

# Metal Analysis in Rice Seedlings

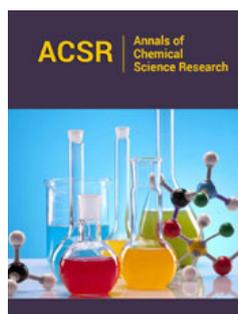
Chooto P<sup>1\*</sup>, Tapachai WA<sup>2</sup>, Duangthong S<sup>1</sup>, Puetpaiboon W<sup>2</sup> and Klinnawee L<sup>3</sup>

<sup>1</sup>Analytical Chemistry Division, Department of Chemistry, Faculty of Science, Prince of Songkla University, Thailand

<sup>2</sup>Inorganic Chemistry Division, Department of Chemistry, Faculty of Science, Prince of Songkla University, Thailand

<sup>3</sup>Department of Biology, Faculty of Science, Prince of Songkla University, Thailand

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**\*Corresponding author:** Chooto P, Analytical Chemistry Division, Department of Chemistry, Faculty of Science, Prince of Songkla University, Thailand

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## Abstract

Rice and rice products are widely consumed all over the world and the determinations of metals via a selection of techniques still play a leading role not only for the samples of rice grains but also extended to rice seedlings with the benefits of modifying essential elements into natural samples as well as to monitor the metal pathways and to envisage the mechanisms of metal uptake. In addition, there are a large number of parameters to be dealt with. To help those interested and favored to start or further their studies reach the purpose of these specific projects, this article provides the overview to understand the trend of upcoming research work concerning metal analysis in rice parts, products and environments.

**Keywords:** Metal analysis; Rice analysis; Rice parts, products and environments; Rice analytical techniques; Seedling analysis

## Introduction

Pathways of metals from environment and nutrients to plants and plant products play an important role in the living of human beings due to the fact that they affect metal uptake from the consumption of plants especially staple food, or to be more specific, rice which is essentially the most consumed food all over the world. The analysis of rice seeds or grains has been widely researched and well-documented. However, the increase of rice seedlings as functional food as well as effects of metal-contaminated environment makes metal analysis in these types of seedling samples unavoidable.

## Benefits

Metal analysis in rice seedlings has a variety of significant benefits in quite different areas. Firstly, it paves the way of using rice seedling as functional food which is also effective and increasing dramatically. In this view, metal speciation is also required due to the fact that different oxidation states of each metal have different effects on living things, in particular humans. Certain forms of the metal can be very beneficial whereas others can be detrimental, which of course depends on the concentration or rate of uptake as well. Secondly, the route of metals in rice and how it would affect the final products namely rice seeds or grains can be better understood and can be applied promptly and properly. Furthermore, this helps in understanding the influence of metals on rice and rice products in direct environments mainly soils and water as well as indirect environment such as air. Finally, the effects of metals in rice seedlings on grazing animals such as cows, buffalos and goats can be taken as an example for other kinds of grass. To name a few, these are just the main uses of the results of metal analysis in seedlings which as a matter of fact leads to much wider applications.

## Parameters

There are a large variety of factors that affect the amount of the metal of interest in the seedlings. Surely, the first is the types and states of the metal itself. This includes different types of oxidation states due to the fact that most metals, in particular transition metals, have various oxidation numbers which of course exhibits a wide range of behaviors and toxicity. Furthermore, accompanying anions also have subtle influence on the metal concentrations in rice seedlings, mainly due to the uptake mechanisms. The next parameters should involve rice growing conditions covering periods of time, in other words, the number of days of growing, the types of nutrients or fertilizers, the methods of growing, species of rice or even the weather and environment conditions. These sophisticated parameters make the studies of

metals in rice seedlings more challenging and interesting given that nowadays we encounter a large variety of conditions and people still have to consume a large amount of rice and rice products every day hence greater chances of risks from metal accumulations in the bodies.

### Experimentation

In order to conduct the experiments with a great number of factors like this, the most appropriate method for growing the seedlings is hydroponics, especially in a greenhouse for better

control. Mainly at first the metal uptake is investigated, and then other factors can be further varied. Finally, the real conditions for growing similar to those applied by farmers are experimented. For all, the seedlings need to be sampled systematically. To briefly state the sampling of rice seedlings, normally the seedlings are grown with certain number of duplicates along with the blank or control ones. They are then sampled by cutting the stems above the roots and dried. After wet ashing, the resulting solutions are further analyzed for metal contents making use of suitable instruments.

**Table 1:** Typical recent methods for analyzing metals in rice products.

Entry	Method	Metals	Sample	Ref
1.1	AAS	Cd, Cu, Pb	Rice parts	[1]
1.2	AAS	As, Cd, Cu, Pb and Zn	Rice grains	[2]
2.1	AES	Cd	Rice grains	[3]
2.2	AES	Al, B, Ca, Cu, Co, Cr, Fe, K, Mn, Mo, Mg, Na, Ni and Zn	Rice grains	[4]
3	ICP-OES	Ni, Hg, Co, Cd and Pb	Rice grains	[5]
4	ASV	Cd and Pb	Rice grains and products	[6]
5	ICP-OES// XANES/EXAFS (for Cd)	Cd, Pb, Cr, Ni, As, Cu, and Zn	Rice parts and soil	[7]

### Acronyms

AAS: Atomic Absorption Spectrophotometry

AES: Atomic Emission Spectroscopy

ICP-OES: Inductively Coupled Plasma Optical Emission Spectroscopy

ASV: Anodic Stripping Voltammetry

XANES/EXAFS: X-ray Absorption Near Edge Structure Spectroscopy/Extended X-ray Absorption Fine Structure

### Analytical techniques

There are a great number of choices for the methods of analyzing metals in rice parts, products and environments including Atomic Absorption Spectroscopy (AAS), Atomic Emission Spectroscopy (AES), Inductively Coupled Plasma Spectroscopy (ICP), Electrochemistry (EC) especially Anodic Stripping Voltammetry (ASV) and other spectroscopic methods for specific metals and their species as exemplified in Table 1. For a large number of

samples with mostly only one metal is involved, ICP in particular ICP-OES seems to be the most appropriate. From the results, the uptake mechanism for each metal can be elucidated and specified. The literature search revealed that most work concerns metals in rice seeds. Only a few involve the rice germination, and none involves metal analysis in rice seedlings. To provide the insight, heavy metal analysis is shown in Table 2 whereas typical recent work for analysis of specific metals is summarized in Table 3.

**Table 2:** Typical examples of recent heavy metal analysis for rice.

Entry	Aspect	Sample	Method	Ref
1	Health risk assessment	Bran oil	ICP-OES	[8]
2	Bio-accessibility analysis	Rice seeds (grains): raw, cooked and digested	ICP-OES	[9]
3	Heavy metal contamination	Soil/Rice parts	ICP-AES/ICP-MS	[10]
4	Effects on fermentation efficiency	Fermenting broth	AAS	[11]
5	Health risk assessment	Rice seeds (grains)	ICP-OES	[12]
6	Metal uptake	Rice plants	ICP-AES	[13]
7	Reduction of toxic metals	Raw and cooked rice	ICP-OES	[14]

### Acronyms

ICP-OES: Inductively Coupled Plasma Optical Atomic Emission Spectroscopy

ICP-AES: Inductively Coupled Plasma Atomic Emission Spectroscopy, which is the same as ICP-OES

ICP-MS: Inductively Coupled Plasma Mass Spectrometry

AAS: Atomic Absorption Spectrophotometry

**Table 3:** Determinations of specific metals in rice.

Entry	Metal	Method	Sample	Ref
1	Cr	ICP-AES	Rice root and shoot	[15]
2	Cu	ICP-OES	Rice root and shoot	[16]
3	Cd	ICP-MS	Soil/Rice parts	[17]
4	Pb	AAS	Rice plant parts	[18]
5	As	ICP-MS	Brown rice grains	[19]
6	Hg	AAS	Rice seeds (grains)	[20]
7	Fe, Mn, Cu, Zn, and mainly Se	AAS//AFS (for Se)	Rice grain, root and shoot	[21]

### Acronyms

ICP-AES: Inductively Coupled Plasma Atomic Emission Spectroscopy

ICP-OES: Inductively Coupled Plasma Optical Atomic Emission Spectroscopy, which is the same as ICP-AES

ICP-MS: Inductively Coupled Plasma Mass Spectrometry

AAS: Atomic Absorption Spectrophotometry

AFS: Atomic Fluorescence Spectrometry

### Metals of interest

There are certain metals that are of special interest in current research. The metal that is the most focused on in our research group is chromium due to the fact that it can be used in the seedlings to become the functional food and help those with diabetes. However, the challenge is that chromium has two main forms including Cr (III) which is essential and beneficial and chromium (VI) which is harmful. Methods of speciation are therefore required here. The second element is copper due to the fact that it is abundant in sesame and can be harmful especially for the elderly in case of excess consumption, which might as well be the same for rice. Cadmium is the next target due to the fact that it is collected in rice parts extremely well. It has been investigated extensively because there have been quite a large number of cases of cadmium toxicity from rice. The fourth element to be mentioned as an example of the focused ones is lead due to the fact that it can be accumulated well in soil, so it is possible to be taken into rice parts accordingly. Luckily, the metal seems to be unlikely to be absorbed into the rice parts, at least for the time being of available research results. Those are just typical examples of specific metals to be focused on in Asian areas especially in Thailand.

### Conclusions

To conclude, the work on metal analysis in rice seedlings is another way to help people to benefit from their living based on the modifications on natural consumer products of rice which are not only safer to but also shed the light on the applications on other types of plants and seedlings as well as show the effects of different types of environment to the rice products and increase awareness to finally result in living better lives for everyone.

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