

PATHOLOGICAL CONDITIONS THAT CAN AFFECT FOOD  
MUSCLE STRUCTURE AND HOW THEY CAN BE RECOGNIZED  
AND CONTROLLED

by:

St. John A. Clottey  
Royal Veterinary & Agricultural  
University, Copenhagen, Denmark  
-----

INTRODUCTION

Three general classes of pathological conditions are often encountered in the muscles of food animals - all of which may lead to rejection of the animal, carcass or part as material for food. They are, in order of importance, diseases caused by infecting agents, degenerative changes, and to a less extent, congenital defects. An additional set of changes are preslaughter alterations in the live animal resulting in profound changes in the quality of the carcass thus leading to a reduction of its value on the market.

Unlike infections, there are here no threats to public health in any of the foregoing conditions. On the other hand, like degenerative and congenital changes, these manifestations may lead to a condemnation of the meat on purely aesthetic grounds.

1. Infections involving Muscles

In muscle, diseases predisposed by infecting agents are of two kinds:

(a) Infections resulting from devitalized muscle tissue. All are of bacterial origin and include clostridial myositis, suppurative myositis and actinobacillus granuloma. All develop from conditions pertaining to wound or injury of muscle among which clostridial myositis is the most important.

(b) Infections of parasitic origin: These are mainly helminth in origin, the muscles affected are highly active having abundant blood and nutrient supply. The organisms involved are Trichinella spiralis which is

responsible for trichinosis in man and pig. The specific species being Cysticercus bovis and C. cellulosa. A less threatening infection also occurs in muscle: sarcosporidiosis which has sarcocystis as its etiological agent.

In both groups, the dangers posed are far-reaching as the diseases can be transmitted to man through consumption of an infected meat. Below is described selected cases pointing to their pathogenesis, symptoms, lesions and control.

#### Clostridial Myositis

Clostridial myositis, as the name implies is a general pathological condition (or inflammatory reaction) caused by the invasion, intoxication and putrefaction of devitalized muscle tissue by clostridia. The result of this invasion is the production of swollen muscle which may also become edematous. The infections are usually localized in the region of the shoulder or the rump in deep tissue. These muscles are therefore the common sites of attack since they are more or less exposed and are vulnerable to the injuries of forced exercise such as attack by dogs. They are also sites for injection of drugs into the animal, in all creating wounds which can cause devitalization of the muscles.

Microscopically, clostridial myositis may evidence an acute condition involving destruction of capillary wall and the seeping out of edematous fluid. In certain instances, the myositis may be accompanied by an acute degeneration and necrosis of the muscle fibers with gas formation. In this connection, it is recognized as a gas gangrene. On the other hand, where severe edema occurs in intermuscular connective tissue with less necrosis of muscle, the condition is termed malignant edema. As a rule, large numbers of Cl. perfringens tend to accumulate in gas gangrene whereas malignant edema harbours chiefly Cl. septicum

A third condition, black leg (on black quarter) sometimes also called emphysematous gangrene with Cl. chauvoei as etiological agent, occurs in calves and sheep. No wound is involved here, although some form of trauma may initiate the muscular devitalization. The infection is acquired by ingestion of spores which are taken across the alimentary mucosa by macrophages and then distributed to the tissues including muscle. Here they remain until activated by the lowering of the muscle redox potential.

Normally death occurs within 24 - 48 hours following the first visible signs of attack. These signs are seen in the first 12 hours during which the muscles involved become swollen and discoloured. Soon they become cold. There is profuse toxemia followed by circulatory collapse and death.

Animals with clostridial myositis especially black leg, (and this includes in addition to calves almost all the large domestic species) are unfit for slaughter for food. They are removed for treatment or if treatment is impracticable, they are condemned and destroyed. Routine vaccinations are highly effective in the control of black leg which is enzootic and selective of its host. Where this is not possible, good management practices, avoidance of injury and high sanitary standards help reduce its incidence. This latter measure is true at least of malignant edema which is sporadic.

### Trichinosis

The causative agent of this myo-infestation, Trichinella spiralis occurs in pig muscles where it spends part of its life cycle as an encysted larva. The other part is completed finally in man where the larva is released into the individual through ingestion of the infected pork. In man the parasite again lodges in muscle bundle, becoming encysted and remaining there throughout the life of the host - further development following only upon ingestion of the infected muscle by another host.

The clinical symptoms in man vary with the severity and stage of the infection, and include vomiting, diarrhoea, sweating, rheumatic and muscular pains. In animals, however, the symptoms of trichinosis are rarely observed. The severity of the invasion depends upon the number of larvae present. Encysting larvae lodge mainly in the aponeuroses or tendons of the highly active muscles, especially the diaphragm, tongue, larynx, the muscles of mastication and the intercostals. Postmortem examination of trichina-infested pork muscle may reveal *calcified* cyst walls harbouring living larvae.

The prevention of trichinosis in pigs is crucial to its elimination in man. Ideally, there are two general methods by which this is accomplished: **E**limination of the parasite from the diet of meat - producing animals, or its removal from the diet of man.

In pig husbandry, garbage (or kitchen and market waste) is commonly fed to these animals. Investigations have shown that swine which are fed such waste have a high incidence of trichinosis while those are fed on grain have a low occurrence of the parasite. On the other hand, when the garbage is cooked prior to feeding, most of the trichina are destroyed. In the U.S., federal laws require that all garbage feed that is channelled through inter-state commerce be cooked to 212<sup>0</sup>F and held at that level for 30 minutes before being fed to the stock.

There is evidence further that certain *forms* of wildlife and pets, have long been known to be sources of trichinosis in pigs. Mice, rats, dogs, cats and furbearing animals are all implicated. The mode of transmission from these forms to pigs is either through fecal contamination or by consumption of the infected *carcass*. The elimination of rodents from around farms is therefore important in the control of the parasite.

Eliminating the parasite from the diet of man has called for distinct methods in various countries. They include:-

- a. Complete abstinence from consumption of meat. This is vegetarian method.
- b. Abstinence from animals which are known to be infected with the parasite (Hebrew and Islamic method)
- c. Identification and elimination of meat which contains trichina (the European method) and
- d. Treatment of meat to assure the destruction of trichina before consumption (the American method).

The European method following the German Virchow's recommendation, basically involves microscopic or trichoscopic examination of all slaughter pork for the parasite. So successful has been the practice that for nearly seventy years, <sup>now,</sup> no outbreak of trichinosis has occurred in Germany that is traceable to inspected pork, and there is no thought of risk when the German consumer eats raw pork. The Scandinavian countries employing the same techniques, have for all practical purposes eliminated trichina infections from their butcher hogs to the extent that only breeder swine are subjected to microscopic examination.

The American method, on the other hand, is based on the principle that thorough cooking of pork and of meat products containing pork, destroys the encysted larvae thus rendering the meat safe for human consumption. Federal regulations stipulate that processed pork products which are customarily purchased without cooking and served, must in the first instance, be treated by heat, refrigeration or curing before use. Heating for instance, must be made to a temperature of at least 137°F, and refrigeration, below (but not above) 40°F.

Much can be said for or against the many different methods of laboratory control of trichina, but the important thing is that it is a system that has proved its merit in several situations - not the least in the German and Scandinavian systems. Here strict inspection coupled with an efficient feed back organization has so successfully aided in eliminating the parasite from slaughter hogs that attention is now being devoted to other classes of pigs such as breeders.

## 2. Degenerative Diseases

Diseases resulting from general disturbance of metabolism are not of particular importance from the public health point of view as those arising from irritations due to bacteria or parasitic agents. This is because no infections as a rule, are involved, hence no immediate dangers are posed.

The degenerative condition in muscle of significance here is nutritional muscle disease (NMD) which occurs most frequently in younger stock. In the sheep, it is often referred to as "stiff lamb disease", while in the calf, it is called "white muscle disease". Foals have an older name "enzootic polymyositis" while it is simply referred to in the pig as "muscle degeneration".

All these conditions are characterized by serious alteration of skeletal (usually appendage) and cardiac musculature - due to nutritional deficiencies and imbalances - sometimes complicated by stress. The lesions, involve areas of skeletal or cardiac muscle which are pale or practically white in colour. Microscopically these areas may be found to be progressing from hyaline (Zenker) degeneration to coagulative necrosis with fragmentation and disappearance of the muscle fibers. In some forms, calcification of some individual muscle fibers place. The weight-bearing muscles such as those of the pelvic and pectoral group become involved, occasionally getting stiff in the process. Lambs have difficulty moving these limbs. In the heart, white areas are less distinct because of the anatomical disposition

<sup>the</sup> of fibers. Macrophages may accompany the condition. There may be evidences of attempts at regeneration but these are generally not so successful.

A deficiency of Vitamin E or alpha-tocopherol seems to be the chief cause of this form of degeneration. This is strongly evidenced in stiff lamb disease. However, where there is oversupply of iron (as happens frequently in iron injections) an antagonistic situation arises which predisposes the stock to muscle degeneration. Recently the importance of selenium as a factor in preventing NMD appears to be outstripping that of Vitamin E. In white muscle disease, at least, the addition of selenium to 0.1 part per million of total ration serves as a preventive measure.

Calves most commonly exhibit muscle degeneration in all its varied forms. In the cardiac and thoracic varieties, the animal shows an edema of the lung, due to hyperemic passive congestion, while accumulation of metabolites in the blood leads to an aseptic fever. Eventually, the heart fails and there is acute death. Prior to this dyspnoea (rapid cessation of breathing) sets in, compensated by abdominal breathing.

These symptoms have often been confused with pneumonia and attempts to treat them as such by use of antibiotics have generally been fruitless. This error need not be made as postmortem findings of similar cases normally show a coagulative necrosis of intercostal and diaphragmatic musculature coupled with cardiac degeneration, involving pale conditions or white areas in the left ventricular septum and papillary muscles. Furthermore the type of management pursued on the farm may tend to provide more clues to the condition. Thus where calves have been under confinement (having been born in winter and held in a barn throughout the season without access to exercise and the limiting nutrients), NMD should be suspected. It may be noted that the pectoral and pelvic forms of the disease are accompanied respectively by symmetrical swelling of the involved muscle groups, and this is soon followed by their hardening and lameness.

Clinical analysis of the serum in NMD cases usually shows an increase in SGOT and SGPT which is indicative of necrotic processes and Zenker type of degeneration. On the other hand, calcium, magnesium and phosphate ~~ions~~ remain normal. Treatment of NMD is by administration of 0.6 mg selenium and 30.0mg  $\alpha$ -tocopherol acetate per 10kg body weight, 2 - 4 times a week.

A few other nutritional disturbances involving selenium, sulfur-containing amino acids and unsaturated fats also occur in the pig, while in horses a non-nutritional condition of muscular damage resulting in release of myoglobin in urine occurs in periods of inactivity of the animal.

From these discussions it seems important that animals should be carefully scrutinized with respect to limiting nutrients where necessary, and be exercised liberally to prevent muscle degeneration and hence ensure <sup>the</sup> safety of the meat supply.

### 3. Congenital Defects

Occasional developmental anomalies in brain tissue and lesions in the central nervous system often lead to disturbance in muscle structure and function. For instance in the condition known as arthrogryposis, the brain and spinal cord do not develop normally, consequently there is lack of proper induction from these centres to regulate the development and activity of the musculature. Through a defect of muscles, arthrogryposis may also affect the skeletal system, in all presenting serious obstretical problems over long term.

In another instance, the lesions involved tend to damage the mediating centres in the brain to the extent that control is lost over the hind limb - most frequently in Holstein-Fresian cattle, thus inducing a state of paralysis (spastic paresis). Clinically and morphologically there is contraction of the Achille's tendon, but not its attached muscle the gastrocnemius. (There is no local lesion in the gastrocnemius or attached



tendon and aponeurosis, since the type of injury normally affecting them is central or upper motor neuron paralysis).

In another condition, calves or lambs attain great increase in size of the general musculature giving rise to the so-called giant calf or giant lamb (the so-called doppenllender or storkalvern) condition. This is hereditary hyperplasia of muscle, particularly of the trunk and limbs mainly the rump, thighs and shoulders. There is also an accompanying deficiency of subcutaneous, abdominal and intermuscular as well as intramuscular fat. Microscopically, the condition is seen as an increase in the number of muscle cells. Other than that the deficiency of fat in the muscles appear normal.

Undesirable hereditary manifestations are easily culled from animal populations by suitable schemes of genetic crossing. The principle here is to breed out the character and then remove it as it shows up phenotypically to prevent its infusion into the population.

#### 4. Preslaughter Alterations in Muscle

Disease in animals does not constitute the sole criteria upon which inspection and control are based. Experience has shown that changes in the condition of animals prior to slaughter can have adverse effect on the quality of the carcass which in turn may provide a basis for its rejection - here on aesthetic grounds. For instance, animals in suffocation or in some kind of exhaustion, or those affected by shipping fever prior to slaughter may evidence bleeding carcasses or muscle and profound changes in the colour and texture of the lean meat. Similarly, fatigued animals or weak, unhealthy ones are not likely to bleed properly. Fatigue also lowers the processability value of meat, as it causes a reduction in its water-holding capacity - something evidenced in pork as the "pse" (pale-soft and exudative) condition.

Besides in beef a condition called 'dark-cutting', which is a term used for dark-muscle colour, may develop following excessive exhaustion. In practice exhaustion can be overcome by allowing the animals a period of rest (at least 12 hours) prior to slaughter during which time the animals are allowed ample supplies of water.

R e f e r e n c e s

1. American Meat Institute Foundation (AMIF) : 1959  
"The Science of Meat and Meat Products". W.H. Freeman & Co  
San Francisco & London.
2. Brandly, P.J. et. al. 1966 "Meat Hygiene" Lea and Febiger,  
Philadelphia Pa, 3rd ed.
3. Jubb, K.V.F. and P.C. Kennedy. 1963 "Pathology of  
Domestic Animals". Vol.2, Academic Press, New York & London.
4. Moller, T. 1973 by Personal Communication.  
Royal Vet. & Agric. Univ., Copenhagen, 1973.
5. Runnells, R.A. et. al. 1960 "Principles of Veterinary Pathology"  
Iowa State Univ. Press., Ames, Iowa 5th ed.
6. Smith, H.A. and T.C. Jones 1966 "Vertterinary Pathology",  
Bailliere, London 3rd ed.

Presented January 8, 1974

Revised July 11, 1978.