

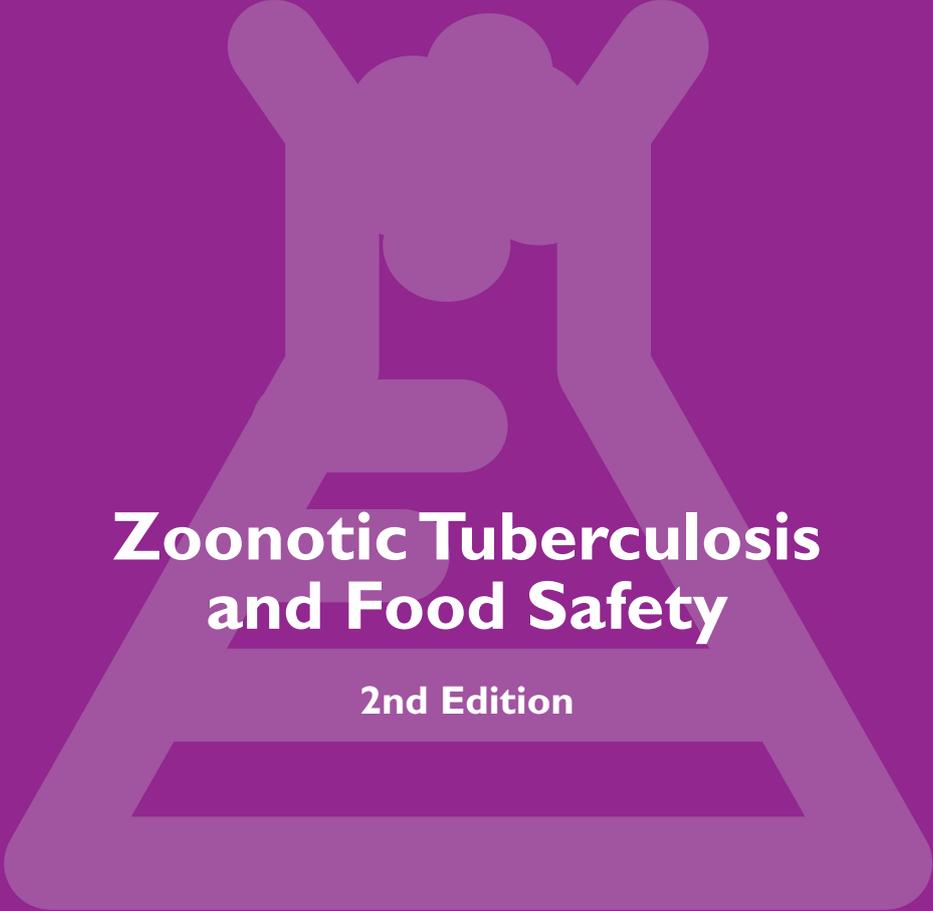


Zoonotic Tuberculosis and Food Safety

2nd Edition



Microbiology



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2nd Edition

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PREFACE TO THE SECOND EDITION

The Food Safety Authority of Ireland (FSAI) published the first edition of this document in 2003. Since the document was published it has been the subject of some discussion, particularly in relation to the hazard of transmission of *Mycobacterium bovis* to humans through consumption of cheeses made from unpasteurised milk taken from infected herds. In drafting the original report, the Microbiology Sub-committee/Scientific Committee recognised the hazard associated with the consumption of cheese produced from unpasteurised milk in general, and the specific hazard of human infection with *M. bovis* if the milk originated from an *M. bovis*-infected herd. The report recognised that, when a herd is officially restricted due to the diagnosis of tuberculosis, either on the basis of a positive tuberculin test or for other reasons, it must be accepted that such a herd has been infected with *Mycobacterium bovis* for some time prior to the commencement of that restriction. Consequently, the hazard of contamination of milk produced by such a herd exists from some time prior to the commencement of that restriction and additionally, the hazard also exists that cheeses made from unpasteurised milk produced by such a herd during this period are also contaminated with *M. bovis*.

The original edition of this report sought to indicate that cheese that had been made from unpasteurised milk, collected from a herd that was “officially tuberculosis free” at the time of milking, but which is subsequently restricted because of detection of bovine tuberculosis, should not generally be regarded as suitable for human consumption. In drafting the report, the members of the Sub-committee were conscious of the implications of such a recommendation for cheese producers and therefore, the report sought to identify certain very limited circumstances in which exceptions could be considered. It is apparent that this qualification has resulted in ambiguity in the report and that this may have contributed to an interpretation of the report as generally implying that restriction of the sale of such cheese was not warranted. This was not the meaning intended by the Microbiology Sub-committee or Scientific Committee.

In view of this, the Scientific Committee requested the Microbiology Sub-committee to review the relevant sections of the document to determine if, in the light of experience, modification of the report was necessary to ensure that priority was given to ensuring clear and unambiguous advice to protect public health.

This report was prepared by the Microbiology Sub-committee and adopted by the Scientific Committee for presentation to the FSAI. It aims to provide the FSAI and other stakeholders with an overview of the science and related issues surrounding the potential for transmission of zoonotic tuberculosis via food.

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I. SCOPE OF THE DOCUMENT

In drafting this document, the Microbiology Sub-committee of the Scientific Committee of the FSAI took, as its task, a consideration of the potential for transmission of zoonotic tuberculosis (i.e., tuberculosis from animals to humans) through the food chain. The document does not seek to address issues relating to the control of transmission of tuberculosis in animals intended for food production, occupational risks of tuberculosis related to animal husbandry or slaughter, or control of tuberculosis transmission from person to person, except in so far as is necessary to provide background for the food safety issues.

2. INTRODUCTION

2.1 Tuberculosis - Defining Characteristics

Tuberculosis is an infectious disease with distinctive clinical and pathological features. Tuberculosis occurs in humans and many animal species including species of animals used for production of food (milk or meat) for human consumption (cattle, sheep, goats and deer). The principal microorganism associated with human tuberculosis is *Mycobacterium tuberculosis*. *Mycobacterium bovis* is the causative agent of tuberculosis in animals used for production of food and accounts for a relatively small proportion of human cases of tuberculosis reported in Ireland. Infection with these microorganisms is chronic and the infected human host may remain entirely asymptomatic or may have mild to moderate illness that does not come to medical attention for long periods. In a proportion of human or animal hosts infected with these microorganisms, the infection may ultimately progress to severe systemic illness. Pulmonary disease is the classical feature and ultimately the disease may progress to death of the host if untreated. The classical pathological feature of the disease in humans is the caseating granuloma. This is an organised aggregation of macrophages surrounding an area of caseous necrosis.

Classically, tuberculosis is suspected in humans because of clinical features of chronic cough, weight loss and signs detected on clinical examination of the chest. In human medicine, characteristic radiological features may support a clinical suspicion of tuberculosis, or radiological features may raise the possibility of tuberculosis in a person in whom it was not suspected prior to radiological examination. Tuberculosis may also be recognised in humans or animals by observation of characteristic macroscopic findings on *post-mortem* examination and by microscopic features of granulomatous inflammatory changes in tissues or lymph nodes on histopathological examination of specimens obtained *ante-mortem* or *post-mortem*. Mycobacteria may be observed on histopathological examination of appropriately stained tissue sections, but the specific species of *Mycobacterium* present cannot be definitively identified by this means.

2.2 Microbiology

The genus *Mycobacterium* comprises more than 70 species. Many species of mycobacteria occur in the environment and are rarely associated with disease in humans or animals. A number of species of mycobacteria are important pathogens of animals or humans. Human tuberculosis is chiefly associated with infection with the species *Mycobacterium tuberculosis*, although *M. africanum* is also important in some regions. Tuberculosis in bovines and many other animal species is primarily associated with infection with *Mycobacterium bovis*. *M. tuberculosis*, *M. bovis* and *M. africanum* together with *Mycobacterium microti* (associated with infection of rodents) form a very closely related phylogenetic group and may be referred to collectively as the *M. tuberculosis* complex (MTBC). Human infection with members of the MTBC produces an indistinguishable clinical picture and the individual species cannot be distinguished from each other based on microscopic examination of stained tissues or other clinical specimens. Determination of which species is responsible for infection in a particular case normally requires culture of the microorganism in the laboratory. Culture of the infecting microorganism remains the gold standard for diagnosis of infection with the MTBC; however, the process may take weeks, as the microorganisms grow slowly *in vitro*. In a significant proportion of cases of human tuberculosis, although there is sufficient clinical and radiological evidence to establish a diagnosis of tuberculosis, it is not possible to culture the pathogen from any clinical specimen and microbiological confirmation of the diagnosis is not achieved. Identification of the particular species involved may now also be accomplished by molecular methods. Sub-typing of members of a particular species is also possible using molecular methods and such techniques may assist in the detection of relationships between microorganisms isolated from different sources.

Well-standardised methods for examination of specific foods for the presence of *M. bovis* have not been developed. While there is no reason in principle why the methods used for culture or molecular detection of *M. bovis* from clinical specimens might not be adapted for application to foods, at present there is not an accepted laboratory process that would permit certification of a food product as “*M. bovis* – free”, or as “free from risk of transmission of zoonotic tuberculosis”.

2.3 Natural History of Human Infection with the *M. tuberculosis* Complex

When bacteria of the MTBC gain access to tissues they proliferate locally. Local proliferation of microorganisms at the site of access to the tissues is associated with an inflammatory response characterised by infiltration of tissue with macrophages and other cells of the immune system. Macrophages phagocytose the bacteria. Following phagocytosis, macrophages present MTBC antigens to T-lymphocytes, which stimulate the development of an adaptive T-lymphocyte immune response over the subsequent weeks.

In the early stages of infection, before the adaptive immune response is fully developed, the macrophages are not capable of preventing proliferation of the microorganisms within the macrophage. During the period when the adaptive immune response is developing, the macrophages containing proliferating MTBC microorganisms migrate to the lymph nodes that drain the site of initial infection. From there they are carried to the regional lymph nodes. For example, initial infection of the tonsils will result in drainage of MTBC microorganisms to the cervical lymph nodes in the first instance, while initial infection of the lung results in drainage of microorganisms within infected macrophages to the lymph nodes at the hilum of the lung. From the regional lymph nodes the microorganisms may gain access to the blood and can disseminate widely throughout the body.

As the adaptive immune response develops, the stimulated T-lymphocytes interact with the macrophages to enhance the ability of macrophages to inactivate the microorganisms. As the cellular adaptive immune response develops, the cells involved form the characteristic histopathological feature, the granuloma.

Arising from the complex interaction between the MTBC bacteria and the developing immunological response, there are a number of possible clinico-pathological outcomes for the host:

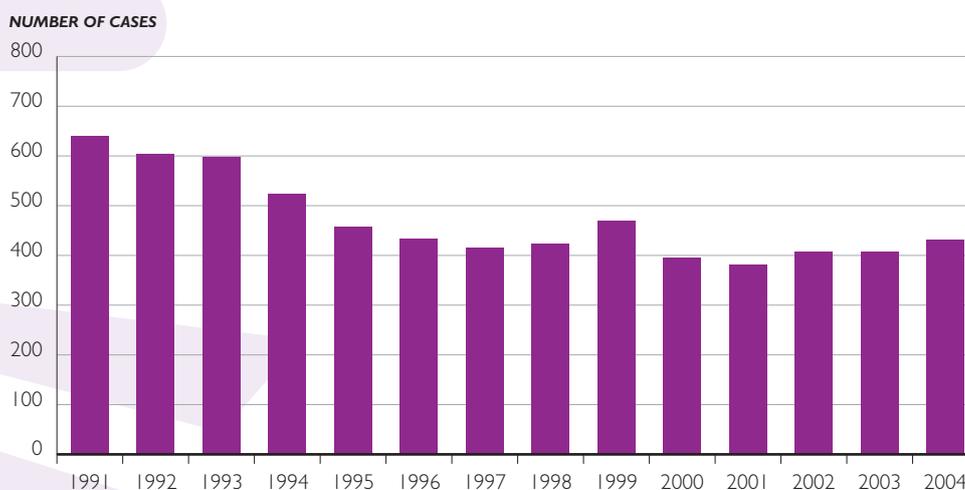
- in a small proportion of infected people (usually the very young infant or those with profound impairment of the cellular immune system), there is no effective immune response and the microorganisms continue to proliferate throughout the body, resulting in relatively rapid deterioration and death. This rapidly progressive disseminated infection is called “miliary tuberculosis”
- in a small proportion of people, a localised, self-limiting disease develops within weeks of initial infection. The classical example of a self-limiting primary infection is tuberculous inflammation of the pleura (pleurisy). The progression of the infection is arrested by the development within about six weeks of infection of a specific cellular immune response. This activates the macrophages to prevent further proliferation of the mycobacteria and resolution of the clinical illness follows
- in the majority of those infected with bacteria of the MTBC, the specific immune response, once developed, effectively controls proliferation of the bacteria before any features of clinical illness develop. This is asymptomatic primary infection. In those in whom primary infection is asymptomatic, the microorganism may not be completely eradicated but may remain viable in the tissues for many years. This is referred to as “latent” infection
- in a minority (perhaps 5 to 10%) of infected people in whom the cellular immune response initially succeeds in containing the infection, the immunological defences fail after a period of months or years. The bacteria then recommence proliferation. In general, immunological failure is not total. The resulting process is one of chronic tissue destruction, wasting and declining health over months or years. This chronic progressive form of tuberculosis is referred to as “secondary tuberculosis”. The lung (pulmonary tuberculosis) is the organ most commonly affected (approximately 2/3 of such cases). Clinical features include persistent cough, weight loss, fever, and night sweats. Ultimately, secondary tuberculosis progresses to death in most cases in the absence of effective anti-tuberculosis chemotherapy.

In summary, most people (possibly 90%) infected with MTBC microorganisms never develop any clinical illness related to the infection. A small proportion of those infected develop a rapidly progressive disease (miliary tuberculosis) within weeks or months of infection and a further proportion develop chronic progressive disease months or years after an initial infection. Those in whom the chronic progressive form of tuberculous pneumonia develops are the principal source of infection for humans as they may shed large numbers of microorganisms into the environment in infectious aerosols.

2.4 Epidemiology of Human Tuberculosis in Ireland

Human tuberculosis had been steadily declining in Ireland over the last 20 years but in recent years the decline in notifications has stopped (see Figure 1).

Figure 1. Notification of Tuberculosis, Ireland 1991-2004



From a trough in 2001 of 381 cases (representing an incidence rate of 9.7 cases per 100,000 population) there has since been a slight increase with 408 cases reported (or 10.4/100,000) in 2002, 407 (or 10.4/100,000) in 2003 and 432 (or 11/100,000) in 2004 (HPSC, 2006).

M. bovis is not a common cause of tuberculosis in humans in Ireland. Between 2000 and 2004, 55% to 65% of all cases of tuberculosis were confirmed by culture of the infecting microorganism in the laboratory. On average, between 1 and 4% of these cultured isolates of the MTBC are identified as being *M. bovis* (see Table I) (HPSC, 2006).

Table I. Cases of Human Tuberculosis Confirmed on Culture as Due to *M. bovis*, 2000-2004

| Year | Cases | Percentage of culture positive isolates of MTBC |
|------|-------|-------------------------------------------------|
| 2000 | 2 | 0.9 |
| 2001 | 7 | 3.3 |
| 2002 | 5 | 2.9 |
| 2003 | 5 | 2.0 |
| 2004 | 5 | 1.8 |

HPSC (2006)

3. ZONOTIC TUBERCULOSIS

3.1 Natural History of Tuberculosis in Animals

The natural history of zoonotic tuberculosis has been best studied in cattle, although the progression and outcome of infections are probably similar in most species of animal used for food production in this country. As with human infection, access of *Mycobacterium bovis* to the tissues is followed by an initial macrophage response that is not, however, sufficient to prevent proliferation of the microorganism. Dissemination of the mycobacterium to local and regional lymph nodes may be followed in rare cases by bloodborne spread to other organs.

In animals with clinical manifestations of tuberculosis, the respiratory tract and draining lymph nodes are the principal *foci* of disease. Clinical manifestations and pathological lesions may also be observed in other organs (liver, spleen, kidney, mammary gland and bone marrow) and their associated lymph nodes, particularly in advanced disease.

The route of infection in most animals is via the respiratory tract. Less commonly, *M. bovis* may also gain entry via the pharynx or gastrointestinal tract. The principal source of infection is shedding of *M. bovis* by infected animals. *M. bovis* is excreted intermittently throughout all stages of the disease and in particular during its advanced stages, when pulmonary lesions discharge *M. bovis* into the bronchi and the upper respiratory tract in considerable numbers. Exhalation of the bacillus follows. Likewise, after infective sputum is swallowed, *M. bovis* is excreted in the faeces and, with some reduction in numbers, persists in the excreta and in the contaminated slurry and environment for 330 days and longer.

In animals, as in humans, pre-clinical infection may be recognised by use of the tuberculin test. This test is based on detection of the specific immunological response to MTBC infection. The test involves intradermal injection of protein antigens derived from *M. bovis* (purified protein derivative, PPD) and inspection three days later for evidence of a local inflammatory reaction at the site of injection. In cattle, PPD is administered in parallel with administration at an adjacent site of protein derived from another species of mycobacterium that is commonly present in the environment (*viz. Mycobacterium avium*). In cattle, interpretation of the tuberculin test is based on measurement of any alteration in skin fold thickness at the site of administration of *M. bovis* PPD and at the site of administration of the comparator antigen, three days after administration of PPDs. Comparison of any increase in the skin fold thickness at the *M. bovis* PPD site with that at the site of administration of the *M. avium* antigen, relative to the initial measurements, is the basis of interpretation. A positive reaction is indicative of infection with *M. bovis*. Animals with a positive tuberculin test are referred to as “reactors”. All herds are required to have an annual test for tuberculosis carried out on all the animals within the herd – each year approximately ten million animal tests are carried out. This level of testing ensures that there is little opportunity for the development of advanced cases of tuberculosis in cattle, thus minimising this possible source of infection for humans. The tuberculin test has some limitations.

Very recent infection (during the weeks immediately preceding the test) may not have resulted in the development of the specific immune response to a detectable level at the time of testing (false negatives). In practice, each year a number of cattle presented for slaughter that were negative at their most recent previous tuberculin test, show evidence of tuberculosis on *post-mortem* inspection. In 1997, 1,700 non-tuberculin reactor cattle were found to have tuberculosis at *post-mortem* inspection; this number had increased to 2,264 in the year 2005. This represents a very small percentage (less than 0.002%) of cattle slaughtered each year.

Conversely, not all reactor animals have tuberculous lesions detected on routine *post-mortem* examination. A proportion of these animals may represent false positive tuberculin tests; however, it is acknowledged that the routine *post-mortem* examination is not a perfect instrument and that discrete tuberculous lesions may go undetected in up to 60% of reactors. It is also recognised that *M. bovis* may be isolated on culture from lymph nodes that appear normal on gross pathological inspection.

The tuberculin test is valuable in the control of zoonotic tuberculosis because early recognition of pre-clinical infection in animals intended for food production and early removal of infected animals from the herd eliminates a future source of infection for other animals and for humans.

3.2 Epidemiology of Zoonotic Tuberculosis in Ireland

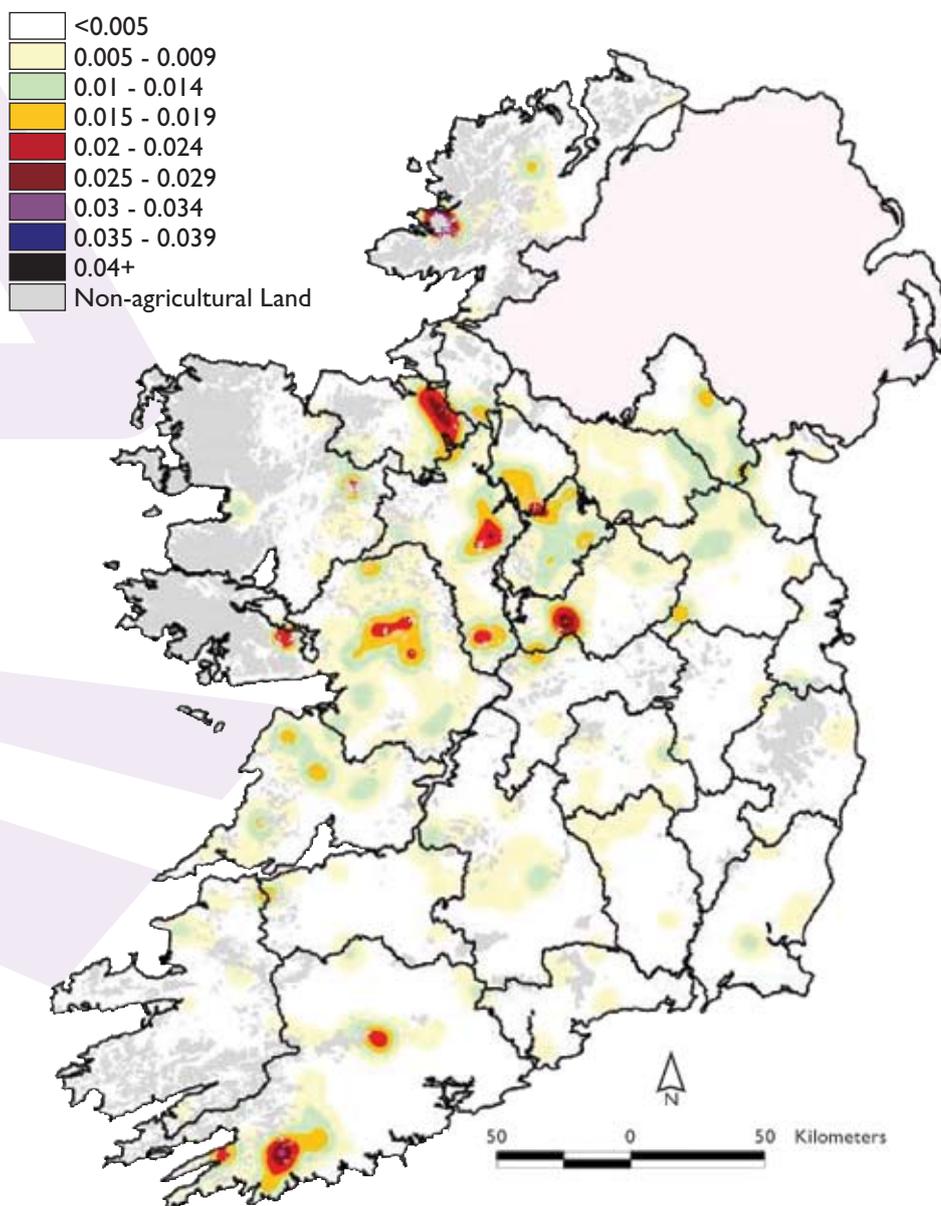
Tuberculosis remains a major animal health problem in Ireland. Most control efforts are focused on cattle and it is for this species that the best epidemiological information is available. Data on the stocking density of standard bovine reactor animals and of animals with visible lesions per km² indicate that the occurrence of tuberculosis in cattle in Ireland is highly localised. In 2005, a particular focus was evident both in the western central and south western counties (Figure 2).

In each year since 1997, approximately 10,000 herds have been restricted due to the diagnosis of tuberculosis in cattle. Tuberculosis in herds may be identified (i) by detection of reactor animals at the annual tuberculin test, conducted on every herd in the State, (ii) at tests on herds currently considered to be at particular risk, or (iii) as a result of meat plant surveillance. In 2006, some 24,200 cattle were removed as tuberculin reactors.

Although there is much less complete information available for other animal species, infection with *M. bovis* does occur in other domestic and wild animals including goats, sheep, badgers and deer.

Consideration of the routes of transmission of zoonotic tuberculosis to cattle, of policies relating to the control of bovine tuberculosis and of reasons for the difficulties in controlling tuberculosis in cattle in Ireland, is outside the scope of this document.

**Figure 2. Density of Tuberculosis Incidence in Cattle per Square Kilometre During 2005
(Kernel Density with Search Radius at 10 km)**



Source: CVERA, UCD

4. LEGISLATION AND CONTROLS GOVERNING USE OF PRODUCTS DERIVED FROM TUBERCULIN REACTOR ANIMALS AS FOOD

4.1 Zoonotic Tuberculosis: Milk and Dairy Products

There is general agreement that the most critical and most effective control measure to prevent transmission of zoonotic tuberculosis through milk is pasteurisation or other effective heat treatment of milk prior to human consumption or further processing. Currently, a small number of Irish herds supply milk to cheesemakers who produce cheese from unpasteurised milk.

Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin¹ prohibits milk of reactor animals from entering the food chain from the time tuberculosis has been diagnosed. However, milk from non-reactor animals in the same herd can be used for consumption or the manufacture of dairy products on condition that this milk is first heat treated. Therefore, this legislation prohibits the use of milk in the unpasteurised state from an officially positive bovine tuberculosis herd for the manufacture of milk or dairy products such as cheese. As an additional risk communication device, Regulation (EC) No 853/2004 also requires that unpasteurised dairy products, like cheeses, are labelled 'made with raw milk' so that the consumer can see that the milk used to make the product has not been heat treated.

Programmes for the early detection and elimination of *M. bovis*-infected cattle represent a safeguard against milkborne transmission of *M. bovis*, by ensuring that infected animals are removed from milk-producing herds once they are diagnosed. Goat herds kept for milk production, which are kept on holdings which also contain cattle, are legally required to be inspected and tested for bovine tuberculosis. In addition, consequential testing of goats is normally performed if the goats are in contact with a cattle herd known to be infected with *M. bovis*. In other cases where goats, sheep or other species are kept for milk production on holdings on which cattle are not kept, Regulation 853/2004 requires that raw milk must come from a herd or flock that is regularly checked for tuberculosis under a control plan that the competent authority has approved.

¹ Enacted in Irish law by S.I. No. 910 of 2005 as amended.

4.2 Zoonotic Tuberculosis: Meat

All animals entering the food chain are subjected to *ante-mortem* and *post-mortem* inspection. In the case of cattle, a tuberculin test must have been performed in the course of the 12 months prior to presentation for slaughter. In the absence of such a recent tuberculin test, the cattle are rejected for slaughter and returned to the farm of origin. As reactor cattle are considered likely to be infected, they are slaughtered separately at the end of each day to facilitate a more detailed inspection of the carcass for evidence of tuberculosis.

If an animal is clinically healthy at *ante-mortem* inspection and has no visible tuberculous lesions on *post-mortem* examination, the carcass is passed as fit for human consumption irrespective of whether or not it is a tuberculin reactor. There are no barriers to trade in this meat within Ireland or within the European Union. In the event that tuberculous lesions are detected in a lymph node draining one organ or part of the carcass only (for example, a fore quarter), that part of the carcass is declared unfit for human consumption. In the event that tuberculous lesions are detected on *post-mortem* examination in two or more organs or regions, the entire carcass is considered unfit for human consumption and is sent for destruction.

5. POTENTIAL FOR HUMAN ACQUISITION OF TUBERCULOUS INFECTION FROM ANIMALS THROUGH THE FOOD CHAIN

5.1 Potential for the Transmission of Zoonotic Tuberculosis via Milk and Dairy Products

As outlined earlier, infection of the mammary gland may occur and may occasionally result in tuberculous mastitis leading to contamination of milk within the mammary gland. Shedding of *M. bovis* in oral/respiratory secretions and in faeces may occur earlier in the course of infection and before a clinical diagnosis of tuberculosis is suspected. Expressed milk may become contaminated with *M. bovis* from faeces or secretions. In the past, the principal route of human infection with *M. bovis* in the general population was via ingestion of raw cow's milk contaminated with *M. bovis*, rather than by inhalation. Human infection with *M. bovis* by the alimentary route is now very uncommon in Ireland.

Properly controlled heat treatment of milk, e.g. pasteurisation, inactivates *M. bovis* and this treatment has had a major impact on reducing the importance of milk as a vehicle of transmission of *M. bovis*. Programmes for screening of cattle (and goats in contact with cattle) for *M. bovis* infection by tuberculin testing, as well as regular checks on registered sheep flocks and other goat herds kept for milk production for tuberculosis under a control plan approved by the competent authority, provide additional safeguards as they facilitate early detection and removal of infected animals. As mentioned earlier, under existing policies, reactor animals are removed and slaughtered, thereby reducing any likelihood of contamination of milk at source.

There are two principal concerns with respect to the potential transfer of *M. bovis* via milk. These are the consumption of contaminated, unpasteurised milk and consumption of dairy products made from contaminated, unpasteurised milk.

1. Consumption of unpasteurised milk on the farm represents a hazard in relation to *M. bovis*². Pasteurisation of milk is a well-established and readily controlled intervention to prevent transmission of this and other infections by milk and dairy products. Where people wish to consume milk produced on their own farm, the use of small-scale domestic pasteurisation units can reduce the risk of milkborne infection with *M. bovis*. It is important that such pasteurisation units be properly operated and maintained.
2. Consumption of dairy products made from unpasteurised milk represents a hazard in relation to *M. bovis* to a potentially wider population. The most common dairy product made from unpasteurised milk is cheese. However, the effect of the cheese production process on the viability of *M. bovis* is not well defined. Validated laboratory methods for the detection of viable *M. bovis* in milk or dairy products are not routinely available. Therefore, there is no practical way to assure that cheese made from unpasteurised milk can be considered "free of *M. bovis*".

² Consumption of unpasteurised milk on the farm represents a hazard not only in relation to *M. bovis*, but also in relation to other pathogenic bacteria, e.g., *Campylobacter* spp. and verotoxigenic *E. coli*.

In the event that *M. bovis* infection is detected in a herd, it is not possible to determine precisely at what point in time infection was introduced into the herd. The infection may have occurred at any time since the previous tuberculin test. Indeed, the infection may have occurred during the weeks immediately prior to the most recent negative tuberculin test. As outlined previously, a period of weeks may have elapsed between the time of infection and the time to development of positive reactor status.

When a tuberculin test, conducted on a herd that had, until recently, been classified as an “officially tuberculosis free herd”³ discloses a new positive tuberculin test result on an animal or animals, the herd is then “restricted”⁴. It is clear that such a restricted herd is not a suitable source of milk for the production of cheese from unpasteurised milk.

In cases in which a herd previously used as a source of milk for the production of cheese without prior pasteurisation of the milk is newly “restricted”, there may be an amount of cheese in storage that was made from milk collected at a time when the herd was “officially tuberculosis free”. Similar situations arise when tuberculosis is diagnosed in a goat herd or sheep flock whose milk is used in the raw state for the production of cheese. Decisions as to the management of such cheese have been controversial.

Arguments in favour of “withdrawal from trade” of such cheese include the following:

1. it is not possible to estimate precisely at what point in time milk from the herd or flock in question became at risk of contamination with *M. bovis*
2. in the absence of pasteurisation, there are not sufficient data available to be confident that the cheesemaking process affords sufficient protection to the consumer
3. there is no readily available laboratory methodology to certify the product as “free of viable *M. bovis*”.

³ Officially Tuberculosis free bovine herd is defined in Article 2 (d) of Council Directive 64/432/EEC on animal health problems affecting intra-Community trade in bovine animals and swine, as amended. This definition requires herds to comply with Annex A I Paragraphs 1 and 2 of that Directive, as regards testing and freedom from TB of all animals in that herd.

⁴ Restricted holding is defined in Article 2 of the Bovine Tuberculosis (Attestation of the State and General Provisions) Order, 1989 (S.I. No. 308 of 1989) as amended. This definition refers to Article 12 of that Order regarding holdings in which bovine tuberculosis is present, with consequent restrictions on movement of bovine animals or their products from that holding.

On the other hand, it is acknowledged that:

1. if any *M. bovis* are present in cheese made from unpasteurised milk, the concentration is likely to be low provided the herd has been subjected to frequent tuberculin testing and that no animals in the herd show any clinical or *post-mortem* evidence of tuberculosis
2. available evidence supports the view that zoonotic tuberculosis is now uncommon in Ireland.

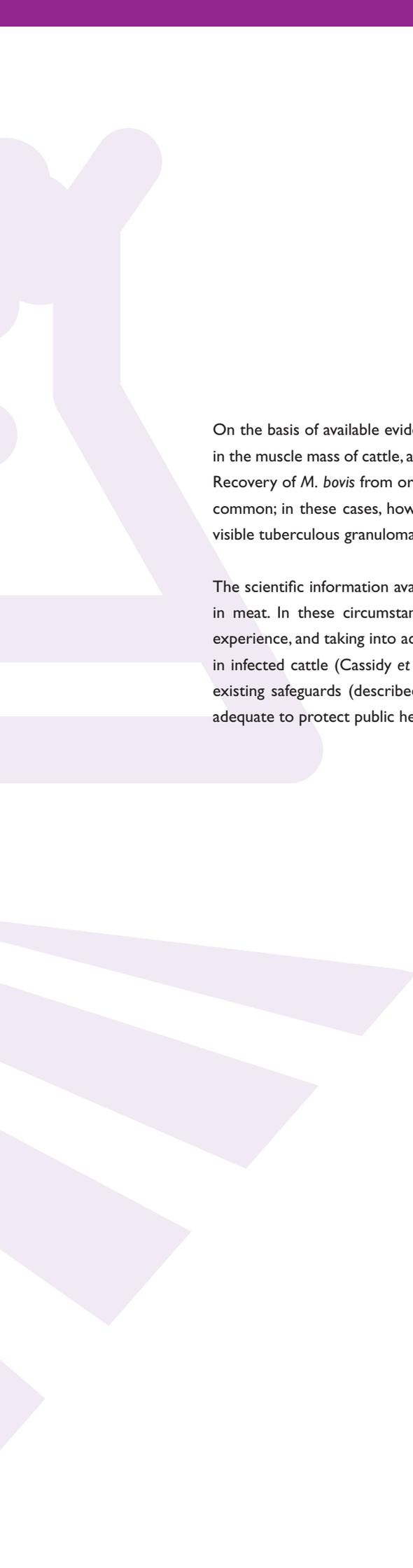
5.2 Potential for the Transmission of Zoonotic Tuberculosis via Meat⁵

The distribution of tuberculous lesions in cattle at slaughter, and in the other food animals such as pigs, sheep goats and deer, is in general, confined to the lymphatic nodes associated with the head, thorax and, less commonly, abdomen. One or several organs, such as the lungs, liver, spleen, kidneys and mammary gland along with the associated lymph nodes and related serous surfaces (pleura and peritoneum) are other less common sites of infection (Corner, 1994, 2006). Involvement of the muscle mass is rare and is mostly encountered only in the advanced stages of the disease at a time when other tissues show overt signs of tuberculosis (Drieux, 1957).

Specific tissues (namely, lymph node, liver, spleen, kidney and mammary gland) which do not display visible lesions of tuberculosis at *post-mortem* inspection may nevertheless carry *M. bovis*. Drieux (1957) reviewed studies of the isolation of *M. bovis* from skeletal muscle in cattle with advanced tuberculosis. Most, but not all of the investigators cited by Drieux failed to isolate *M. bovis* from muscle or were able to isolate it by guinea pig inoculation only, or infrequently by culture. This suggests that *M. bovis* was present only in low numbers. However, in two of the reports cited by Drieux, *M. bovis* was recovered from muscle in a high proportion of cases studied.

The Advisory Committee on the Microbiological Safety of Food, in its report on *Mycobacterium bovis* to the Food Safety Agency (UK), following a qualitative risk assessment, considered that “the risk, if any, from the consumption of meat sold as fresh meat for human consumption following assessment and action by the MHS staff in UK abattoirs is very low” (Food Standards Agency, 2003).

⁵ The legal definition of meat in Point 1.1, Annex 1, Regulation (EC) 853/2004, refers to all edible parts of the animal including blood. The more common meaning of the word meat is with reference to parts of the animal harvested for human consumption, primarily comprised of skeletal muscle, but often containing smaller quantities of other tissue types, such as connective, neural, lymphatic, or vascular tissue. This latter context is used for the purposes of this report.



On the basis of available evidence, it is reasonable to conclude that the occurrence of viable *M. bovis* in the muscle mass of cattle, and of other food-producing animals infected with *M. bovis*, is uncommon. Recovery of *M. bovis* from organs such as the lungs, liver, spleen, kidneys and mammary gland is more common; in these cases, however, other evidence of infection is likely to be present in the form of visible tuberculous granulomata in the lymph nodes draining these organs.

The scientific information available does not permit a quantitative risk assessment regarding *M. bovis* in meat. In these circumstances, the Microbiology Sub-committee considers, that given historical experience, and taking into account the nature and distribution of tuberculous lesions and of *M. bovis* in infected cattle (Cassidy *et al.*, 1998), deer (Griffin and Buchan, 1994), and other food animals, the existing safeguards (described earlier in this report and which are subject to periodic review) are adequate to protect public health. However, this matter continues to be the subject of review.

6. CONCLUSIONS

1. Current information shows that human zoonotic tuberculosis is uncommon in Ireland.
2. Transmission of zoonotic tuberculosis through milk derived from infected herds has, in the past, been a major public health problem that was largely solved by the introduction of milk pasteurisation and the programme for the eradication of tuberculosis in cattle. Therefore, there are grounds for concern regarding the continuing consumption of unpasteurised milk and dairy products derived from unpasteurised milk.
3. Transmission of *M. bovis* to humans through the consumption of meat has not been documented as a public health concern during surveillance for tuberculosis in many countries over a number of decades. The risk, if any, from the consumption of meat sold as meat for human consumption following official controls conducted by the competent authority in abattoirs in Ireland is very low.

7. RECOMMENDATIONS

7.1 Action to Control Zoonotic Tuberculosis

1. Efforts should continue to control or eliminate tuberculosis in cattle and other animals used for food production as this may be expected to reduce or eliminate the ultimate source of *M. bovis* infection.

7.2 Prevention of Transmission of Zoonotic Tuberculosis to Humans

1. The critical role of effective, well-controlled pasteurisation in ensuring the safety of milk and dairy products must be continually emphasised and the effectiveness of the pasteurisation process in individual plants should be closely monitored.
2. Milk intended to be consumed, or to be further processed, without prior heat treatment, i.e. pasteurisation or equivalent heat treatment, should come from registered herds or flocks that are subject to an official tuberculosis control plan. In the case of cattle, the control plan should include herd inspection and herd testing for tuberculosis every six months to minimise the risk of delay in detecting infected animals. Likewise, goat herds and sheep flocks kept for milk production should be subject to an official tuberculosis control plan that addresses public health concerns in terms of food safety.
3. Cheese manufacturers producing cheese from unpasteurised milk should be required to source milk only from registered herds or flocks that are subject to an official tuberculosis control plan.
4. Upon detection of tuberculosis in a herd or flock, all cheese made from unpasteurised milk originating from that herd or flock since the most recent herd or flock inspection or negative herd tuberculin test should be regarded as unsuitable for human consumption.
5. The practice of informing farmers and farm families of the particular risks associated with the consumption of milk from tuberculosis-positive herds should continue.
6. When private domestic consumption of milk, produced on the farm is practised by farm families, the use of effective and well-maintained, small-scale pasteurisation units is recommended.
7. Dairy farmers, cheesemakers, their families and visitors to their premises should be advised about the risks associated with the consumption of unpasteurised milk from any animal species.
8. At risk population groups should be alerted to the risks associated with drinking unpasteurised milk and consuming dairy products made from unpasteurised milk.

9. The sale of unpasteurised milk intended for human consumption, originating from all farm animals, should be prohibited.
10. The current policy with respect to the controls on the use of beef from tuberculin reactor cattle should continue.
11. Auditing of the *ante-* and *post-mortem* inspection of carcasses at abattoirs so as to verify compliance with EU legislation regarding the control and removal, from the food chain, of carcasses or parts thereof, considered unfit for human consumption because of the presence of tuberculosis, or for other reasons, is recommended.

7.3 Research and Information Gathering

1. Nationally, 55-65% of human cases of tuberculosis are confirmed by culture. *M. tuberculosis* complex bacilli isolated from humans are identified to species level to differentiate *M. bovis* from *M. tuberculosis*. This degree of identification is very valuable. It would be of additional benefit if all isolates of *M. bovis* cultured from humans were subjected to detailed molecular typing to determine what, if any, relationships exist between strains of *M. bovis* currently circulating in cattle and other animal species (goats, badgers and deer) and those strains infecting humans.
2. Detailed investigation of all laboratory confirmed cases of human infection with *M. bovis*, for evidence of a history of consumption of unpasteurised milk or dairy products made from unpasteurised milk, and residence on farms at any point in their lives, is important and should continue to be performed. Continued, timely availability of this information at a national level (as provided by recent Health Protection Surveillance Centre reports) is recommended so as to ensure a better understanding of the epidemiology of human infection with *M. bovis* in Ireland.
3. Development of validated laboratory methods for routine examination of various food matrices, e.g. milk, dairy products and meat, for *M. bovis* is recommended.

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