IBEX

WHITE PAPER:

DETECTING BONE FRAGMENTS IN MEAT PRODUCTS

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Quality Management System accredited to ISO9001:2008 and ISO13485:2012

Abstract

Detecting bone fragments in meat products is just one aspect of food safety which is important to both consumers and food producers. Fresh meat products pose particular challenges: the sample shape is not regular and there is some variation in size and shape from one sample to the next; the thickness of the product varies; unintentional bone fragments are probably not visible on the outside of the sample; and they are generally small compared to the surrounding flesh. X-ray absorption contrast and image recognition techniques have limited application in this field – there is little or no absorption contrast, and edges and shapes cannot necessarily be clearly identified or associated with bone fragments.

IBEX technology, by restoring energy information to X-ray images, overcomes the limitations in order detect bone fragments in meat products through a difference in material-related signals, regardless of absorption contrast. Two case studies are presented: bone fragments in diced chicken and in a whole, large chicken breast .

Introduction

Food safety is important for the consumer, for both health reasons and a positive eating experience. The producer is concerned, not only for those reasons but also since below-standard product affects production efficiency and brand image.

X-ray imaging is in routine use in food processing lines, but hits limitations where the absorption contrast of the foreign object compared to good product is poor or non-existent, and/or where shape or edge recognition cannot identify the contaminants.

IBEX technology overcomes these constraints by restoring energy-dependent information to X-ray images, giving contrast between the signals from different *materials*, regardless of the absorption contrast. In this way, foreign matter is identified by its material difference from normal product.

Raw meat products such as chicken breast pieces or diced chicken are a particular example. Sample shapes and thicknesses vary considerably over a single sample and between samples. By teaching the system the "signature" of normal chicken flesh, anomalies in material signal caused by unwanted material, such as bone fragments, can be detected.

Multi-Absorption Plate (MAP) Technology

IBEX MAP (Multi-Absorption Plate) technology modulates the X-ray spectrum reaching the detector in a regular manner across its surface. It is described in detail in our White Paper, available from the Resources page of our website.

Experiment

Two studies are presented:

1. Fresh chicken breast was diced and set in a clear plastic tray 12 cm × 12 cm (Figure 1). Small pieces of bone around 1 mm thick were hidden in the mass.
2. Two rib bones and a fan bone were inserted in a large, whole,

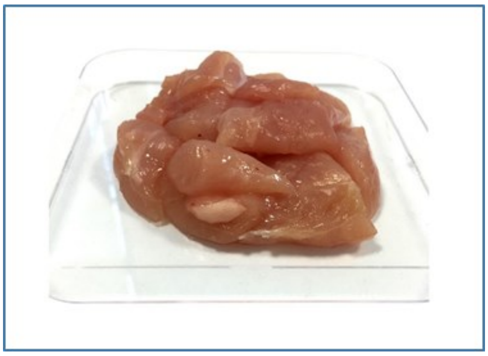

Figure 1: Diced chicken sample containing fragments of bone deliberately introduced.

fresh chicken breast at positions where they might appear in a real case. Fan bones have low levels of calcification and are therefore normally more difficult to detect than other bones.

Images were collected using a commercially-available, low-power, micro-focus tungsten X-ray tube running at 90 kV, 3.9 W. The detector was a Dexela 1512 CL CMOS flat-panel detector (74.8 µm pixel size) fitted with an IBEX MAP. Total image acquisition time in these particular tests was 12.8 s for each of the sample, brightfield and darkfield images (0.55 mAs per image) . An image was also collected of a wedge -shape of chicken flesh. This was used to train the analysis system to recognise the material signature of chicken tissue

The sample images were then analysed to provide an image showing *materials* contrast, irrespective of the absorption contrast.

Results and Discussion

The absorption contrast image of the diced chicken sample, obtained by filtering the shadow of the MAP from the data, is shown in Figure 2. The

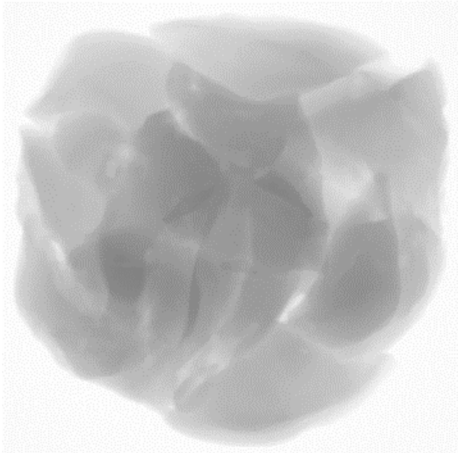

Figure 2: Absorption contrast image of the diced chicken sample, with the effect of the IBEX MAP stripped out. The locations of the bone fragments are not evident from this image, as there are different grey-levels in different areas, and shapes and edges do not give reliable clues.

positions of the bone fragments cannot be reliably determined from this image, either by changes in absorption or by shape or edge recognition. Grey-levels in regions of thick flesh are similar to those in areas of flesh containing bone fragments. In addition, there are areas with abrupt changes in contrast, indicating edges, which are not necessarily related to bone; and some bone fragments may have tapered thickness, leading to less clear definition of the edge.

The IBEX materials contrast image is shown in Figure 3, where chicken flesh is displayed at a similar grey-level in all regions, regardless of its thickness, while anomalous regions (bone fragments) have higher contrast. The locations of the bone fragments are clearly revealed.

Having obtained the materials image, image processing techniques can be used to present the information in different ways, e.g. to produce an image showing the locations of the

Figure 3: IBEX materials image showing chicken flesh mid-grey and revealing bone fragments in black.

Figure 4: Classified materials image, showing the locations of the bone fragments only.

bone fragments only (Figure 4) or an absorption contrast image with the positions of the bone fragments overlaid (Figure 5).

IBEX materials contrast technology again proved essential for identifying the positions of the bone fragments to the whole, large chicken breast sample with three bone fragments deliberately inserted. While one or two of the rib bones might be located in the absorption contrast image by eye, the fan bone is not discernible. IBEX materials contrast brings them to light.

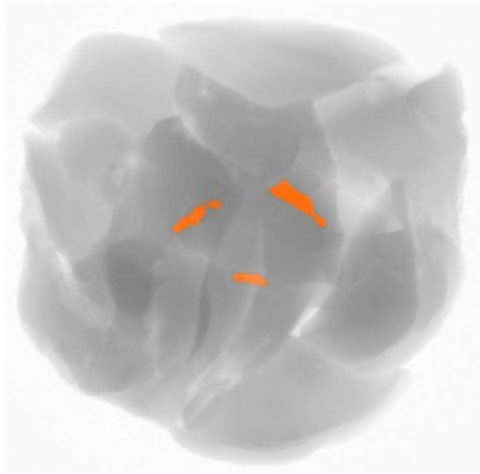

Figure 5: The positions of the bone fragments overlaid on the absorption image of the contaminated diced chicken sample.

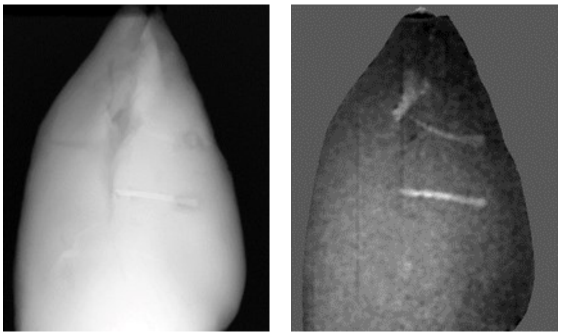

Figure 6: Absorption contrast image (left) of the chicken breast sample containing three bone fragments deliberately placed. Right: IBEX materials contrast image, revealing the locations of all three bone fragments (light contrast). From top to bottom: fan bone, rib, rib.

Conclusions

IBEX technology has successfully identified bone fragment contamination in a mass of diced chicken and in a large whole chicken breast via contrast in the materials signal, irrespective of the absorption contrast. This overcomes limitations of methods based X-ray absorption contrast and has potential benefits in the food industry.

About IBEX

IBEX Innovations Limited was created in 2010 to develop and commercialise an innovative X-ray detector technology.

IBEX is based in modern facilities on the NETPark Science Park in the North-East of England, where it employs a team of highly skilled scientists, engineers and business professionals.

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