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PIXE analysis of three kinds of vegetables from Sudan using low energy Van de Graaf accelerator

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Abstract
Particle-Induced X-ray Emission (PIXE) is an analytical technique used for determining quantitatively trace-elements concentrations with an enviable sensitivity [1,2]. This multi-elemental analysis tool was shown to be particularly well suited in a large number of applications in various fields ranging from archeology to biology, medicine and environmental sciences. Here in this work analysis of three kinds of vegetables mostly used by Sudanese people particularly in the rural areas were preformed, elements detected are S, Cl, K,Ca, Ti, Fe, Cu and Zn, PIXE technique was used to investigate the elemental composition on a microscopic scale with the elemental mapping; complementary ion beam techniques are used to provide information on the major and minor components. Analysis of these vegetable by μ-PIXE showed that the levels of trace elements were enriched and/or depleted. On the other hand the characterization of concentration by μ-PIXE showed a marked difference of elements between them. GeoPIXEII and RUMP software were used for determination of the trace elements. The results show a high concentration of some elements such as S, Cl, K and Ca. Elemental distributions.

Keywords: Nuclear Microprobe; hard tissues; PIXE
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Background

The Sudan is a large country with a great diversity of climatic and agro-ecological zones. The country is also very rich in plant genetic resources. Three number of wild species and landraces of vegetables were collected .

a) **Hibiscus** Shbdriiff locally termed Karkadeh, grows at many regions in Sudan. It is commonly used as a beverage, hot like tea or cold as cordial. It is also exported as a water soluble powder. The drink is usually prepared by soaking the Karkadeh leaves in water, it has a red colour and nice taste, and the people in Sudan believe that it is good for the blood. There is a general interest in analysing this drink.[**3**]

b) **Okra** is the family Malvaceae is one of the most popular vegetables in Sudan. The dried okra pods locally called "Waika" and are mostly obtained from the wild types found in the rain-fed

c) areas of the Sudan, where wide natural genetic variability of okra exists.[4]

d) **Corchorus olitorius** is one of the most important leafy vegetables in Sudan is grown in many parts of the country. Wild **Corchorus** species are found in different regions of the country. Have an important role in the diet of the Sudanese people. Jew's mallow, purslane and rocket are the most important types of leafy vegetables [**5**]

Introduction

Analysis for activation using protons of 1-3 MeV has been given a substantial step forward with the improvements of the micro-analysis mode and development of sophisticated software for on/off line deconvolution of x-ray spectra. Some of the field in which nuclear microprobe (NMP) has been most powerful is in bio-medical studies for which the low levels of detection limits combined with the availability of multi-techniques and multivariate capabilities has proven to be the instrument of choice in many applications. Furthermore, needs to explore smaller regions of bio-medical materials and tissues to the micro and nano scales has prompted the X-ray microscopist to consider the technique of elemental mapping by micro-PIXE with proton beam probes of the order of 1 μm. In recent years applications of PIXE in the biomedical field have opened important areas of research with a significant sensitivity to compete with techniques such as XRF, EDXRF, EMP and/or SEM [6,7,8,9]. The micro-PIXE technique is used to investigate the

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morphology as well as the elemental composition of human tissues on a microscopic scale. In addition, complementary ion beam techniques are used to provide information on the major and minor components. This work will describe an overview of bio-medical projects particularly in relation to spatial distribution of trace metals as evaluated by the technique of Dynamic Analysis (DA) [10].

Experimental techniques

Three kind of vegetables (Hibiscus, Corchorus olitorius and wild okra) are collected dried and grinded to powder then pressed into pellets radius of 10mm irradiations were performed on the outer surface of the pellet with 3.0 MeV protons using the NMP at iThemba LABS, Somerset West, South Africa. Since information at high beam resolution was not a requirement, the proton beam was focused to a size of ~3 x4 μm^2. Scanned areas of ~ 200 μm^2 and beam currents ranging between 100– 200 pA (with a integrated total charge of about ~0.3 μC) were used. Beryllium absorber 125 μm thick was interposed

Results and Discussions

Trace elements S, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Cu, and Zn, were determined by μPIXE. Their concentration levels are shown in Table 1. The PIXE results represented in the table give detailed information concerning the precise location of some elements within the leaf of the three samples. The analyses were directed primarily to the centre of the pellets. In the micro analysis of small pellets areas it is of extreme importance the optimization of experimental parameters which will determine the accuracy and minimisation of the minimum detection limits. Recently there has been a renewed interest in the application of nuclear microprobe in the biomedical field. Further on, the possibility of reaching nano size levels for the proton probe open new avenues for the application of NMP. Elemental mapping was not the primary aim of this investigation, as we were specifically interested in the concentration levels as deduced from the total X-ray yield of the particular irradiated area. The need for microanalysis arises from the fact that the actual variability of elemental content. From the figure 1 the result showed that all the three samples are rich in K and Ca and the concentration of the other elements such as Sc, Ti, V, Cr, Fe and Zn are much closed to each other. between target and the Euryres detector to reduce the high intensity Ca X-ray signals. Pile-up rejection was controlled by a beam-on-demand system, which deflected the proton beam temporarily to allow for correct digital pulse processing at high-count rates. Further details about the

Table1: Elemental concentrations foundbyPIXE

Elements	Samples		
	Wild Okra	Corchorus olitorius	Hibiscus
S	1433±80	1731±130	2095±128
Cl	8416±211	2233±40	2233±40
K	15647±133	37023±304	30335±188
Ca	8431±88	13067±133	10915±44
Sc	89±21	53±36	111±17
Ti	28±3	56±4	76±6
V	11±3	n.d*	21±6
Cr	3±1	n.d*	n.d*
Mn	16±1	130±6	730±7
Fe	230±7	476±12	185±2
Co	n.d*	5±2	n.d*
Cu	4.8±0.5	8±1	3.8±0.6
Zn	35±2	25±2	32.5±0.8

n.d*: not detected

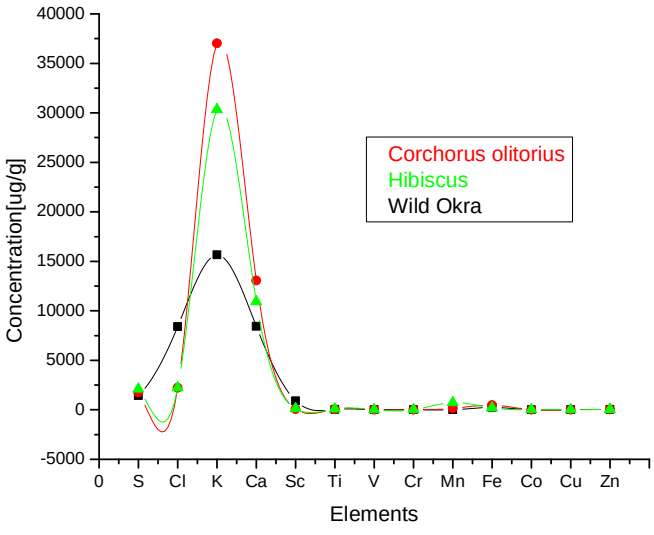

Figure1: The elemental distribution for the three leaves

experimental set-up at the microprobe have been previously reported **[**11,12**].** The dominant elements as determined by PIXE were S, Cl, K, Ca, Fe, Zn and Cu,

using the K_{α} Evaluation of X-ray spectra was performed with the software package Geo-PIXE II **[**13**].**

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