Microbial update
red meat products

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In order to fully consider the microbiology of meats, we must first define what we mean by the word 'meat'.

'Meat' is widely used and probably has as many definitions as users. Most dictionaries define meat as 'the flesh of an animal when it is used as food', which is an excellent simple definition, but will include the flesh of mammals, birds, fish, shellfish and even insects.

This is definitely too large an area and needs to be reduced. In food terms we usually divide animal flesh foods into subcategories such as 'red' meat, 'white' (or poultry) meat, fish and shellfish. For this article, the focus will be on red meats and their products

Red meats are derived from a number of animal species including cattle, sheep, pigs, goats, deer, horses and camels. Red meat is mainly considered as the voluntary skeletal muscle tissue from the animal concerned (connective tissue and fat may be associated with these muscles), but may include some edible organs (offal) and involuntary muscle (heart). The exact description of what may be considered as meat will usually be defined in a country's legislation, and such documentation should be consulted if in doubt.

Foods derived from meats are very diverse and include cuts of raw muscle, edible organs, raw reformed/comminuted products (burgers/grills/sausages etc), raw fermented products (salami), raw cured products (bacon/ham), and raw/cooked dried materials (jerky/biltong).

Added to this are processed products such as retorted shelf stable products (canned meats) and perishable ready to eat meats (cooked, sliced, chilled meat). This huge diversity both of animal type, meat type and process type creates a large matrix of products in which the microbiology is challenging and variable.

The animal

All meat products will start as being a part of an animal. This has to be slaughtered and butchered in order to obtain the primal materials for any meat product.

The microbiological quality of meats will start to be affected at this point. Generally the skeletal muscle tissue of any animal will be of good microbiological quality; much will be close to being sterile.

However, the outer hide/skin and gastrointestinal tract (gut) will be highly contaminated with a range of micro-organisms that may include human pathogens.

The challenge at the abattoir is to kill and butcher the animal, whilst preventing the muscle tissue from becoming contaminated by organisms mainly coming from the skin and gut.

Slaughter

Animal hides/skin will be contaminated with mud/soil/faeces from the areas in which they have been reared, it is important to attempt to minimise the level of this highly contaminated material entering the abattoir/slaughter house.

Ensuring that animals are clean and kept in clean conditions prior to entering the abattoir is a positive step. Once slaughtered the animal can tend to fall to the floor. If this is contaminated with soil/faecal material it will add to the general contamination on the skin. Keeping slaughtering areas as clean as possible will reduce that risk of widespread contamination.

Equipment used during slaughter may add to contamination; some work has even indicated that a contaminated captive bolt will add to contamination of some deep organs within cattle, whilst dirty knives will certainly transfer contamination around the carcase.

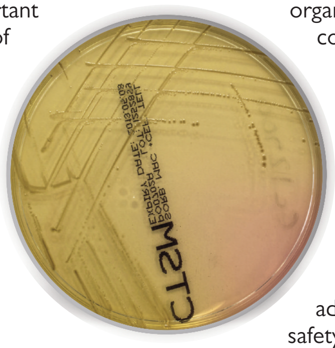
As noted previously, the hide and gut will be contaminated with organisms at very high levels, and it is of the greatest importance that these areas are carefully handled to reduce the risk of contaminating muscle tissues. Removing the skin will eliminate a large source of micro-organisms, but if done incorrectly can cause a major cross contamination of the carcase. Likewise careful removal of the gut eliminates a major contamination source, but any gut leakage or piercing can massively contaminate the carcase.

Different carcase types may be subsequently washed or trimmed and this can help remove surface micro-organisms if done well; however, at this stage the cleanliness of equipment, tools and operators becomes important, as does the temperature of storage.

Storage of primal cuts

Once the carcase has been split into primal cuts, it is stored before further cutting. At this stage microbiological contamination will be primarily on the surface and depends on the previous history of the meat and the hygienic conditions under which it has been prepared. In systems where carcases have been well prepared under good hygienic conditions, total bacterial populations can be less than 10^4cfu/cm^2.

The population will be made up of a large range of different types of micro-organism, some may be considered spoilage organisms, others potential human pathogens. The way the meat is stored will greatly influence the potential growth of this population and the resultant shelf life of the meat, and additionally has food safety implications.



Sorbitol MacConkey with Cefixime Tellurite – a selective and differential medium for the detection of E. coli O157.

Storage in air

Some cuts will be overwrapped and packed in air. In such conditions the formation of metmyoglobin (giving a brown colouration) and aerobic bacterial spoilage could limit shelf life to a number of days.

Bacterial populations are dominated by aerobic psychrotrophic bacteria such as Pseudomonas spp, Acinetobacter, Enterobacter and sometimes Brochothrix thermosphacta.

Storage in vacuum pack

In these conditions aerobic organisms are inhibited and anaerobes, facultative organisms and microaerophiles dominate. Lactobacillus, Carnobacterium and

Leuconostoc can develop well and populations of 10^7-10^8/cm^2 can be attained. The extent of growth of many organisms is determined by pH and temperature; at pH's below 6 Brochothrix can be favoured, whilst above 6 Shewanella may begin to grow. Enterobacteriaceae will develop better at temperatures of 5°C and above, but more poorly as the temperature approaches 0°C.

In vacuum packs, a special mention must be made of some Clostridium spp.

C. estertheticum has been known to cause gas formation, pack distention and off odours in deeply chilled vacuum packs, whilst the potential risks of growth of and toxin formation by psychrotrophic C. botulinum must be considered a risk, and appropriate control should be in place.

Modified atmosphere

In some cases red meats are stored in modified atmosphere packs containing elevated levels of oxygen (70-80%) and carbon dioxide (20-25%) in order to maintain a bright red meat colouration.

Spoilage can be caused by lactic acid bacteria and Brochothrix. If packing is done in very high levels of carbon dioxide then lactic acid bacteria will dominate most other organisms. Populations of Corynebacteria and members of the Enterobacteriaceae can also develop in these conditions.

Food safety implications

Generally, the safety of raw meats will be determined by their treatment before consumption. If a raw meat is to be consumed in a raw state, then the absence of all pathogens on that meat has to be the aim.

If the meat is to be processed before eating, then the absence of pathogens would still be an ideal situation, but if an occasion occurred when a pathogen were present, the process used should be designed to eliminate it.

For vegetative pathogens (salmonella, listeria, E. coli O157) a familiar process would be the application of a cooking process of 70°C for two minutes (or equivalent) immediately before eating. Usually this temperature should be attained at the slowest heating point within the product.

In whole muscle cuts, microbiological contamination will usually be on the surface of the meat, and a surface cook (for example production of a rare steak) will eliminate most contamination, however it is possible that organisms could enter deep muscle tissue (knife cuts, tenderisation, general damage, or tissue structures) and the risks of cooking of any meats 'rare' should be considered on a case-by-case basis and be based on a risk assessment and a knowledge of the hazards associated with particular meats.

As an example, if it is believed that meat products could be internally contaminated with microbiological hazards, for example cysts of parasites, viruses (Hepatitis E has been associated with pork in some recent reports), then such meat should be treated in a way that would ensure any contaminants did not pose a risk to human health.

After cooking, if a meat is not to be consumed immediately it should be maintained hot (>63°C), or cooled as rapidly as possible to below 8°C.

The failure to cool meats properly can result in germination and growth of Clostridium perfringens spores. If this organism grows to high enough levels it can cause food poisoning.

Processed meats

Raw meat products can be processed in a wide variety of ways to produce a range of other products. Ground or comminuted products such as burgers or sausages are raw and intended to be cooked before eating.

These products are very different in their distribution of micro-organisms to whole muscle cuts. In comminuted products, the microflora will be distributed throughout the product, and not predominantly on surfaces, therefore cooking must ensure that the whole of the inside reaches a temperature that will eliminate potential pathogens (for example 70°C for two minutes at the slowest heating point).

In some areas, ground meats will be eaten raw. There is always a food safety risk involved in this practice as it can be very difficult to completely assure freedom of such products from human pathogens.

Some raw meats are 'cured' using various salts to produce a very different style of end product. Salting has long been used to extend the shelf life of raw meat by preventing the growth of spoilage organisms. Some salting processes use nitrite, which is reported to affect the growth of Clostridium botulinum and produce a 'safer' product.

One of the concerns of recent 'low sodium' health promotions, is that the reduction of salt in these products, also reduces their ability to resist microbial attack. This could shorten their shelf life or increase the risk of pathogen growth. Any producer considering reducing salt levels in such products should assess the microbiological risks of doing this and potentially consider either reducing shelf life or adding other allowable preservation systems to maintain quality and safety throughout life.

It is possible to treat raw meats in a way to reduce the risk of pathogen presence, and thus produce a product with a low risk to consumers. A good example are traditional salamis, where good quality meats will be mixed with spices and a lactic starter culture. The culture will grow, outcompeting other organisms and reducing the pH of the product.

The final product should be of low water activity, preventing most organisms from growing, whilst the action of the starter culture will help to eliminate low levels of any potential pathogens that could be present within the raw meat.

The final product is usually stable at room temperature for a long period. In such products, care must be taken to ensure that the fermentation is done well and the starter culture grows quickly, reducing pH. Some food poisoning outbreaks in these products, have been linked to poor fermentation conditions.

Other low water activity meat products include jerky and biltong. Jerky can be made from a variety of animal species, but is usually heat processed during the drying process. This process should be developed to assure destruction of human pathogens and the water activity should be low enough to prevent microbial growth at room temperature.

Biltong is a similar type of product, however the meat is dried in its raw state. Whilst the low water activity of the final product will prevent growth and produce a microbiologically stable product at room temperature, any pathogens present on the raw meat may not be eliminated.

These products have to be produced from high quality meat handled hygienically; producers must ensure that raw materials used in producing biltong style products are completely free of human pathogens.

Recently in some kitchens, there has been a move to the use of 'sous vide' cooking to produce high quality cooked meat products. Sous vide cooking utilises a lower cooking temperature applied over a long time period to achieve safety whist keeping meats tender and moist.

The issue with reducing cooking temperature is that this cannot be done indefinitely, at some point the temperature

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becomes one that will not kill bacteria, but will allow them to grow. As an example, the literature would indicate that Cl. perfringens can grow at temperatures of around 52°C. The concerns over low temperature cooking has led to The UK Advisory Committee on the Microbiological Safety of Food recommending that 60°C is the lowest temperature that can be used for low temperature cooking (this should be used for a time that gives an equivalent process to 70°C for two minutes), unless a full microbiological validation of the cooking process is done.

Cooked meats

Mention of cooking meats has already been made. Cooking processes should be designed and validated to ensure destruction of human pathogens that may be present in raw meats.

Usually a temperature of 70°C for two minutes (or equivalent) at the slowest heating point will be considered an absolute minimum process. After cooking the meat should be either be consumed immediately, kept at a temperature of >63°C before consumption; or cooled quickly to <8°C and stored at chilled temperatures (an absolute maximum of 8°C, but lower will extend product life to a greater extent).

Many products of this type are packed and sold to consumers as chilled ready-to-eat products (for example sliced meats).

In such products one of the major concerns not mentioned before is the risk associated with Listeria monocytogenes. This is a psychrotrophic organism, able to grow at chilled temperatures and it is a human pathogen.

Factories producing ready to eat meats should be designed and monitored to ensure that L. monocytogenes is not able to become a resident organism.

Products should be routinely tested for the organism as is required by current European legislation, and producers must do appropriate studies to ensure that their shelf life does not allow the organism to grow to levels of 100/g or more within its shelf life.

Often ready-to-eat cooked meats are placed in low oxygen containing modified atmosphere packs (MAP) to extend their shelf life.

This introduces a potential microbiological risk from psychrotrophic C. botulinum, an organism that can develop under these conditions. Unless particular controls measures are in place (for example product is at a pH of <5, or a water activity of <0.97, or has a salt content of >3.5%), then such products should be given a shelf life no greater than 10 days at a storage temperature of 8°C or less. Canning of meats is a specialist area that cannot be covered in any detail here. Those wishing to undertake this process require specialist knowledge or should contact appropriate organisations that can help them develop safe processes.

Conclusions

Red meats form an important part of the human diet being a rich source of protein. They have been consumed around the world, in a large number of different forms and generally have a very good food safety record.

Microbiologically, raw red meats can potentially be contaminated with human pathogens, and the way we handle animals before slaughter, the slaughter process, meat cutting and raw meat storage can greatly influence the microbiological quality of the final raw meat product.

Further processing of raw meats produces a huge range of products, all have microbiological risks, but all also have a history of safe production.

The key is for producers to ensure that they understand what risks exist for their products, and what control measures they need to implement to reduce those risks. When this is done, the results will be high quality and safe products. ■

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