CHICKEN BONE DETECTION

Facts on detection capabilities for X-ray systems based on chicken bone composition variations.

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Introduction

This note provides an explanation of why some bones can be detected by X-ray inspection, whilst others cannot.

The testing of an X-ray system is typically based on selecting small bones and cutting of small pieces of these bones, which are subsequently placed into a chicken fillet or a deboned leg (meat) (the product). The product is subsequently scanned by the X-ray system, and its ability to detect the bone in question is assessed.

However, a bone is not just a bone. The detectability of a bone depends on its calcification level.

Quantification of a bone calcification level

The medical sector has worked with a quantification of tissue, bones, fluids etc for many years. This is due to using CT (computerized tomography) for medical diagnosis. The quantitative distinction is based on differences in X-ray attenuation using the so-called Hounsfield Unit (**HU**). This scale is based on water having the value of 0 HU, whereas air has the value -1000 HU. A calcified bone from e.g. pork is typically in the range 600-1000 HU (or beyond), whereas soft-bone (cartilage) is much lower (e.g. 100-250 HU) the due to the much lower abundance of calcium minerals (e.g. hydroxyapatite).

For chicken, the bone HU value depends on the age of the chicken, its feeding, its breed, and many others. For chicken in general food production, **an average HU is about 370 HU** for calcified bone, but varying from the level of cartilage (soft-bone) (100-250 HU) up to 1000 HU for the larger and most calcified bone.

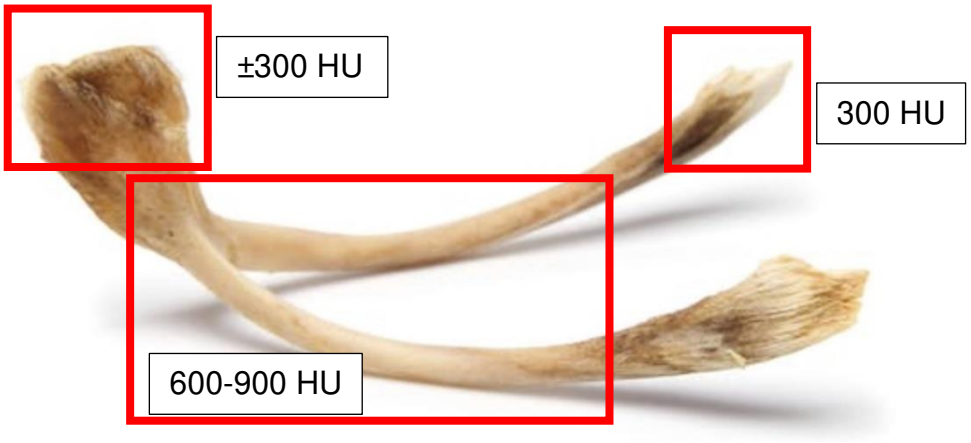

Fig. 1. A chicken wish bone with the typical HU values of the bone in different positions.

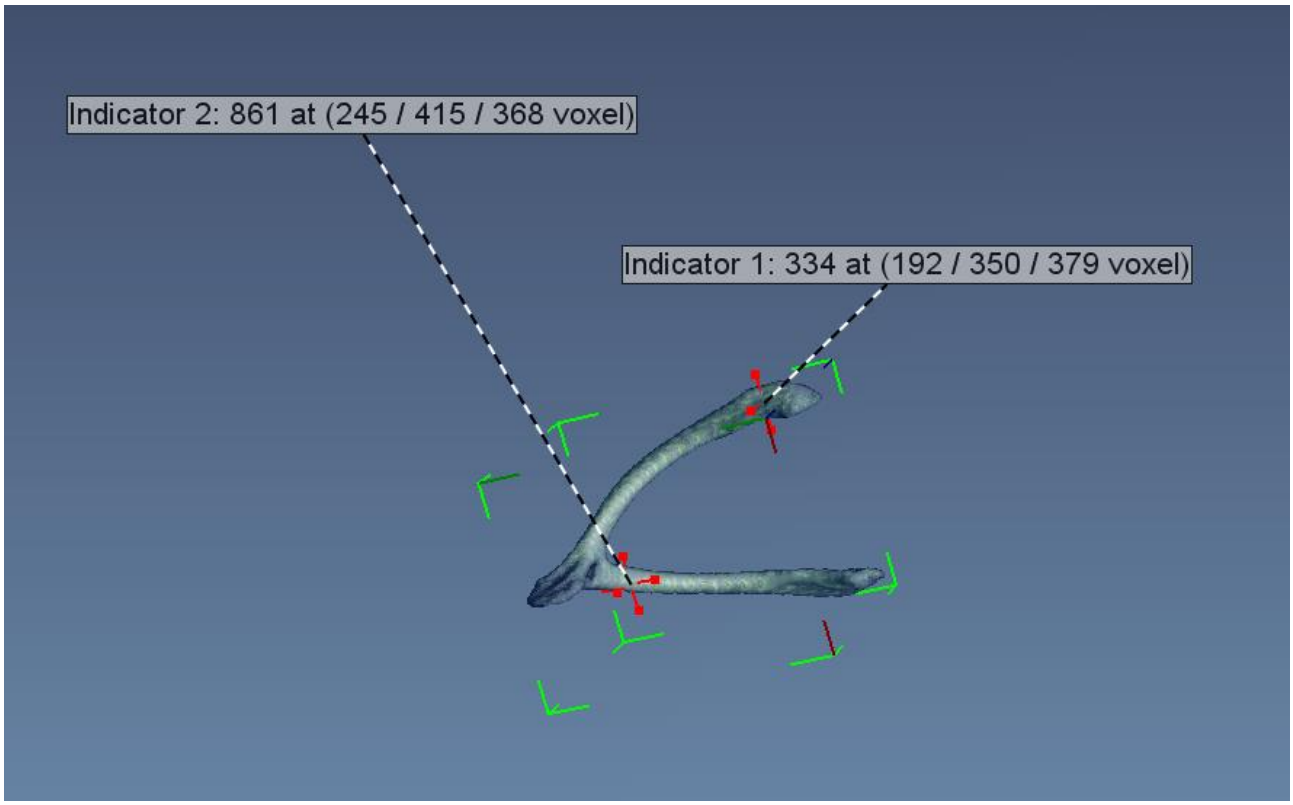

Fig. 2. CT reconstructed image of a chicken fan bone showing the computed HU values in two specific positions with a 0.5 mm voxel size. Courtesy of the Danish Meat Research Institute, DMRI.

Detection of chicken bones relative to the HU value of the bone

Since the detection of a bone depends on the HU value of the bone, it makes no sense to consider only the dimension in three dimensions when evaluating the bone detectability.

A comparison of different X-ray systems must therefore be made with exactly the same bone pieces. This is unfortunately difficult, since practical conditions may cause loss of the (very small) bone pieces, etc.

The optimal solution therefore is to apply a test sample (Fig. 3) with artificial bone pieces (made of a polymer with hydroxyapatite) with a HU value as the average chicken bone, or as a typical calcified bone (with HU value around 600).

Fig. 3. Test samples with artificial bone pieces in the form of cylindrical samples 10 mm long and with diameters from 1 to 5 mm, all with 370 HU value (average chicken bone). Test samples provided by DMRI.

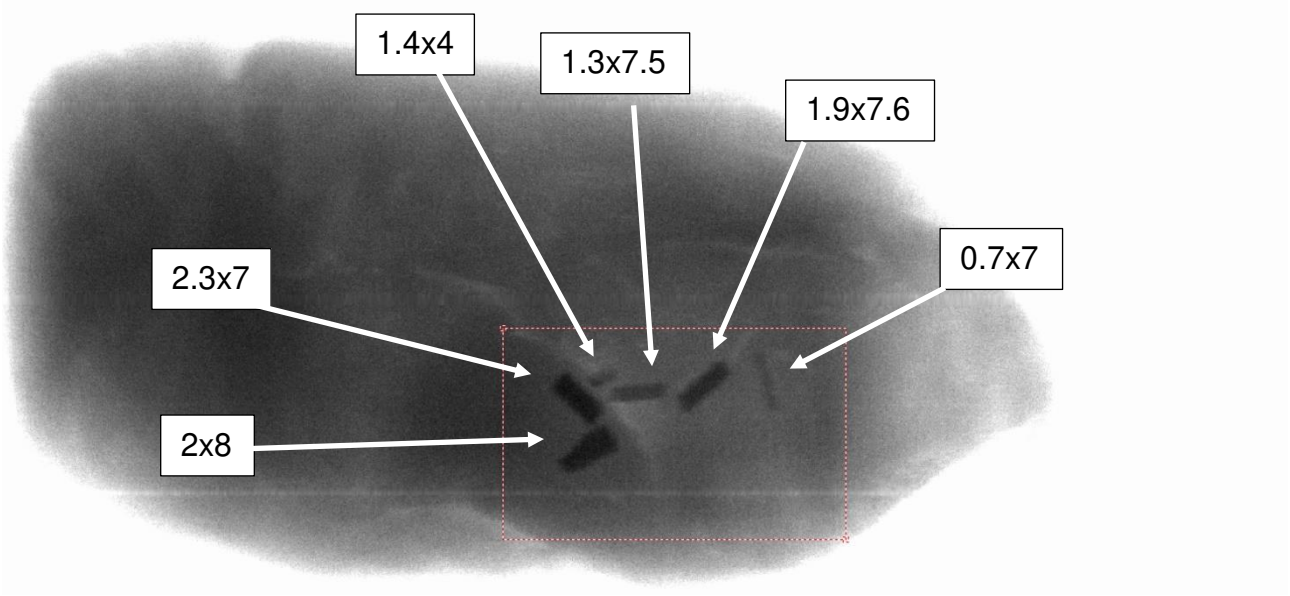

Fig. 4. Low-energy X-ray image of chicken fillet with artificial bone pieces in the form of cylindrical samples with a HU value of 550, and diameter and length (in mm) indicated. Fillet is 34 mm thick. All artificial bones shown in the figure are detected in a standard InnospeXion HYMCIS X-ray system.

Concluding remarks

The above analysis unveils that comparison of different X-ray systems should be based on standardized test samples placed on product with the same thickness and the same attenuation characteristics.

If bones are selected randomly from case to case, a comparison is at best subjective, at worst totally misleading.

Importantly, from the above it is also clear that internal quality control verifications of X-ray system detection capability (as performed on a regular basis, i.e. hourly) must be based on well known, certified, calibration and test samples.

In the case of chicken bone detection capability, it makes sense to use test samples with HU values in the range 400 to 550 HU, as these conform to the average range of calcified bones in general chicken production.

Please note that bones differ according to chicken age, breed, feeding etc., and that chicken from e.g. organic production or production sites with focus on animal welfare may have bones with higher general HU-values.

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