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Studies of Trace Elements in Some Varieties of Rice (*Oryza sativa*) by Energy Dispersive X-ray Fluorescence Technique

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Applicability of Energy Dispersive X-ray Fluorescence (EDXRF) technique for trace elements in some varieties of rice (*Oryza sativa*) from different fields of the region was demonstrated. The work being presented here includes trace element analysis of some rice varieties. Concentration of metals K, Ca, Mn, Mg, Fe, Al, Ti, P, Na, Zn, Cu, and Si in rice from eastern Vidarbha zone are studied. All the samples were analysed without any chemical treatment. To investigate any possible contamination in the grinding procedure or loss of some elements due to the drying process a few samples were analysed by total reflection X-ray fluorescence technique. The effects of chemical fertilizers, perticides and herbicides on the elemental concentration of rice grain were also investigated by this technique.

INTRODUCTION

In recent years the technique of energy dispersive X-ray fluorescence (EDXRF) spectrometry has gained worldwide acceptance in non-destructive multielemental analysis of a variety of rice samples over a wide range of concentrations (ppm to 100%)[1]. The main application is the determination of major, minor and trace elements present in various types of samples such as food, blood and the medical formulations. Trace elements play an important role in the cell activity, the formation of skin, muscle, bone and blood. Through food and medicine, they cause chemical reactions that lead to proper digestion, the absorption of nutrients from food and production of hormones. Their deficiency in food is known to cause a variety of diseases. Some of these trace elements known to be essential for growth of human physique are C, H, O, N, S, Ca, P, K, Na, Cl, Mn, Ti, Mg, Cu, Fe, Ni, Si and Zn totalling to twenty six essential elements[2–5]. There are other elements which are known to be present in animal body and are not essential. They are acquired in the body as environmental contaminants[6]. The role of the essential or toxic elements is greatly influenced by the chemical environment provided by the other co-existing elements. Therefore methodologies based on multielement analysis such as EDXRF can

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provide extensive information to determine the correlation of various elements present in the food.

Regardless of the advances in the analytical technique for determining elemental concentration, in rice cereal there is major lack of information concerning the correlation in these cereals. Rice is the staple food of over half of the world's population having high yielding capacity. It is classified primarily as tropical and subtropical crop. For high grain yield application of fertilizers and insecticides is common practice in paddy cultivation. These fertilizers and insecticides produce an increase in toxic elemental concentration at microlevel in rice plant parts and hence in grains due to absorption of these chemicals. The knowledge of these values of trace elemental concentration can provide a better understanding of the role of each element in developing a human physique.

EXPERIMENTAL

All samples were collected from different zones of Eastern Vidarbha region. Around 5–20 g of rice were collected from different fields and stored in a polyethene bag. The grains were dried for 24 h in an oven at 35°C in a glass beaker without any washing. Subsequently the samples were powdered in an agate mortar with a particle size of 20–100 μm. Pellets of 2.54 cm diameter were prepared using hydraulic press at a pressure of 10 tonnes/cm. A minimum of three pellets of each sample were made to reduce the error in the analysis. Boric acid powder was used as plasticizer.

The energy dispersive X-ray fluorescence spectrometer consists of a tungsten X-ray tube and a molybdenum secondary target. The X-ray generator was operated at 20 kV and 50 mA. A characteristic radiation was detected using argon flow scintillation counter over the range 0–110°C with 6 μm polypropylene window. The data was analysed using UniQuant-2 package and evaluated using the fundamental parameter method, as well described in the literature[7, 8].

RESULTS AND DISCUSSION

To establish reproducibility of the instrument technique six pellets of the same sample were analysed. The pellets are referred as Ji and the results are enumerated in Table-1. The results of the analysis in $\mu g\ g^{-1}$ (dry weight) of 47 samples were collected from different field areas of the zone under study and are displayed in Table-2. The standard deviation is high because of the variation in the elemental content from sample to sample.

The EDXRF analysis cited in Tables 1 and 2, shows that various trace elements are existing in different micro levels in all reported varieties of rice (*Oryza sativa*). In particular the percentage of NKP is above 100 $\mu g\ g^{-1}$, though it varies a bit amongst varieties of rice. The major cause for higher percentage of NKP in compararison to other trace elements is due to excessive application of fertilizers,[9] in addition to urea, which has saturated field soil. According to Mastuo[10] fertilizers are usually applied 30–100 kg/ha to most alluvial rice fields. Elements such as iron, zinc, manganese, and copper are detected in lower concentration, which leads to the fact that these elements form insoluble inorganic ligands by reacting with other solvents existing in soil. The chemical analysis of soil and pH measurements leads to the fact that stratified layers of limestone and blocks absorption of elements such as Zn, Cu, Fe and Mn by rice plants takes place.

The requirement of rice plant for most of the microelements is low, a fact which may explain why, except for NKP the role and interrelation of other microelements have not been much investigated. Iron plays a catalytic role either in an inorganic form or combined with organic compounds as a component of redox enzymes[11].

Most of the rice varieties are grown in the warm and humid tropics, unfortunately, tropical conditions also favour the proliferation of insects on rice plants. The insect problem is accentuated further in some areas and does not undergo a distinct diapause or dormancy but occurs throughout the year in overlapping generations. Therefore, pesticides and insecticides are mixed in the field water or spread on the plants during cultivation and gets distributed throughout the tissues. The elements, *viz.*, Mg, Al, Ti and Ni are residues of pesticides and insecticides absorbed by plant tissues and pertain in rice grains in various micropercents, which may be a hazard to human physique.

The EDXRF analysis gives out a ready reference for elemental concentration in cereal rice and is of immense economic importance in everyday life. Elements cited in Tables 1 and 2 showed that they are occurring in micrograms in all reported varieties. These elements do not have much variations amongst different varieties of rice (*Oryza sativa*). Further studies are in progress to establish a relationship between element intake by different parts of rice plant and their percentage of existence amongst various varieties of rice.

TABLE-1

ELEMENTAL CONCENTRATION ($\mu g\ g^{-1}$ dry weight) of variety H.M.T.

Trace element	Elemental concentration $\mu g\ g^{-1}$						Mean	S.D.
	J1	J2	J3	J4	J5	J6		
K	107.9	112.3	106.4	108.6	120.5	105.9	110.3	5.5
Ca	15.7	16.0	12.7	11.0	18.9	12.3	14.4	2.9
Mn	1.6	3.0	1.4	2.5	3.1	1.9	2.3	0.7
Mg	30.2	36.0	29.3	31.6	35.5	26.7	31.5	3.6
Fe	7.0	9.1	5.6	7.9	7.6	4.8	7.0	1.6
Al	9.5	10.1	8.8	5.9	9.4	9.5	8.8	1.4
Ti	22.8	26.4	19.3	26.8	20.1	23.4	23.1	3.1
P	89.0	95.6	83.8	90.1	85.7	83.9	88.0	4.6
Na	25.1	29.3	28.6	26.3	23.2	21.8	24.6	3.2
Zn	7.2	6.6	9.4	8.4	5.3	4.3	9.2	3.0
Ni	2.4	3.5	4.2	6.3	3.1	4.6	4.0	1.4
Cu	5.6	7.3	8.2	5.8	9.3	3.4	6.6	2.1
Si	12.1	14.3	16.8	11.3	10.5	9.8	12.5	2.6

TABLE-2

BASIC STATISTICAL DATA FOR THE TRACE ELEMENT CONCENTRATION (μg g^{-1} dry weight)

Element	Jaya			Jagannath			Pankaj			Ratna		
	Mean	Range	S.D.	Mean	Range	S.D.	Mean	Range	S.D.	Mean	Range	S.D.
K	150.2	120.0–169.3	17.1	137.8	136.3–142.6	2.7	115.4	108.0–121.5	4.3	138.4	135.6–142.4	2.7
Ca	9.3	7.6–12.5	1.8	17.5	26.6–29.5	1.1	14.3	12.4–16.3	1.3	10.6	9.4–11.5	0.9
Mn	1.5	0.9–2.3	0.5	1.3	0.8–2.1	0.5	2.4	2.1–3.6	0.6	3.6	2.8–3.9	0.4
Mg	36.8	28.0–43.6	5.2	45.8	41.3–49.6	3.4	39.8	37.6–41.3	1.5	31.3	29.6–33.4	1.5
Fe	1.6	1.3–2.1	0.4	1.3	0.6–2.2	0.7	5.3	4.6–5.9	0.5	2.1	2.0–2.8	0.4
Al	11.6	9.8–15.3	2.1	7.6	6.8–7.9	0.3	4.6	3.9–4.9	0.4	6.3	5.8–6.8	0.5
Ti	21.0	19.6–23.5	1.9	24.0	22.9–26.4	1.3	18.0	17.4–19.3	0.7	14.4	13.5–15.6	1.2
P	105.6	99.5–111.3	6.8	118.6	115.7–120.4	1.8	133.1	131.7–138.5	3.1	125.1	118.4–135.3	5.9
Na	34.8	30.8–39.7	3.4	37.5	36.8–39.3	1.2	26.8	25.4–27.6	0.9	26.3	25.9–27.2	1.1
Zn	9.3	8.6–9.9	0.5	5.4	4.8–6.2	0.5	10.8	9.6–11.9	0.8	9.5	9.3–10.4	0.5
Ni	6.2	6.2–8.3	1.4	2.1	1.8–2.5	0.3	2.4	2.3–3.6	0.8	0.9	8.0–10.3	0.2
Cu	5.5	4.8–7.2	1.0	3.8	3.3–4.8	0.7	5.9	4.9–6.4	0.6	4.8	3.6–5.2	0.6
Si	12.6	12.6–15.1	1.4	12.5	8.6–13.9	2.7	17.1	16.3–19.5	1.6	12.8	10.5–16.9	2.6

REFERENCES

1. R.F. Van Grieken and A.A. Markowic, Hand Book of X-ray Spectrometry, Marcel-Dekker, New York (1993).
2. H.J.M. Bowen, Trace Elements in Biochemistry, Academic Press, New York (1966).
3. V. Valkovic, Trace Element Analysis, Tayror and Francis, London (1979).
4. ———, Analysis of Biological Materials for Trace Elements Using X-ray Spectroscopy, CRC Press, Boca Raton, FL (1980).
5. P. Bratter and P. Schramel, Trace Element Analysis in Medicine and Biology, Walter de Gruyter, Berlin (1980).
6. Madan Lal and R.K. Choudhary, *Indian J. Phys.*, **65B,** 30 (1991).
7. J. Bohman and V. Isakson, *X-ray Spectrom.*, **20,** 305 (1991).
8. A. Rindby, *X-ray Spectrom.*, **18,** 113 (1989).
9. S.V. Rao and Krishna Rao, *Andhra Agr. J.*, **9,** 255 (1961).
10. H. Matsuo, Arg. Asia, 4th Eng. Edn., p. 104 (1966).
11. A.V. Ishizuku and A. Tanaka, *J. Sc. Soil and Manure, Japan*, **31,** 97 (1961).

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