primary and secondary metabolism to signal transduction, hormone perception, energy metabolism, and gene regulation [2].

Plants have been used therapeutically for thousands of years and continue to be the main treatment modality for a large percentage of the world's population. Furthermore, herbal medicine usage is increasing in Western countries as complementary (and sometimes alternative) treatments in conjunction with allopathic medicine. At the same time, the usage of allopathic medicines is being increasingly incorporated into the medicinal systems of developing countries, often resulting in the concurrent usage of both systems [3].

These trace elements play an important role in metabolic activity, such as the training of seeds and fruits, pollen health, protein synthesis, training and carbohydrate transport, calcium transportation, hormone formation, cell tissue formation, and cell tissue formation, Structural and physiological stability of roots and flowers, plant tissue, cell division, cell wall formation, cell expansion and enzyme activation in plant metabolism [1-2]

Elements that plants need to survive are called “plant nutrients”. Nearly every element present in nature can be seen in plant tissues when they are analyzed. Even though plants are nutrient-selective, some heavy metals that can enter plants' bodies passively can become involved in the food chain [3].Their uptake from the environment is crucial since these elements cannot be synthesized by the organism itself.

In recent years, many industries and pharmaceutical companies have shown increasing interest in the use of natural products of plant origin in specific formulations, both for medicinal specialties and for the production of functional foods. According to the World Health Organization (WHO), about 80% of people in developing countries use traditional herbal medicine [4].

Due to complex nature of Medicinal plant raw materials and can be contaminated with metal impurities from environment. Therefore, the content of elemental impurities typical for plants should be controlled in comparison with the existing conceptions of recommended or permitted daily exposures of human consumption of some chemical elements. The toxicity of plant-based metal elements has caused serious disease symptoms in humans being. Hence, it is important to assess and evaluate the content of various elements plants so as to provide information on toxicities of elements according to the recommendation of the regulatory legislation [2]. To ensure the safety, efficacy, and quality of traditional medicines which have come to be widely used internationally, expansion of their knowledge base and strengthening of relevant regulations are essential [3]. Accordingly, WHO launched the International Herbal Pharmacopoeia projecting 2020 [4].The current study set out to assess the potential risks to human health associated with the concentrations and nutritional components of *Semecarpus anacardium* seeds, which are historically utilized in Indian medicine. Thus, the standardisation of plant raw materials is among the most important problems of the production of herbal medicines. Thus, the first goal of this study was to optimize and validate and ICP-OES method to determinate the elements Ca, Mg, Fe and, K in *Semecarpus anacardium* seed [2,3,4]

II. MATERIALS AND METHODS

2.1 Instrumentation/Equipment:-

The ICP-OES Perkin-Elmer Model Optima 8300, an inductively coupled plasma optical emission spectrometer with axial and radial viewing plasma configuration and data handling system, controlled with Syngistix software was used. For method development and Validation the instrument operated at a 40 MHz free-running ratio-frequency and was equipped with an S10 autosampler from Perkin-Elmer. A chemically resistant Gem-tip cross-flow nebulizer connected to a Scott double-pass spray chamber made comprised the nebulization system. An injector constructed of alumina was utilized in a torch, with an Echelle grating, the polychromator's spectral range was 165–782 nm, and its resolution at 200 nm was 0.006 nm. Dual view Segmented array-charge-coupled device (SCD) detector with 235 subarrays was employed. The plasma was viewed axially. The Milli Q-water produced from Milli pore water system. Borosil type glassware and calibrated 1000–5000 µl pipettes were used. Analytical balance for weighing of Mettler-Toledo (Model-XPR205) used. The analytical parameters of the ICP-OES instrument are summarized in Table 1.

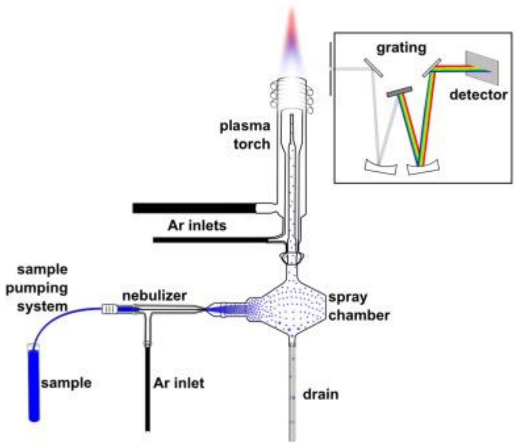


Fig.(a): Schematic diagram of ICP-OES

2.2Reagents and Chemicals:-

Hydrochloric acid (37% Make-Carlo Erba Grade) purchased were from Merck chemicals limited. ICP standards of Potassium, Calcium, Iron and Magnesium each 1000 mg/L and USP Reference Solution of Elemental Impurities Class 1 and 2A Mixture, USP Reference Solution of Elemental Impurities 2B Mixture solution and USP Reference Solution of Elemental Impurities Class 3 multi-element standard solution were purchased from Inorganic Venturies. Diluent solution prepared by using deionised water with a resistivity of >18 MΩ cm, generated by a Milli-Q Plus pure water generating system. The *Semecarpus anacardium* seeds commonly called by different names such as bibba, bhilwa and bhallataka were collected from Village- Umberwadi, Tal-Gadhinglaj District-Kolhapur, Maharashtra.The seeds were washed with water and air dried. In order to evaluate true identity and correct quantitation of elemental impurities, avoid the contamination of *Semecarpus anacardium* seeds from environmental material.

2.3 Method development and optimization of method parameters

The principal goal of our research study is to develop an accurate and precise ICP-OES method to quantify possible elemental impurities such as Potassium, Magnesium, Calcium and Iron present in *Semecarpus anacardium* nut. The Plasma torch alignment was performed by using a Mn solution (1µg/g) at emission line 257.61 nm to evaluate that the optics are optimized and are focused on the analytical zone of the plasma. This alignment procedure will ensure maximum sensitivity and signal-to-noise. During the development of the method, Potassium, Magnesium, Calcium and Iron standard solution of known concentration was monitored at different emission lines such as 285.213nm, 279.553 nm and 280.271 nm for Magnesium; 766.490 nm, 404.721 nm and 422.298 nm for Potassium; 317.933nm ,393.366 nm and 315.887 nm for Calcium ; 238.204 nm and 239.562 nm by aspirating the solution. The responses of Potassium, Magnesium, Calcium and Iron are very prominent at 766.490 nm, 285.213 nm, 317.933 nm and 239.562 nm respectively when applied the target power of RF 1450W.Also the Spectral interferences were checked using the Test sample, matrix blank and standard solution. The matrix blank and standard solutions were consecutively nebulized and the corresponding spectrum registered in the range of +/- 0.8 nm of the wavelength of the maximum intensity for all emission spectral lines studied. In this way, inter-element overlapping spectral interferences were discarded by observing the spectra registered. Once the spectral interference-free condition was confirmed, the signal-to-background ratio (R) elements were calculated by Eq. (1)

No possible inferences were observed at this emission lines and good baseline was observed than other wavelengths. During method development, the Target limit (J) of each elemental impurities (Mg, Ca, K and Fe) considered was 0.25 ug/mL (0.25ppm) and Test concentration of 1mg/mL (1000 ppm). But the actual content found for K (21%), Ca (10%), Mg (5%) and Fe (0.03%) and hence such high content can lead to non-linear detector response. In order to overcome this problem, the Test concentration was adjusted to 0.1mg/mL (100 ppm). During the method development, above said wavelengths were optimized to get better sensitivity and also evaluated by recovery study at selected wavelength and by visual inspection of spectra. The unspiked samples were used to quantify elemental content in the sample. The developed analytical method was validated as described in USP chapter <233> Elemental Impurities-Procedure and according to International Conference on Harmonization ICH Q2 (R2) guideline.

$$R = \frac{\text{Intensity of Element in Sample}}{\text{Intensity of Element in Blank}} \quad \text{Eq. (1)}$$

2.4 Preparation of Solutions:

2.4.1 Calibration Stock Solution A:-

Weighed accurately about 95.33 mg of Potassium Chloride (Equivalent to 50 mg of Potassium, Make-Avantor) in a 50 ml clean dry volumetric flask, mixed, and made up to volume with 0.1% Hydrochloric acid Solution. (Concentration of K-1000 ppm).

2.4.2 Calibration Stock Solution B:-

Pipette 1.0 mL of Iron stock standard (1000 ppm), 2.0 mL of Magnesium stock standard (1000 ppm), 2.0 mL of Calcium stock standard (1000 ppm), and 2.0 mL of Calibration stock solution A (Potassium-1000 ppm) in 15 mL Tarson tube and dilute to 10 mL with 0.1% Hydrochloric acid Solution. (Concentration of Fe-100 ppm, K-200 ppm Mg-200 ppm, and Ca-200 ppm)

2.4.3 Calibration standards:-

The calibration standards were prepared at 30% (0.3J), 50% (0.5J), 80% (0.8J), 100% (1J),
120% (1.2J) and 150% (1.5J) of the target limit for each elemental impurities in the final analysis.

2.4.4 Residue on Ignition:-

Weighed 10 *Semecarpus anacardium* seeds, transferred in mortar and crushed in small piece with the help of pestle. Weighed approximately 1-2g of these crushed material in cleaned, dried, previously weighed Silica crucible. Initially, heat the material at about 450-550°C to charred it completely and then moisten with 1 mL Sulfuric acid. Ignited gently to remove all fume and kept in muffle furnace at 800°C+/-50°C until total carbon consumed for about 3-4 hrs. Then weighed crucible and calculated residue on ignition.

2.4.5 Sample Solution:

Test Stock Solution A:-

Weigh 10.0 mg of residue obtained in "residue on ignition test" in 15 mL Tarson tube and dilute up to 10 mL with diluent. (1000 ppm)

Test Solution: -

Pipette out 1.0 mL of Test stock solution A in 15 mL Tarson tube and dilute up to 10 mL with Diluent. Filter this solution through 0.45u Nylon filters and used for aspiration.

Table 1: -Operating conditions for Optima 8300 ICP-OES instrument

Instrument used:	:	Elemental Spectrometric system (ICP-OES)	
Detector	:	Optical detection system	
Spray Chamber	:	Cyclonic	
Spectral profiling	:	No	
Resolution	:	High	
Purge gas flow	:	High	
Read delay time	:	90 seconds	
Replicates	:	3	
Read time	:	Auto	
Source equilibration delay	:	30 sec	
Monitor nebulizer back pressure	:	No	
Plasma L/min	:	12	
Auxillary L/min	:	0.2	
Nebulizer L/min	:	0.70	
Power watts	:	1450	
View distance	:	15.0	
Plasma view	:	Axial	
Diluent	:	10 mL Conc. Hydrochloric Acid in 1000 mL water	
Sample flow rate	:	2.00 mL/min	
Sample flush time (sec)	:	30	
Peak algorithms	:	Peak area	
Points/peak	:	5	
Spectral overlap and background	:	Auto	
Assign internal standard	:	No	
Assign internal standard check	:	No	
Wash	:	Between samples	
Wash Location	:	0	
Wash Rate (mL/min)	:	1.00	
Wash Time (sec)	:	30	
Wavelengths		Element	Wavelength (nm)
		Fe	239.562
		Mg	285.213
		Ca	317.933
		K	766.490

2.5 Method validation Studies

The validation process of the analytical method of ICP-OES technique was performed as per USP Chapter<233> Elemental Impurities-Procedure and according to ICH Q2 R2 guideline regarding accuracy, precision, selectivity, Limit of detection and limit of quantitation and linearity using the experimental setting that provided the optimal conditions.

2.5.1 System suitability

System suitability tests are method specific rather than instrument specific test performed to verify that the analytical system is fit to use immediately before committing the samples for analysis. System suitability was determined by preparing series of Calibration standard solutions of Potassium, Magnesium, Calcium and Iron in the concentrations range for Potassium, Calcium, Iron (1.5 ppm, 2.5 ppm, and 4.0 ppm, 5.0 ppm, 6.0 ppm and 7.5 ppm) and for Fe (0.75 ppm, 1.25 ppm, 2.0 ppm, 2.5 ppm , 3.0 ppm and 3.75 ppm) and six replicate injection of standard solution (target concentration) of each element and aspirated to ICP-OES system as per methodology.

2.5.2 Specificity/Selectivity:

Specificity is the ability to ensure that the analytical procedure for sample preparation and measurement allow a reliable determination of metals in presence of components such as impurities, matrix and carrier gas. The procedure must be able to unequivocally assess the Target elements in presence of components that may be expected to be present, including other Target elements and Matrix components. The selectivity in the case of ICP-OES method is related to possible interferences of the emission spectrum at specific wavelengths. The emission lines used for quantitation of each element, based on known interferences and baseline signal at selected wavelengths observed empirically during the measurement. To demonstrate specificity of method, Potassium, Magnesium, Calcium and Iron Standard solution, USP Reference Solution of Elemental Impurities Class 1 and 2A Mixture (As, Cd, Pb, Hg, Co, Ni and V), USP Reference Solution of Elemental Impurities 2B Mixture (Ag, Au, Ir, Os, Pd, Pt, Rh, Ru, Se and Tl) and USP Reference Solution of Elemental Impurities Class 3 multi-element standard solution(Ba, Cr, Cu, Li, Mo, Sb, and Sn), test sample (control sample) and test sample spiked with Potassium, Magnesium, Calcium and Iron (at target concentration) were aspirated as per ICP-OES test methodology and determine the Potassium, Magnesium, Calcium and Iron contents.

2.5.3 Limit of detection and limit of quantitation:

In order to establish the sensitivity of analytical method, the limit of detection and limit of quantitation parameter was performed. The Limit of detection and quantitation was determined by injecting low concentration of elemental impurities in six replicate injections.

2.5.4 Linearity:

Linearity of analytical method is defined as the ability for showing the response of the analyte is proportional to the analyte concentration within a given range. The peak response obtained from the ICP-OES was plotted against corresponding concentrations to obtain the calibration graph. The results of the linearity study gave linear relationship over the concentration range from LOQ (30%) to 150% for Potassium, Magnesium, Calcium and Iron.

2.5.5 Accuracy (recovery):

Accuracy expresses the familiarity of conformity between the value obtained and the value which is accepted either as a predictable true value or an accepted reference value. USP requires that samples are spiked to concentrations ranging from 50 to 150% of J when determining the accuracy of the method where J is the concentration (w/w) of elements at the target limits stated in USP, diluted to the working range of the instrument. In this study since *Semecarpus anacardium* is the herbal product for which the ICH Q3 D guideline is not applicable, but it is necessary to determine the content of Potassium, Magnesium, Calcium and Iron elements in *Semecarpus anacardium* seed. In this case dilution was unnecessary and J therefore equals the USP target limits. The accuracy of the method is determined by recovery studied for Potassium, Magnesium, Calcium and Iron. The sample solutions were prepared in triplicate by spiking for Potassium, Magnesium, Calcium and Iron and at LOQ level, 50%, 100%, and 150% of specification and analyzed individually as per test method. The recovery can be calculated by the equation,

$$\text{Recovery (\%)} = \frac{(T_f - T_s)}{T_a} \times 1000 \quad \text{Eq. (2)}$$

Where,

T_f= % Amount of each elemental imp. found in test spike,

T_s= %Amount of each elemental imp. found in test as such/ control sample

T_a= %Amount of each elemental imp. added in test spike

2.5.6 System Precision:

The closeness of agreement between a series of measurements obtained from multiple sampling of the same homogeneous sample under given conditions. System precision was demonstrated by aspirating standard solution of Potassium, Magnesium, Calcium and Iron at limit level (100% level) and measured six times.

2.5.7 Method precision (Repeatability):

Method precision of analytical procedure was assessed by measuring the concentration (content) of six independently prepared samples solutions or spike solution at 100% of the test concentrations. Method precision (Repeatability) was determined by preparing six sample solutions individually spiked with Potassium, Magnesium, Calcium and Iron at target concentration (100% level).These spiked solutions were aspirated into ICP-OES system as per methodology and determined content of the Potassium, Magnesium, Calcium and Iron.

III. RESULT AND DISCUSSION

3.1 System Suitability: -

System suitability results were evaluated by regression analysis where, intensity (Counts/S) of element of interest in Calibration standard solutions should be linear and correlation coefficient should be NLT 0.99. From the linear solutions, correlation coefficient, y-intercept, slope, and residual sum of squares (STEYX) were calculated, and thus the linear relationship of concentration vs Intensity (Counts/S) was verified over the range specified. Drift obtained for the Standard solution (target concentration i.e 1.0J) before and after the analysis of the sample solution should be NMT 20% of each target element and RSD of six replicate injections of standard solution should be not more than 20%.Results were given in Tables 2.

Table 2: Result Summary of System Suitability

Element	Correlation coefficient	%Drift	%RSD	Slope	y-Intercept	Steyx
Mg	0.9998	-0.43	1.10	131551.83	15370.94	6403.9
Ca	0.9999	0.55	0.77	75677.48	6949.90	1805.6
K	0.9992	3.31	1.50	219277.40	-49515.88	21622.7
Fe	0.9999	-0.05	0.65	32264.61	1656.93	461.7

3.2 Specificity/Selectivity:

The Method able to unequivocally assess each Target Element in the presence of components that may be expected to be present, including other Target Elements and matrix components as shown in figure (b), (c), (d) and (e). Data shows that there were no spectral interferences from Class 1/2A, Class 2B and Class 3 elements was observed.

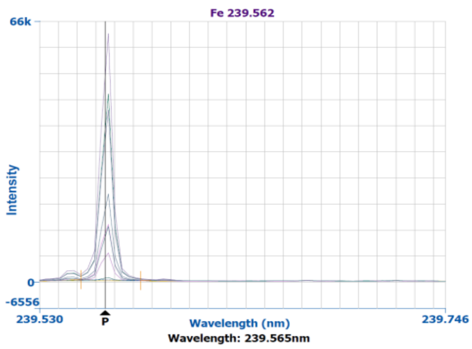


Figure (b)

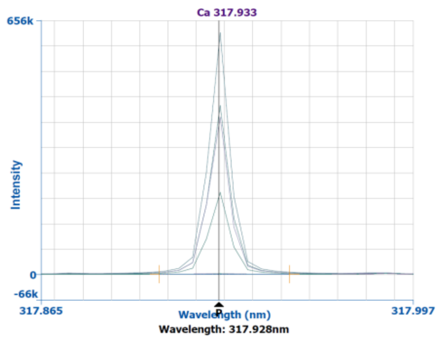


Figure (c)

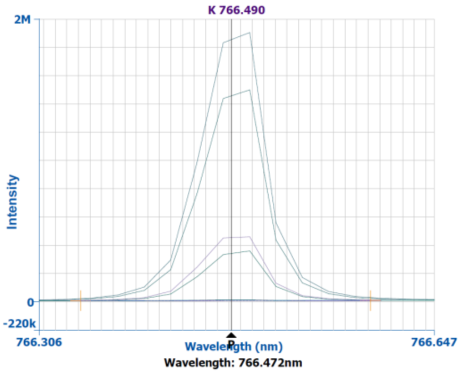


Figure (d)

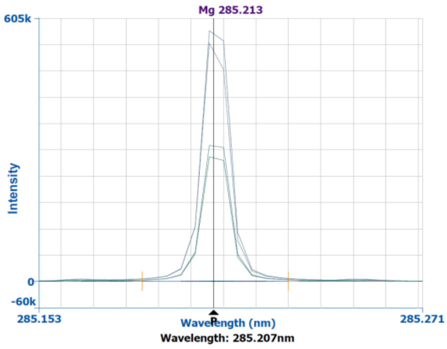


Figure (e)

3.3 Limit of Detection and Quantitation:

The acceptance criteria were RSD for six replicates obtained for LOD and LOQ solution not more than 15% for LOD and 10.0% for LOQ. %RSD of six replicates obtained for LOD and LOQ solution and Concentration (µg/mL) was summarized in table 3.

Table 3:-Result summary of Limit of Detection and quantitation

Element	%RSD		Concentration (µg/mL)	
	LOD	LOQ	LOD	LOQ
Mg	1.09	1.52	0.6697	1.4853
Ca	0.63	1.24	0.6808	1.4819
K	2.37	1.84	0.6865	1.3720
Fe	0.73	1.03	0.3393	0.7442

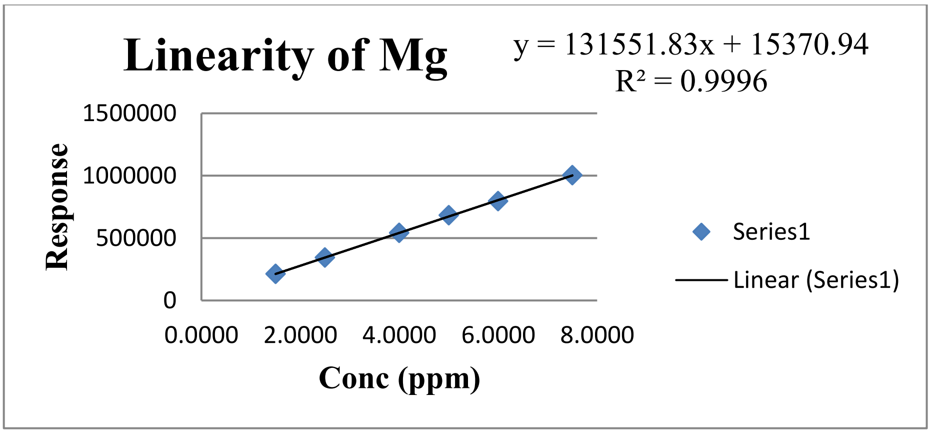
3.4 Linearity:

The linearity of Analytical method was assessed from the regression analysis, the correlation coefficient of determination (r) was 0.9990 for all four analytes, indicating a linear relationship between the concentration of analyte and response under the peak. Linearity results for four analytes are shown in Table 4 and linearity graphs shown in Graph I to IV.

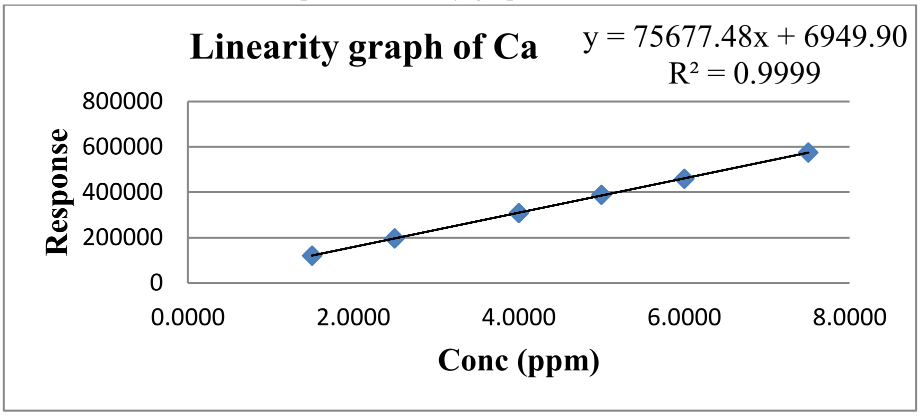
Table 4: Linearity results for Elements

Element	Correlation coefficient	Slope	y-Intercept	Styx
Mg	0.9998	131551.83	15370.94	6403.9
Ca	0.9999	75677.48	6949.90	1805.6
K	0.9992	219277.40	-49515.88	21622.7
Fe	0.9999	32264.61	1656.93	461.7

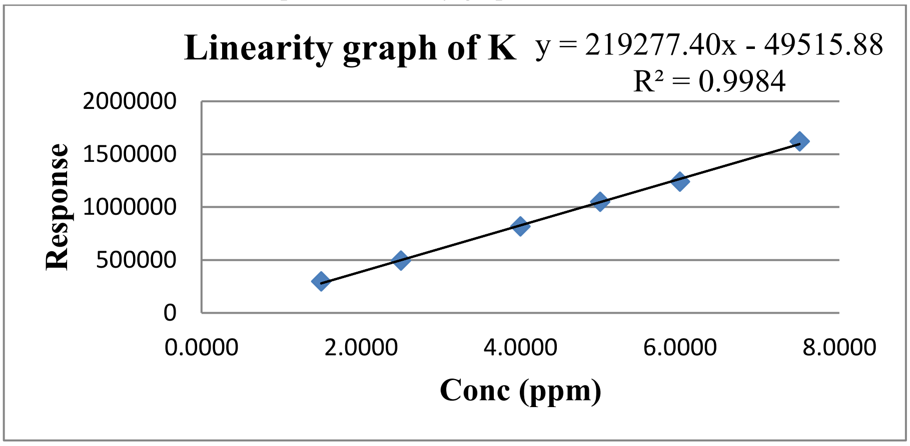
Graph I: Linearity graph of Magnesium



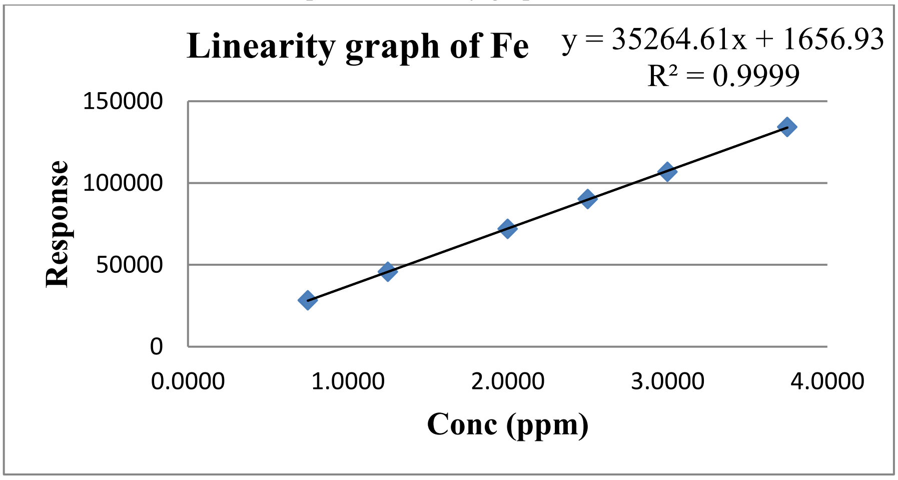
Graph II:-Linearity graph of Calcium



Graph III:-Linearity graph of Potassium



Graph IV:-Linearity graph of Iron



3.5 Accuracy:

Acceptance criteria for accuracy as USP Chapter <233> Elemental Impurities-Procedure where defined as Mean % Recoveries obtained for each elemental impurity should be between 70.0 %-150.0% at 50% to 150% level and should be in the range of 50% to 150% at LOQ level. Results of Test as such and Accuracy tabulated below table 5 and 6.

Table 5: Result Summary of Amount found in Test as Such

S.No	Element	% Amount Found
1	Mg	4.9900

2	Ca	9.3283
3	K	20.5950
4	Fe	0.0368

Table 6: Result summary of Accuracy for Magnesium, Calcium, Potassium and Iron

S.No	Accuracy Level	Mean% Recovery (triplicate preparations)	%RSD
Results for Magnesium			
1	LOQ Level (30%)	84.68	4.78
2	50% Level	91.76	2.69
3	100% Level	89.92	0.81
4	150% Level	83.70	1.32
Results for Calcium			
1	LOQ Level (30%)	70.23	4.17
2	50% Level	88.66	6.37
3	100% Level	88.67	1.57
4	150% Level	84.41	0.88
Results for Iron			
1	LOQ Level (30%)	90.48	0.66
2	50% Level	89.78	0.84
3	100% Level	89.35	0.79
4	150% Level	87.31	0.28
Results for Potassium			
1	LOQ Level (30%)	96.42	17.55
2	50% Level	133.37	7.67
3	100% Level	126.84	1.59
4	150% Level	107.86	2.13

3.6 System Precision:

The RSD of six replicate aspirations of standard solution at limit level should not be more than 10.0% to demonstrate the System precision of analytical method. The results were within the acceptable criteria. The experimental system precision results are shown in Table 7.

Table 7: - Result Summary of System Precision

Inj.No.	Potassium	Magnesium	Calcium	Iron
Inj-1	1033854.1	680704.3	386231.6	90109.0
Inj-2	1036326.2	683521.6	387608.6	90351.8
Inj-3	1038936.2	685533.5	390058.1	91238.1
Inj-4	1007566.3	686393.2	389788.8	90787.2
Inj-5	1048064.8	692762.8	390226.4	91641.0
Inj-6	1051373.7	701443.3	395010.0	90351.8
Mean	1036020.2	688393.1	389820.6	90746.5
SD	15515.90	7542.26	2997.53	593.54
%RSD	1.50	1.10	0.77	0.65

3.7 Method Precision:

For Method Precision, the RSD for the % amount of each Elemental Impurity found and % Recoveries for each elemental impurities should not be more than 20.0 % for the replicates of six preparations. Results were given in Tables 8.

Table 8: Result Summary of Method Precision

S.No	Element	RSD of %amount recovered (%)	RSD of % Recovery (%)
1	Mg	4.34	4.12
2	Ca	7.00	6.76
3	K	11.86	11.72
4	Fe	0.88	0.65

IV. CONCLUSION

The quantification of elemental contaminants found in medicinal plants and herbal medicines around the world requires particular consideration. The world has a vast number of plants that have been utilized by people for decades, and more and more people are using medicinal plants to treat a variety of illnesses. In order to determine such impurities, there is an inevitable need for developing and validating analytical methods with sensitivity. In this work a simple, robust and reliable ICP-OES method has been developed and validated for quantitation of four elemental impurities in *Semecarpus anacardium* seed according to regulatory guideline ICH Q2 (R2) and the new USP chapters <232>Elemental Impurities – Limits and <233> Elemental Impurities –Procedures .The proposed method presented excellent accuracy and precision as after performing addition and recoveries study the data showed that method achieved the USP requirement of accuracy for all elements, providing spike recoveries in the range of 70.23–133.37 %(over range LOQ(30%)-150% of target concentration). Among the main advantages of the proposed method is the use of ICP OES for the analysis of elements in plasma with high sensitivity, high sample yield and accuracy. Therefore, the developed method for quantification of four elemental impurities found to be selective, accurate and precise in accordance with regulatory guidelines and can be successfully employed for routine commercial analysis of *Semecarpus anacardium* seed.

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