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XRF

Foreign Matter Analysis in Food using the XGT-9000

Application Note

Food
XGT23

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Abstract: This application note introduces foreign matter analysis in food products using the XGT-9000. There are three analyses as follows: Foreign particles on an oily salami, foreign matter inside a laminated ham and sausage, and a fly found in a drink product.

Keywords: Foreign matter analysis, Food, µ-XRF, Transmission X-ray imaging, Partial vacuum

Introduction

Foreign matter inspection with analytical instrument helps food companies to identify the type of foreign matter and to find out the root causes of the foreign matter.[1] It is significant to clarify whether the contamination in their food products happened during the production process or entered at the consumer site.

µ-XRF is a non-destructive elemental analytical technique. Thanks to the higher penetration of the X-ray beam, µ-XRF can detect foreign matter in a deeper position of food than SEM-EDS can. Foreign matter analysis without destructive sample pretreatment helps food companies preserve the defective products as their evidence.

This application note introduces three foreign matter analyses using the XGT-9000 X-ray analytical microscope on food products as follows: Foreign particles on an oily salami, foreign matter inside a ham in a laminated package and a sausage, and a fly found in a drink product.

The XGT-9000 X-ray analytical microscope

The XGT-9000 X-ray analytical microscope (Figure 1(a)) is an energy-dispersive X-ray fluorescence microscope with micro-probes and a motorized XYZ stage, which enables users to hit target foreign matter on a sample and to acquire map imaging on it. In addition, the XGT-9000 has the following unique features for food application:

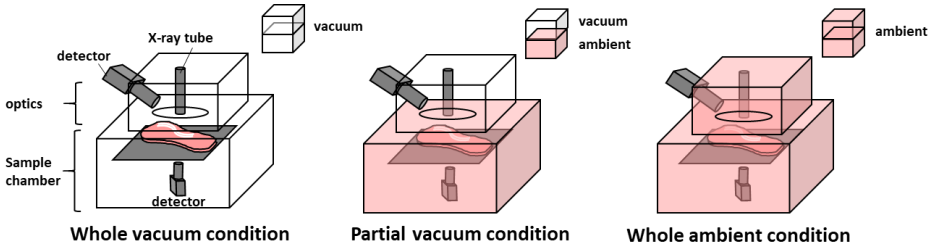
1) Various micro-probes whose spot sizes are down to 10 µm to up to 1.2 mm. It can effectively hit the target foreign matter while it remains in the food itself.

2) Transmission X-ray imaging to detect and visualize foreign matter hidden inside food.

3) Multiple atmospheric conditions in the instrument (Figure 1(b)). In particular, a partial vacuum condition is effective to analyze light elements down to Na in a sample which cannot be put in vacuum (e.g. hydrous food, oily food, or food in a package).

(a)

(b)



	Whole vacuum condition	Partial vacuum condition	Whole ambient condition
Sensitivity of light elements (Na, Mg, Al, Si, P, S)	◎	○	×
Sample protection for hydrous samples and packaged food	×	◎	◎

Figure 1. (a) The XGT-9000 X-ray analytical microscope (b) The diagram and comparison table of atmospheric condition

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1. The micro-probe reveals whether a suspicious particle on a salami is black pepper powder or a metal foreign particle.

Black pepper powder on food is sometimes mistaken for metal foreign particles. Elemental information of the suspicious particle enables food companies to ensure the quality of their food products. The size of black pepper powder is sometimes hundreds of µm. Such a small particle will be missed during the picking operation. Therefore, non-destructive analysis with a micro-probe is efficient for this analysis.

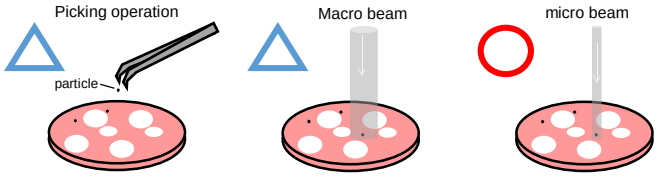

Figure 2. A diagram of comparison of analytical techniques

Figure 3 shows foreign matter analysis on a salami using the XGT-9000 with a 100 µm probe under the partial vacuum condition. Figure 3(b) shows two small particles whose sizes are approximately 500 µm. They are difficult to identify visually to determine if they are black pepper powder or metal particles. Figure 3(c) shows the spectrum comparison between the two particles. The result revealed that Particle-A is an iron particle while Particle-B is not metal.

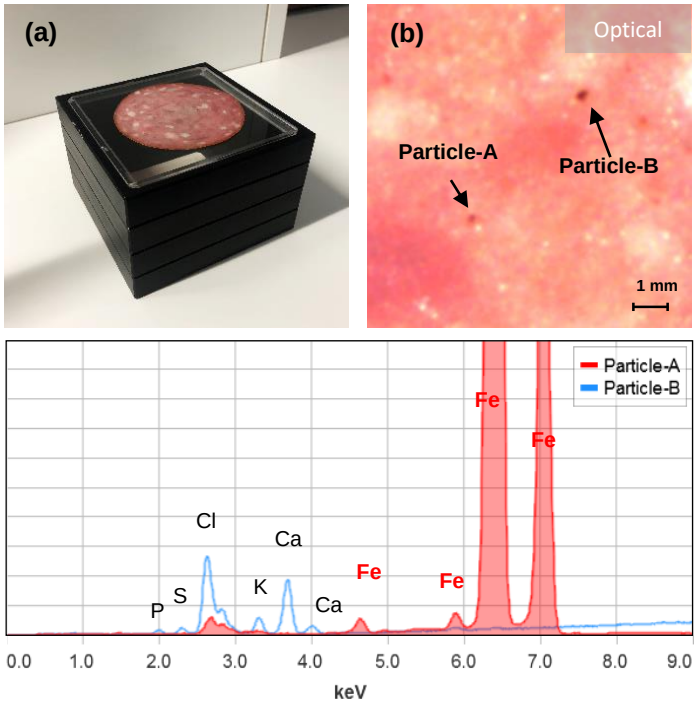

Figure 3. Foreign matter analysis on a salami using the XGT-9000. (a) Sample setting (b) The optical image of the suspicious particles (c) The spectrum comparison of Particle-A and –B.

2. Transmission X-ray imaging reveals foreign matter inside a ham in laminated film and a sausage

Fluorescent X-rays are partially absorbed though the path from the sample. Therefore, foreign matter deep inside the sample can sometimes not be visualized by fluorescent X-ray imaging. The XGT-9000 is equipped with transmission X-ray imaging as well as fluorescent X-ray imaging. Transmission X-ray imaging can visualize the distribution of the density difference of the sample and makes it possible to find foreign matter deep within the sample.

Figure 4 and Figure 5 show foreign matter inspection by the transmission X-ray imaging function of the XGT-9000 on a ham in laminated film, and a sausage, respectively. Though we cannot find any foreign matter on the optical images, the transmission X-ray images clearly visualize the existence of a staple inside. The staples were prepared as foreign matter for this measurement. Figure 4(b) and Figure 5(b) were completed in 30 minutes for whole the ham and in less than 10 min for the sausage, respectively. The measurements were carried out under the partial vacuum condition. Thus, transmission X-ray imaging is effective to identify the foreign matter position non-destructively.

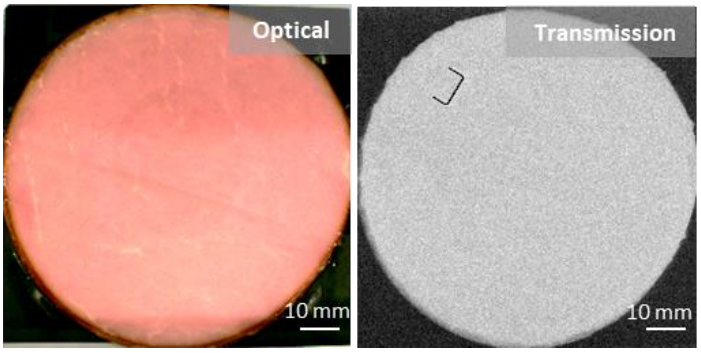

Figure 4. The optical image and transmission X-ray image of the ham in laminated film acquired with the XGT-9000.

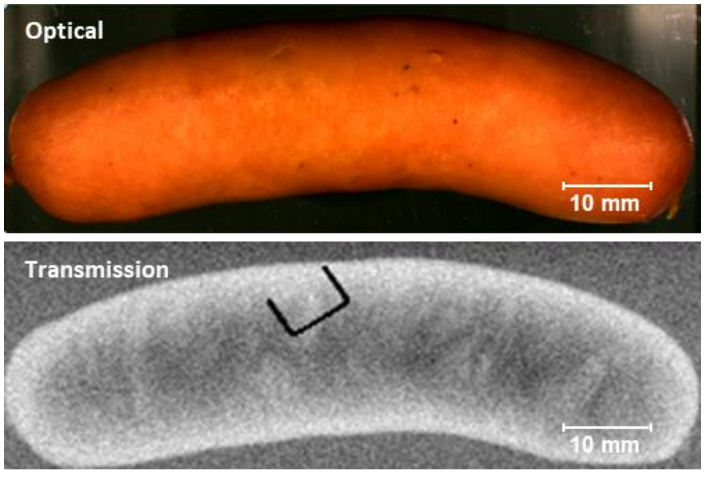

Figure 5. The optical image and transmission X-ray image of the sausage acquired with the XGT-9000.

3. Partial vacuum allows light element detection in a fly as a contaminant

An insect, such as a fly, is one of many possible unintentional contaminations in food products. However, insects exist at consumer sites, as well. Therefore, it is often difficult to ensure whether it accidentally happened during the production process or at consumer sites. Previous research reported that some of the light elements in an insect body can be used as an indicator to estimate when the insect entered in the food. For example, the research reported that sulfur remains and potassium gradually leaks from an insect body into beer, and the ratio of potassium to sulfur (K/S ratio) in a fly is introduced as an indicator to estimate when the fly entered in the beer.[2]

Here, the partial vacuum mode is significant to detect the light elements like sulfur in a hydrous sample without compromising the sensitivity. As shown in Figure 6, the peaks of P, S, K, Ca, and Fe can be detected in a fly under the partial vacuum condition, while the peaks of P and S cannot be detected clearly under the whole ambient condition.

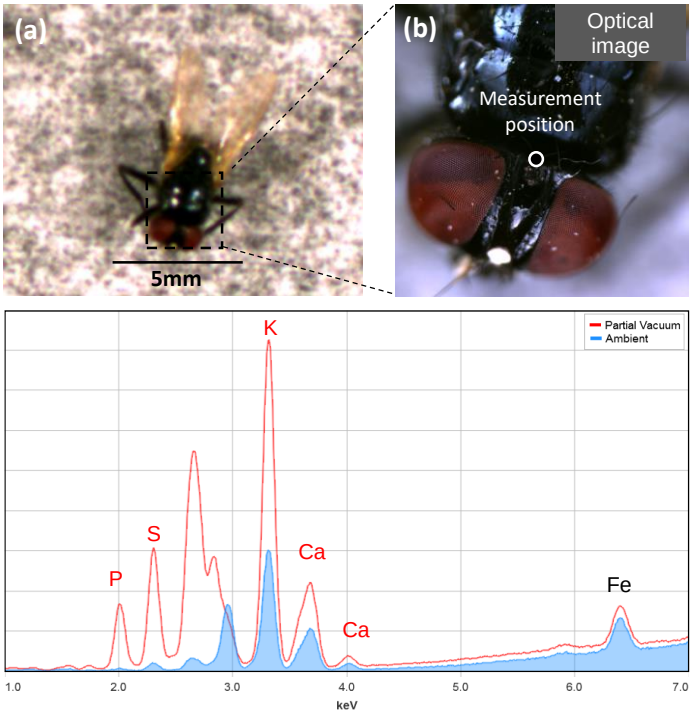

Figure 6. Elemental analysis on a fly as contaminant in food.
(a) The whole image of the fly (b) The detailed optical image of the fly (c) The spectrum comparison under different atmospheric condition (partial vacuum vs ambient).

Finally, the XGT-9000 sample holder is removable from the instrument (Figure 7(a)). The sample holder consists of a replaceable sample tray, and the tray can be washed with dishwasher detergent. It can avoid proliferation of germs or mold, and keep the instrument sanitary after food analysis.

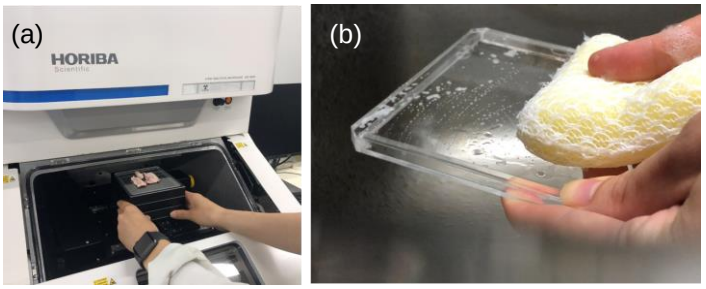

Figure 7. (a) The sample replacement operation (b) The washable sample tray of the XGT-9000.

Conclusion

The XGT-9000 is a powerful, non-destructive elemental analytical instrument for foreign matter inspection of food products. The XGT-9000 has various unique features specialized for food application such as micro-probes, transmission X-ray imaging, and the partial vacuum mode. It helps to clarify the foreign matter in food products.

Reference

1) Lee et al. (**2017**) A study on the identification of animal hair in food. *J. Food Hyg. Saf*., 31 (1), pp 57-63.

2) Asahi Breweries, Ltd Kobayashi et al (**2008**) Method for the determination of insect period of contamination in food. Japanese Patent No. 4035435.

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