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メタデータ	言語: English
	出版者: GRADUATE SCHOOL OF ENGINEERING OSAKA
	CITY UNIVERSITY
	公開日: 2019-08-23
	キーワード (Ja):
	キーワード (En): Tabletop XRF analyzer, EDXRF,
	Quantitative XRF analysis
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URL	https://doi.org/10.24544/ocu.20190823-004

Title	Elemental analysis of three kinds of teas by tabletop XRF analyzer	
Author	Zhu, Jingyuan / Takahashi, Haruna / Tsuji, Kouichi	
Citation	Memoirs of the Faculty of Engineering Osaka City University.	
	Vol.59, pp.1-5.	
Issue Date	2018-12	
ISSN	0078-6659	
Туре	Departmental Bulletin Paper	
Textversion	Publisher	
Publisher	Graduate school of Engineering, Osaka City University	
Description		

Placed on: Osaka City University Repository

Elemental analysis of three kinds of teas by tabletop XRF analyzer

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(Received October 31, 2018)

Synopsis

In this research, we investigated three kinds of tea samples by using tabletop XRF analyzer JSX-1000S (JEOL Company, Japan). Each tea sample was tested in original state, powder state and tablet state with different mass values. We could show the minimum mass for quantitative XRF analysis. By analyzing the X-ray spectrum recorded for these samples, we found the possibility of XRF analysis as a method of tea quality control and detecting tea producing area.

KEYWORDS: Tabletop XRF analyzer, EDXRF, Quantitative XRF analysis

1. Introduction

With the growth of the global economy, food trade is becoming more frequent than ever before. Consumers are willing to pay a high price for organic and non-polluting foods. Especially in tea industry, the price of famous brand tea made from specific regions is much higher than that of the ordinary brand. Therefore, the certification of the tea origin is commercially important. In addition, depending on elemental composition of tea, drinking it has risk of side effect to human organism. Therefore, it is very necessary to qualitatively and quantitatively analyze the elemental composition of teas.

According to Salvador's research¹), Fe, Ni and Cu have been successfully characterized in tea samples using energy-dispersive X-ray fluorescence (EDXRF) technique. This paper shows that EDXRF method is useful for quality control to obtain 'chemical fingerprints' of tea products. Meanwhile, in Rajapaksha's research²), X-ray fluorescence spectrometry (XRF) technique effectively gave us the concentrations of 13 elements (Mg, P, S, Cl, K, Ca, Mn, Fe, Cu, Zn, Br, Rb and Sr) in tea samples. This result helps to confirm the origin of 58 tea samples from four production districts in Sri Lanka.

These two research groups mentioned above inspired us to consider the possibility of use a tabletop XRF analyzer to acquire element composition and concentration of tea products. This XRF analyzer provides quick, easy elemental analysis that is non-destructive and available for different kinds of solid and liquid samples³). By the analysis of the XRF intensity and the comparison with standard sample, we can obtain the concentrations of several elements detected in tea samples, leading to certification of the origin of tea products.

2. Experimental

We measured three kinds of tea products-green tea (ITOEN Company, Japan), roasted tea (ITOEN Company, Japan) and barley tea (Top Value Company, Japan). Every tea product was tested in original state, powder state and tablet state. In each state, we tested samples mass values of 0.3 g, 0.5 g, 0.7 g and 0.9 g. Therefore, we prepared 36 pieces of tea samples for investigation. To prepare the powder samples, we smashed the tea and then sieved the powder to have a diameter less than 0.46 mm particles. To prepare tablet samples, we put tea powder (same material as powder samples) into a tableting machine and put it in the pressure pump for 5 minutes under a pressure of 10 MPa. Fig.1 shows the grinder for preparing powder samples and the tableting machine for preparing tablet samples.

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(a) M20 (IKA Company, Germany)

Fig.1 (a) Grinder for making powder state samples and (b) tableting machine for making tablet state samples.

We used a tabletop EDXRF instrument: JSX-1000S (JEOL Company, Japan) as an XRF analyzer. Fig.2 shows the appearance and internal structure of JSX-1000S. As an EDXRF instrument, an X-ray tube and an X-ray detector are installed below a sample chamber. This EDXRF analyzer enables a quick and easy elemental analysis with an easy software for operation. The functions for conventional qualitative and quantitative analysis are equipped. Including solution-based applications, the desired analysis can be executed automatically according to pre-recorded recipes. The new smart fundamental parameter (FP) method makes it possible to obtain high accurate quantitative results without preparing a standard sample. This FP method includes automatic correction for thickness and residual ingredient balance.



Fig.2 Tabletop EDXRF instrument, JSX-1000S (JEOL Company, Japan)

Samples were put into a holder (a white plastic hollow tube with transparency film covered under bottom, shown in Fig. 3(a)) and set in sample chamber shown in Fig. 3(b). By using an auto sample changer (Fig. 3 (b)), up to twelve samples can be analyzed at one time. For EDXRF analysis, an X-ray tube (Rh target) was operated with a voltage of 30 kV, and a current of 0.030 mA. EDXRF measurement was performed for an acquisition time of 1000 second with a collimator size of 9.0 mm.

⁽b) PT-20 (JASCO Corporation, Japan)



Fig.3 (a) Sample holder and (b) auto sample changer.

3. Results and Discussion

3.1. X-ray spectrum

Fig.4 shows the X-ray spectrum of three kinds of tea products tested in powder status with a mass of 0.5 g. Elements of P, S, K, Ca, Mn, Fe, Cu, and Zn were detected. Same elements were also detected in other samples with different status and mass. The peak originated from Rh was mainly observed, because it is the primary X-rays emitted from the X-ray tube. Although we set an acquisition time in 1000 seconds for each sample, a clear X-ray spectrum appeared very quickly in less than 200 seconds.



Fig.4 X-ray spectrum of three kinds of tea products (0.5g samples in powder status)

3.2. Green tea

Fig.5 shows the XRF intensities of K, Fe and Zn detected for green tea samples (original status). There is significant increase of these three elements when sample mass increased from 0.3 g to 0.5 g. However, XRF intensities of P, S, Ca, Mn and Cu did not show so much change by the increase of mass in original status. We considered that the minimum mass of green tea samples would be more than 0.5 g. As for powder and tablet status, the XRF intensities of elements were almost the same for different mass samples. Therefore, the concentration of elements in green tea would be evaluated for the mass more than 0.5 g by using calibration curve.



Fig.5 XRF intensities of K, Fe and Zn detected in green samples (original status)

3.3. Roasted tea

Fig.6 shows XRF intensities of elements detected for the roasted tea samples (powder status) in different mass samples. Except Mn, XRF intensities for all other elements were almost the same for different mass samples. Besides powder status samples, XRF intensities of original status and tablet status samples almost has no change with the change of mass. All roasted tea samples were dry, and this may be the reason why the same XRF intensities were detected for different mass and status of samples. Because of no significant change in XRF intensities, therefore, the concentration of elements in roasted tea would be evaluated by using calibration curve.



Fig.6 XRF intensities of several elements detected in roasted tea samples (powder status)

3.4. Barley tea

Fig.7 shows XRF intensities of K and Ca element detected in 0.3 g barley tea samples. Concerning K and Ca element, original status showed a highest XRF intensity. This may be because these two elements existed in the shell of barley tea seed and therefore could be easily detected in original status samples. This phenomenon does not show up in 0.5 g, 0.7 g and 0.9 g samples. In three status of barley tea samples, as the mass increases, the XRF intensities does not increase proportionally concerning the mass. Therefore, the quantitative XRF analysis would be possible for elements in barley tea by using calibration curve.



Fig.7 XRF intensities of K and Ca elements detected in 0.3 g barley tea samples.

4. Conclusions and future works

Using JSX-1000S XRF analyzer, it was possible to detect elements in tea products. We measured tea samples with different sample conditions. It was found that the minimum sample mass depended on the element (energy of X-ray fluorescence) analyzed. The qualitative analysis of tea products would be possible by applying a calibration curve with standard tea sample. The EDXRF spectrometer can be applied not only for solid samples but also for liquid samples⁴⁾. Thus, a drinking tea solutions will be the next sample using a tabletop EDXRF spectrometer. After the tea leaves are put into boiling water, the liquid tea samples would be measured by the same XRF spectrometer at a room temperature. Comparison of both solid and liquid samples will be helpful for safety and tea quality control.

5. Acknowledgement

This work was supported by JSPS KAKENHI (17H03080, 18H01755, 171000132).

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