The black bone syndrome in broilers – a challenge for breeders?

by Colin Whitehead and Bob Fleming, The Roslin Institute and R(D)SVS, University of Edinburgh, Scotland.

The blackening of broiler leg bones and the spreading of the discolouration into adjacent meat, especially after cooking, has been reported intermittently in recent years. However, more recent observations on broiler processing lines and supermarket products are suggesting that the problem is much more widespread and fundamental than has been appreciated. It has implications for both broiler meat product quality and bird welfare and is now being described under the name black bone syndrome (BBS).

We have been carrying out studies in our laboratory to obtain a better understanding of the physiological characteristics and factors involved in the development of BBS.

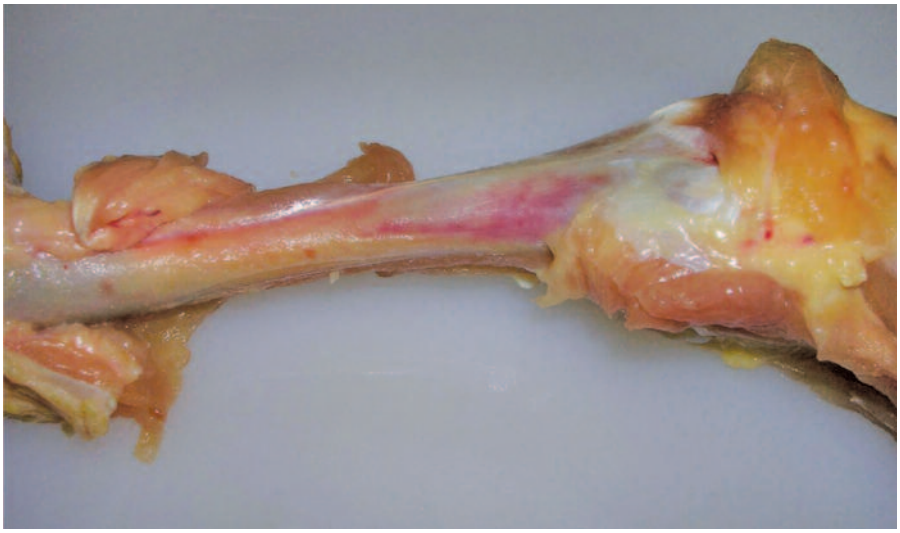

Fig. 1. Blood leaking through proximal tibia and collecting under the periosteum.

Fig. 2. Black bone and meat after freezing and cooking.

BBS appears to be associated with leaking of blood from the marrow through the bone structure. This can be observed in freshly killed birds on processing lines, most frequently in the tibia but also sometimes in the femur. The leakage of blood in the tibia occurs in the proximal end, just below the growth plate.

The blood may then diffuse down the bone under the periosteum (the organic layer overlying the mineralised bone surface). This situation is shown in Fig. 1. The problem of BBS seems to be made worse by freezing un-deboned leg portions.

Presumably the freezing process forces more blood from the marrow through the bone and into adjoining meat. Cooking may contribute further to this process and also blackens the blood. The final result is a blackened and unappetising appearance of the meat surrounding the bone, as shown in Fig. 2.

We have found blackened bones to be widespread in frozen supermarket products (samples are shown in Fig. 3) and not connected to specific types or sources of broilers or broiler products.

This is already having market impacts because there are now reports that fast-food outlets are stopping using frozen broiler leg portions or using deboned meat instead.

Understanding the cause

To understand the cause of BBS, we need to consider how leg bones grow. They increase in length by the process of endochondral bone growth in which cartilage cells (chondrocytes) first multiply and then change their character to ultimately allow

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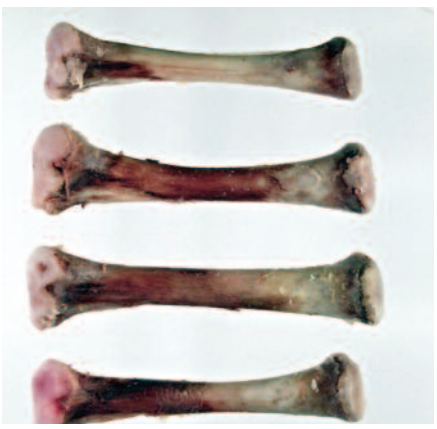
Fig. 3. An example of black bone syndrome in frozen supermarket samples.



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the accumulation of bone forming cells (osteoblasts) which produce cancellous bone.

However, bones thicken by a different process, intramembranous ossification. In this process, the periosteum covering the outer bone surface contains osteoblasts which produce cortical bone directly.

Formation of bone on the outer surface is accompanied by resorption of bone on the inner (marrow) surface so that the bone widens as an expanding ring of bone.

However, the bone formed in young broilers is not solid mineralised bone. Instead, it is full of holes in a somewhat porous structure. Findings by Williams et al. (2000) suggest that the degree of porosity has been increasing with continued selection of broiler genotypes for ever faster growth, so it seems that there may be finite populations of osteoblasts trying to accommodate faster rates of bone growth by producing an increasingly porous bone structure.

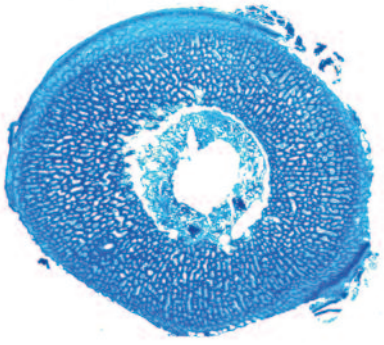


Fig. 4. Histological cross-section of mid-shaft of broiler tibia. Mineralised bone is coloured blue.

The osteoblasts try to fill in these pores, but fail to do so before they are overtaken by bone resorption as the bone widens. This bone structure is illustrated histologically in the midshaft cross-section of a broiler tibia shown in Fig. 4, where the blue colouration represents mineralised bone and the lighter areas in the bone are the pores. Note that the pores in bone are not the same as pores in eggshells, which are straight channels running directly through the shell, but are in a more random, though probably loosely interconnected structure.

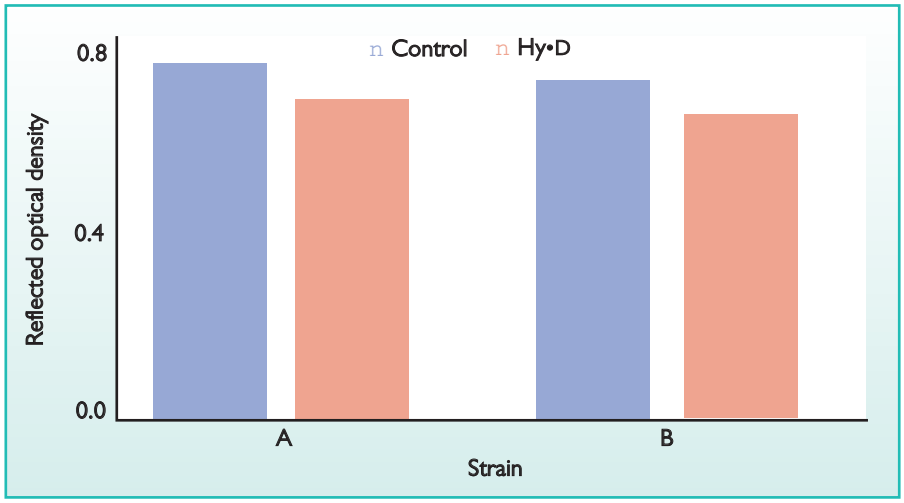


Fig. 6. Mean reflected optical densities (10-15mm from proximal end) of two strains of broilers fed diets supplemented with 0 or 69mg 25-hydroxyvitamin D (as Hy•D).

This structure in the midshaft is still strong and able to bear the weight of the bird.

However, we have found a different situation in the shaft of the bone immediately adjacent to the proximal growth plate, the area through which the blood is seen to be leaking.

Here, the bone is much thinner – it can often be depressed by moderate finger pressure – and we have confirmed this by histological examination as shown in Fig. 5.

In this section, the mineralised bone is stained light red and blood cells from the marrow cavity are stained dark red.

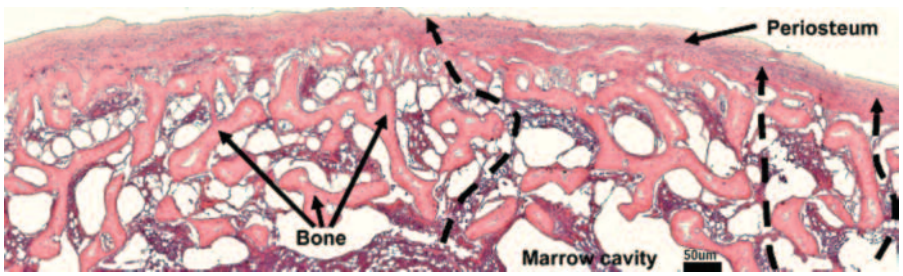
As can be seen, the overall mineralised area is very thin and comprised of poorly connected strands of bone, of more cancellous than cortical appearance. There are obvious routes in this structure through which blood could seep and collect under the periosteal layer.

So the BBS problem appears to have an underlying fundamental physiological cause, in which rapid bone formation in modern broilers is resulting in inadequately mineralised bone.

This is manifest at the moment in problems of product quality, but continuation of this trend may ultimately result in welfare problems for the birds themselves through development of pathological problems from bone structural defects.

So, what can be done about the problem?

Fig. 5. Structural bone in cross section of proximal tibiotarsus (at level = 10% of bone length). The bone (light red) appears more cancellous than cortical, with many possible routes (dotted arrows) leading from marrow cavity to external periosteal layer (x10 objective, H&E stain).



The long term answer would appear to require breeding companies to pay more attention to bone structure in their selection of future breeding stock. However, in the short term it is possible that nutritionists might be able to help alleviate the problem by paying attention to factors that can maximise bone quality.

Improving vitamin D status

Calcium, phosphorus and vitamin D are the most obvious nutrients to consider and, indeed, there is evidence that improving the vitamin D status of diets through the use of 25-hydroxyvitamin D_3 (as Hy•D, supplied by DSM Nutritional Products) can be beneficial.

Saunders-Blades and Korver (2006) showed that improvement of bone mineral by inclusion of the vitamin D_3 metabolite 25-hydroxyvitamin D_3 (as Hy•D) can reduce blood leakage and discolouration and improve the consumer acceptance of poultry meat. We have followed this up by comparing various characteristics of bone from another study on the feeding of Hy•D carried out by IRTA in Spain.

The treatments involved supplementation of the diets of two different strains of broilers with either 0 or 69mg 25-hydroxyvitamin D (as Hy•D), in addition to a normal dietary content of vitamin D_3. We measured the reflected optical density (as a measure of bone blackening) in the area of 10-15mm from the proximal ends of frozen tibias. As shown in Fig. 6, the measure of blackening was less in both breeds of broilers in birds given the Hy•D supplement and the overall effect was statistically significant (P=0.043).

It is possible that further research may identify improved calcium and phosphorus nutritional practices which, when combined with the use of Hy•D, may further contribute to the alleviation of the BBS problem. ■

References are available from the authors on request.