Modified Analytical Result of Catharanthus Roseus by Using PIXE Through Complementary Techniques

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Research Article

Keywords: Catharanthus roseus, Elemental analysis, PIXE, Complementary techniques, Analytical results

Posted Date: January 19th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1264867/v1>

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Abstract

Catharanthus roseus is a medicinal and herbal plant that has been studied extensively for its biological effects on the metabolic and immunological systems, as well as human health. Using various analytical techniques, the concentrations of the elements in Catharanthus roseus vary. Proton-induced x-ray emission with a 2-3 MeV energy apparatus with a Si (Li) detector was used to identify the important major, minor, and traces for the study, which had good sensitivity, selectivity, and reduced detection limits with correct results. The C. Roses plant includes an abundance of vital components and minerals, according to the results of the analysis. Cl, K, Ca, Ti, V, Mn, Fe, Cu, Zn, Br, and Sr were all investigated in substantial amounts. However, when compared to other complementary analytical techniques, elements with low Z, such as Na, Mg, Al, P, and S, and with a medium Z, such as Sc, Se, Cr, and Co, as well as high Z, such as Cd, Rb, Ba, Pb, and U were not identified through improper and overlaps analysis of the PIXE spectrum. As a result, the reasons for the analysis of the non-detected elements should be evaluated, and the results should be finalized using other C. roseus complementary analytical procedures.

Introduction

Catharanthus roseus (C. roseus) is regarded as one of the most important medicinal and herbal plants in the world. Minerals and trace elements play a critical role in the human body's metabolic process, which has a significant biological impact on antioxidant enzymes and the immune system, which serve as several lines of defence [1]. The purpose of this study was to look at and identify the major constituents of critical elements in C. roseus from the selected area. Different procedures are used to determine the elements concentrations in Catharanthus roseus. The results of this study's will be valuable for cancer chemotherapy medications, which are extremely important to humans. The PIXE [2] approach should evaluate in case of some additional elements for instance of Catharanthus roseus in contrast to earlier complementary analytical techniques. Such as including previous PIXE results, Energy Dispersive X-ray Fluoroscence, Atomic Absorption Spectrometer, and Inductively Coupled Plasma Mass Spectrometer on C.roseus plant.

The present study related to C. roseus biomaterial analysis by using PIXE technique with modified results and also the limitations of technique. The limitation arises due to selecting material which is very complex material which contain wide range of elements at various atomic number elements. It gives the idea where the PIXE fails to determine the elements, stripping problems and other experimental factors in more or addtional elements during spectrum analysis. Simultaneously gives the idea of another complementary technique which will be required to give the complete analysis of the complex materials like C. roseus.

Methodology

Fresh leaf samples of Catharanthus roseus medicinal plants were collected, cleansed with double distilled water to remove surface contamination, dried overnight in an oven at 600 degrees, and powdered

with an agate mortar and pestle. A 150 tonne hydraulic press machine was used to weigh and compress 150 mg of each powder sample, resulting in thin pellets with a constant thickness of 1 mm and a diameter of nearly 10 mm. Each sample was replicated three times. The pellets from each sample were examined using PIXE. Using proton generated x-ray emission with a 2-3 MeV energy apparatus and a Si (Li) detector, the required minor and trace for the inquiry were determined [3].

The leaf of a NIST 1515 apple (certified values) is utilised as a biological reference material. The Si (Li) detector, all samples at once, has a resolution of 140-160 eV and 5.9 keV. The targets were set at a 45-degree angle to the beam's direction. The proton beam was collimated to a 4 mm diameter and directed at the target. A high-resolution Si (Li) detector was used to record the characteristic X-rays generated by each sample [4]. The spectra were gathered over a long enough period of time to produce acceptable statistical accuracies. The built-in software GUPIX [5] does the quantitative analysis.

Results

The elements S, Fe, Na, Cl, K, Ni, and Co were determined using the ICP-MS approach [6]. The elements Na, K, Ca, Mg, Cr, Fe, Zn, Al, Cu, Pb, Cd, Mn, and Ni were detected in the flowers of *C. roseus* using an atomic absorption spectrophotometer [7], EDXRF was used to examine elements in the same composition, such as P, S, Cl, K, Ca, Mn, Fe, Cu, Zn, Se, Br, Rb, and Sr [8]. The elements, notably only Cl, K, Ca, Ti, V, Mn, Fe, Cu, Zn, Br, and Sr, were analysed by previous PIXE analysis [3] in significant quantities for the qualitative investigation of trace elements and their content in *Catharanthus roseus*. However, PIXE, compared to above complementary techniques that use precalational analysis of spectrum, may be able to detect more additional elements.

Finally, at quantifications of above leaf or flower, we must identify residual components using the PIXE technique, and therefore physical mechanisms behind the analysis are examined using the PIXE spectrum in contrast to AAS, XRF, and ICPMS [9] for future research. The goal of this study was to look at and determine the more additional constituents of vital elements in local *C. roseus* including by comparing previous PIXE to the other techniques stated above.

Discussion

Phytochemical screening of different extracts from leaves and flowers was used to determine the plant's therapeutic usefulness. The components found in the medicinal plant utilised were determined using particle induced x-ray emission (PIXE) and inductively coupled plasma mass spectrometry (ICP-MS) techniques. The metals in dried leaves and flowers were identified using ICP-MS methods, as well as a solvent extract of *Catharanthus roseus*. Both PIXE and ICP-MS were used to identify and quantify the elements V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Rb, and Sr, whilst Li, Be, Al, As, Se, Ag, Cd, Ba, Tl, Pb, and U were determined by ICP-MS, and Cl, K, Ca, Ti, and Br were determined by PIXE [10].

For quantitative examination of various elements, an AAS was utilised and used to identify thirteen elements from the leaves and flowers of the *C. roseus* plant, including Na, K, Ca, Mg, Cr, Fe, Zn, Al, Cu, Pb, Cd, Mn, and Ni. The key trace elements for the study were determined using GF-AAS, which had excellent sensitivity, selectivity, and reduced detection limits with accurate results. The results revealed that the *C. rose* plant contains considerable amounts of important elements and minerals (Fe, Zn, Se, Na, Ca, Mg, and K). The medicinal flowers like a variety of *Catharanthus roseus* (*Vinca rosea*) were investigated using AAS and Ca, Cr, Cu, Fe, K, Mg, Na, Ni, Cd, Pb, and Zn were analyzed. On an average, the quantity of Na, Mg, and Al were found to be the highest among these flowers, followed by Ca and K. The average amounts of Zn, Cu, and Ni were quite low; Cr was detected in the lowest quantity [11]. The results showed a high level of Fe and Zn and their important trace elements were also present, such as Co, Cr, Cu, and Ni [12].

The elemental compositions of *C. roseus* leaves and flowers were previously examined that are PIXE was used to analyse the elements Cl, K, Ca, Ti, V, Mn, Fe, Cu, Zn, Br, and Sr. However, EDXRF was used to examine the elements P, S, Cl, K, Ca, Mn, Fe, Cu, Zn, Se, Br, Rb, and Sr. Therefore the elements like Sc, Se, Cr, Co, Cd, Rb, Ba, Pb and U are not determined by previous PIXE results are discussed with following experimental factors in the present study.

Due to the Si (Li) detector employed for analysing elements with $Z < 17$ with X-ray energy of 0-2 keV, PIXE with 2-3 MeV has restrictions [13]. Only elements with an atomic number (Z) of 11 may be determined using PIXE and XRF. Similarly, elemental identification of 1-4 keV low energy X-ray lines falls in EDXRF because background intensity largely controls the detection limits, whereas PIXE is good for media Z elements, which have relatively higher characteristic X-ray energies and can be used as a substitute for PIXE in matrix composition.

Despite the fact that these elements had previously been reported in chemical analysis, the elements Li, no X-ray, and Be with an X-ray energy of $K = 0.108$ keV were not discovered. Similarly, due to above detector limits, the elements F with X-ray energy $K = 0.677$ keV and Na ($K = 1.040$ keV) to P ($K = 2.010$ keV) were not discovered in the current PIXE examination, but these elements were investigated by prior analytical methods. Actually, the study began with the presence of element S ($K = 2.309$) in the composition. The following element, F, is a trace or minor element in the composition, however due to the low energy 2 keV characteristic X-ray, it is not a trace in this PIXE analysis. Similarly, prior analytical approaches have detected the primary components Na, Mg, Al, and minor or trace P and S in the composition of *C. roseus*, however these elements were not identified in this study due to PIXE experiment limits and hence low energy X-rays absorbed by detector window.

The inaccuracy is due to Ti-K and Fe-K having X-ray energies close to 4.5 keV in this PIXE spectrum (4.509 and 4.647 keV), respectively, and Ti-Ba having the same X-ray energies (4.469 and 4.509 keV). Because of the above overlapping peaks, PIXE spectrum is not given its proper value in the case of significant elements like Ti. In the determination of Fe, PIXE spectrum failed miserably. Because the Co-K and Fe-K X-ray energies overlap, it's hard to detect Co, while Ti-K and Fe-K have the same or almost K X-ray energies (4.509 keV and 4.647 keV). Deconvolving two peaks from neighbouring elements might be

tricky at times. To compute the actual concentration value of not only Fe, but also the neighbouring components of Fe in composition using PIXE [14], some corrections are required.

Cobalt detection by PIXE in vegetable composition is not achievable for two reasons: Co-K α and Fe-K β and Ni-K α and Co-K β interferences of the above two peaks of cobalt are not identified, and cobalt was also present in *Catharanthus roseus* and its value was only low in earlier analysis. Because Fe is a substantial component in these spectrums, the X-ray generated by this element will dominate the energy spectrum. PIXE demonstrated once again in the case of trace elements that no detection is entirely due to matrix composition by using an interference matrix, i.e., X-ray of K (Z+1) and X-ray of K (Z) [15], and by correcting minor interference values.

The elements K and Ca are important in the composition; because to the high concentration, K and Ca summing peaks in the spectrum [16] of *Catharanthus roseus* could interfere with X-ray lines of Sc and Ti. Due to overlapping and resolution issues in PIXE, the primary concentration values of Ti and Fe, as well as the small or trace concentrations of Sc, V, Mn, Co, and Ni, may not represent exact values. In addition to the foregoing, the elements Sc, Cr, and Co exhibit traces of *Catharanthus roseus* composition that were previously found but are no longer visible due to the overlapped Ti and Fe peaks in the PIXE spectrum. In the above spectrum, Sc is sandwiched between two significant elements, Ca and Ti.

These elements' X-rays overwhelm the Sc elemental peak, thus it isn't visible in the spectrum. Because Co is sandwiched between the Ca and Fe significant concentration components, Co concentration values are not visible in the PIXE spectrums. Because of extremely small quantities (0.17–1.01ppm) and spectrum overlaps, Cr and Cd were not identified [17]. Cd's K-X-rays have a energy of >20 keV and L X-rays have a energy of 4 keV, resulting in spectral coherence that is disguised by Ca, K significant elements, and eventually not detected. The elements Rb with Br and U which have the same coherence of X-ray overlaps, have a similar difficulty.

Because uranium has energies of 98.440 keV, 111.303 keV (K-X-rays), 13.614 keV, and 17.220 keV (L-X-rays), 3.171 keV, and 3.336 keV, respectively (M-X-rays). In the case of PIXE detection using a Si (Li) detector, the X-ray energy from the experiment should only be 1–20 keV, but K-X-rays have larger energy, hence detection using K-X-rays is not achievable. However, because the Z of U > 83 exceeds the Z validity of M X-rays, according to PIXE theory, M X-rays are limited. Finally, the following coherences result from the foregoing discussion: L-X-ray energies of U are similar to K X-ray energies.

There is an obvious probability of U L α = 13,614, 13,438 eV lines overlapping with Rb K α = 13,395, 13,335 eV lines, which are not resolved by the Si (Li) detector, since the author discussed non-interference of Th and U with Rb. The K X-ray energies of Br 13.292 keV, Rb 13.396 keV, and Sr 15.835 keV are similar to the L X-ray energies of U. The composition of these elements, Br, Rb, and Sr, is sketched out in the preceding data. As a result of the aforementioned causes, PIXE spectrum analysis does not identify U in the composition [18]. Because the matrix composition encompasses a wide range of elements present in that composition and interferences of peaks in the PIXE spectrum due to comparable characteristic X-rays, these elements are not found in the *C. roseus* composition in the current PIXE analysis [19, 20].

Conclusions

It is not a trace in this PIXE study due to the low energy 2 keV characteristic X-ray of low Z like Na, Mg, Al, P, and S. Prior analytical methods such as AAS, ICPMS, and EDXRF have detected the principal components Na, Mg, Al, and minor or trace P and S in the composition of *C. roseus*, but these elements were not detected in this work due to PIXE experiment limitations such as detector efficiency and hence low energy X-rays of these elements.

With a basic or standard spectrum, such as the SRM 1515 (apple leaf) standard, this isn't a problem because the main peaks don't overlap and their intensities can be estimated immediately away. It's especially significant in crowded spectra like matrices, where several components' X-ray series overlap a lot. The least-squares fit is performed in these circumstances by modifying the height of each element's principal line while preserving the intensities of all subsidiary lines at various elements which were not detected by PIXE compared with complementary techniques in an appropriate ratio computed from the database with the necessary matrix modifications.

In particular, plants with a matrix consisting of low to high-Z elements and, due to their comparatively high K, Ca, Ti, and Fe content, spectral interferences traceable to escape and summation peaks in the X-ray spectra should be given attention at Sc, Cr, Co, Se and Rb, Cd, Ba, Pb, U. The GUPIX programme may successfully tackle these spectral processing issues, which are not entirely of the media Z elements like Sc, Se, Cr, Co and also high Z elements like Rb, Cd, Ba, Pb, and U. Thin-target PIXE allows elemental concentrations to be determined without having to account for X-ray self-absorption and proton halting in the target, as is the case with thick-target PIXE.

Due to K's double ionisation satellite, PIXE makes up a significant proportion of its parents, and it can be discovered by fitting when it is simple. Apart from that, the overall picture implies that with PIXE, matrix corrections to relative X-ray intensities are substantially larger, hence matrix compositions should be approached with caution. The relative strength of a particular line of element Z in a given matrix should be changed in relation to the "thin-target." for matrix corrections.

In PIXE analysis, the iron X-ray absorption in an iron specimen, such as the *C. roseus* composition, is higher. This is not, however, the primary source of the matrix's continuous "shelf." The left side of the peak is largely caused by secondary bremsstrahlung, which is somewhat suppressed by the absorber; the intrinsic low-energy shelf caused by poor charge collection in the Si (Li) detector is, of course, a minor contribution.

For *C. roseus* composition, PIXE responds to a concentration range and a dynamic range of peak intensity of $1: 10^5$. Weak peaks in the composition of trace elements are Sc, Se, Cr, Co, Cd, Rb, Ba, Pb and U. To preferentially attenuate the lower-energy X-rays of the matrix elements, a thin aluminium sheet must be interposed. Even so, the peaks of the matrix at major elements like Ca, K, Fe, Ti are frequently many orders of magnitude more powerful than the peaks of the trace elements like media and high Z were Sc, Se, Cr, Co, Cd, Rb, Ba, Pb and U. Peak distortions these elements must be adequately documented even if

they account for less than 1% of total intensity at Sc, Se, Cr, Co, Cd, Rb, Ba, Pb and U trace elements to finalise the elemental quantification of *C.roseus* medicinal plant by PIXE analysis.

Declarations

Competing interests

Sir, this is a part of research work at Andhra University, Visakhapatnam, and Andhra Pradesh, India. The topic related to material analysis by using PIXE technique and also the limitations of technique. The limitation arises due to selecting material which is very complex matrix material. Also it gives the idea where the PIXE fails to determine the elements, simultaneously gives the idea of another complementary technique which is used to give the complete analysis of the complex materials like *C. roseus*.

Declaration

Authors Declare that have no conflict of interest

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