Microbial update

dairy

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Milk has been recognised as an important part of the human diet throughout history, being a valuable source of calcium, protein, carbohydrate, fat, and micronutrients such as vitamins and minerals. It can be treated in many ways to form a diverse range of dairy products and these are consumed in large quantities by people from all over the world. Increasingly milk from different animal species is being used to create new and novel food products and the raw materials for this, or indeed the products themselves, may be transported globally. Milk can be made into a wide range of different product types:

- Drinking milk. This can be 'as it comes' from the animal as a 'raw' untreated product, or variously pasteurised, sterilised UHT processed. It may also be available as skimmed or semi skimmed and flavoured products.
- Cream is the fat rich portion of milk. This is often further classified according to local legislation (single cream, double cream, pouring cream, whipping cream etc).
- Concentrated milks are products in which a part of the moisture has been removed. Good examples are evaporated milk and condensed milk.
- Dried milk products will contain low levels of moisture and will be microbiologically stable at ambient temperatures. Again there are many different forms often based on different fat contents.
- Fermented milk products are a major grouping and include yoghurts. These products are formed by the rapid fermentation of milk with lactic starter cultures. Fermentation usually occurs at an elevated temperature in order to allow rapid culture growth, whilst limiting the growth of organisms that naturally occur in the milk. As the fermentation proceeds the pH drops producing a more stable product than the original milk. There is an increasing market for milks fermented using probiotic cultures that are reported as delivering some beneficial properties.
- Emulsified products such as butters and dairy spreads are water in oil emulsions that can be produced in a variety of ways. Butters may or may not contain salt. Spreads may contain preservatives.
- Cheeses are produced by coagulation of milk protein. This is often achieved through casein digestion, but acidification can also be used. There are a wide range of cheeses produced in countries around the world. These can be produced from milks from different animals and contain a range of additional ingredients from nuts and fruits, to various moulds.
- Ice creams are products derived from milk, that may contain a range of stabilisers, sugar, nuts, fruits, confectionery. They are frozen products.

Sources of micro-organisms

In healthy animals, milk may emerge from the udder in a near sterile form, however udder infections can be common (some reports suggest that in the UK 33% of dairy cattle suffer from mastitis), and this can result in various types of staphylococci, streptococci and even Escherichia coli contaminating the inside of the udder and therefore occasionally being present in milk as it exits the udder.

Milk can be contaminated once it has exited the udder. The udder surface will be contaminated with a wide range of materials including soil, bedding and manure, all rich sources of micro-organisms that may include spore formers (both bacillus and clostridia), micrococci, and potentially a range of both enteric (salmonella) and non-enteric (listeria) pathogens. These organisms can contaminate the milk if milking hygiene is not of the correct type. In order to control this source of cross contamination the washing of udder surfaces and the use of cleaned and sanitised milking equipment is highly important.

Once milk is outside of the animal, a variety of environmental contamination issues may contribute to contamination of milk, and care must be taken to ensure that conditions and equipment used are clean.

Milk is nutritionally a rich environment for microbial growth. Many micro-organisms

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are able to grow in this product. Initially the main control used to minimise growth is temperature reduction. This will prevent the growth of mesophilic organisms and reduce the growth rate of psychrophilic organisms.

Milk is often transported from farms to processors in a refrigerated form. Once at the processor, it will receive a heat process to reduce microbiological contamination. It is of considerable importance to effectively control microbial growth in raw milk before any heat process is applied.

Heat processes are designed to cope with certain levels of micro-organism, very high levels may not be effectively reduced by a given process, and of course even if levels are reduced, spoilage may have already occurred and the quality of the heat processed milk may be unacceptable to the consumer.

One particular form of spoilage is caused by the growth of certain psychrotrophic organisms in raw milk. These can result in the production of heat stable enzymes.

When such milk is pasteurised the organisms are destroyed, but the enzymes remain and will cause subsequent spoilage of the product, even though microbial levels are low.

The consumption of raw milk needs to be briefly considered. Regulations concerning the sale of raw milk differ from country to country, but in some areas it is possible to purchase raw milk for human consumption.

There have been a number of outbreaks of food poisoning from organisms such as salmonella and E. coli O157 linked to the consumption of raw or incorrectly pasteurised milk. This must lead to the conclusion that the risks of contracting food poisoning from the consumption of raw milk are considerably higher than those from consuming correctly pasteurised milk. These views are also expressed by the UK Advisory Committee on the Microbiological Safety of Foods (ACMSF).

Heat processing of milk

Most milk is heat treated before it is used. Correct processing should eliminate any food poisoning organisms present in the milk, and considerably reduce the numbers of potential spoilage organisms (spore formers will not be eliminated).

The most widespread method of heat treatment in the dairy industry is pasteurisation. Pasteurisation can be achieved by the use of a number of time/temperature processes, and these are often fully detailed in national or international regulations (those wishing to undertake pasteurisation, should consult local legislation to obtain correct values for the process).

The types of process that can be used include 30 minutes or more at temperatures of 61-66˚C; or 15 seconds or more at temperatures of 71˚C or higher. Moving away from pasteurisation, considerable quantities

of milk are processed using ultra high temperatures (UHT). This involves the use of temperatures well above those used in standard pasteurisation (140˚C) for 2-5 seconds. This type of process is aimed at producing commercially sterile milk, which has the advantage of considerably extending the shelf life and in many cases produces a product that does not rely on chilled storage for stability and is therefore stable at ambient temperature.

Post process contamination

Processed milk can still support the abundant growth of micro-organisms and must be protected from any post process recontamination. Spoilage of refrigerated processed milk results in development of off-flavours often described as unclean, fruity or putrid, whilst physical changes can be a ropiness or partial coagulation. The micro-organisms involved may be spore formers that have survived the process, or post process contaminants. Organisms involved include: pseudomonas, flavobacterium, chromobacterium, alcaligenes, bacillus and members of the enterobacteriaceae.

Correctly pasteurised milk that is protected from post process recontamination should possess little risk with respect to food poisoning. However, it should be pointed out that some major outbreaks of food poisoning have been linked to pasteurised milk.

The largest recorded outbreak of salmonellosis in the USA occurred in 1985 and was linked to pasteurised low fat milk contaminated with Salmonella typhimurium. This caused over 16,000 cases of food poisoning, and was thought to have occurred because of cross contamination between processed and raw milk at the processing plant. A similar incident occurred in 1994 in the UK with E. coli O157. Here over 100 people contracted food poisoning, with post process contamination of raw milk being the potential cause.

Dairy products

The microbiology of dairy products produced from milk will be dependent on the microflora in the milk, and factors affecting the processes that are applied to the milk to turn it into the 'dairy product'.

● Cream

Cream is the fat rich fraction of milk that is usually removed by centrifugation of warm milk. Classification of cream into half, double, clotted etc is based on fat content and is usually defined by legislation. In order to maintain shelf life and quality, creams are usually pasteurised or UHT treated. Microbiological issues with cream are similar to those of milk, these being survival and subsequent growth of heat resistant spore formers (Bacillus spp. can cause bitty creams), and growth of post process contaminants (Pseudomonas spp. can cause off odours and flavours). The only microbiological control that is applied to cream is refrigeration.

● Butter

Butter is a water in oil emulsion. Production methods will vary, but the key raw material is cream, which is worked or churned to produce the required emulsion. Butter has a low water activity and is often considered a microbiologically robust material. However, it must always be remembered that whilst the overall water activity of butter is low, it is an emulsion and the water activity in the water droplets will be high. Salted butters have an advantage here, as whilst the overall salt concentration of the butter may be low, the salt is only present in the water phase, thus there may be a high concentration of salt in the water droplets. Microbiologically, organisms cannot grow in oils, therefore they will only be a problem in the water droplets. A variety of organisms can grow in butter causing souring, fat hydrolysis, protein degradation and off flavours. Lactic acid bacteria and members of the coliform group can cause acid production, whilst pseudomonas, alcaligenes, acinetobacter and flavobacterium can cause lipolytic and proteolytic change. Pathogens can sometimes be found in butter. These will usually be contaminants that enter the product after pasteurisation of the milk or cream. There have been a number of outbreaks of listeriosis linked to butter in both the UK and other countries, and this should be kept in mind when considering the microbiological risks associated with this product.

● Cheese

Various authors suggest that there may be over 1,000 different types of cheese produced throughout the world. This in itself makes it difficult to summarise anything about cheese microbiology. Cheeses are made with milk from a variety of animal species, from raw and pasteurised milk, and

may be produced by fermentation with a starter culture or coagulation via heat or pH change. Subsequent processing of the cheese may require addition of salt, dehydration or mould ripening. All of these variables will affect the microbiology of the final product.

Raw milk cheeses will be made with a raw material that could contain a range of spoilage organisms or indeed pathogens.

There needs to be a careful control of raw milk quality and a knowledge that the method of production and subsequent storage will exert control over these organisms. Such cheeses are often clearly labelled so that higher risk groups within a population (pregnant, very young, old, immunocompromised etc.) can avoid their consumption, if they so wish. The main spoilage issues that occur in hard cheeses relate to mould growth, usually with Penicillium, and this results in the growth of a visible mould colony on the cheese surface.

Generally, cheeses have an excellent safety record. There are of course recorded incidences of food poisoning, but considering the amount of cheese consumed throughout the world, these are not that frequent.

- **Yoghurt**

In yoghurt production, the milk is pasteurised and then deliberately inoculated with chosen strains of lactic acid bacteria, known as 'starter cultures', often originating from milk. The two important starter cultures used in yoghurt production are Lactobacillus delbrueckii subspp. lactis (formerly Streptococcus lactis) and Streptococcus thermophilus. These bacteria together produce acid and the typical yogurt flavour.

Mixtures of mesophilic and thermophilic micro-organisms can also be used as in the production of some cheeses. In recent years 'probiotic' yoghurts have become popular. These use 'probiotic' strains of particular lactic acid bacteria such as Lactobacillus acidophilus and Bifidobacterium, and are marketed as having positive health benefits to the consumer. Yoghurts are acidic products.

This, together with chilled storage, will prevent common bacterial spoilage organisms from growing. The major spoilage issue will arise from yeast growth, which can cause gas formation and 'blowing' of the yoghurt pack.

There are few instances of food poisoning linked to yoghurt, the chill storage with low pH being a fairly robust microbiological control. However, mention should be made of an outbreak of botulism linked to yoghurt in the UK. This outbreak had nothing to do with the yoghurt base itself, but arose because a canned hazelnut puree, used in production of the flavoured yoghurt was not correctly produced. This allowed Clostridium botulinum to grow and produce toxin within the canned nut product. When this was mixed with the yoghurt, it transferred the botulinum toxin causing an outbreak of food poisoning involving 27 cases with one reported death. Thus, when assessing the microbiological risk associated with any product, it is of the greatest importance to consider all of the materials used in production. Major raw materials may be microbiologically robust and be considered to have little risk, but minor constituents may constitute a major hazard.

Dried dairy products

A variety of milk products may be dried, including whole milk, skim milk, whey, buttermilk, cheeses and cream. Drying is usually done by the application of heat. In the case of liquids, spray drying is frequently used.

Dried dairy products may be rehydrated and consumed directly, or used as ingredients in other products (bakery, chocolate, confectionary, baby foods, ice cream, animal feeds). The microbiology of the dried dairy product will be mainly governed by the microbiology of the material before drying.

The drying process itself may destroy some organisms, however, it must be remembered that micro-organisms become more resistant to heat in dry environments. Thus the drying process itself may allow a more heat resistant micro-organism to survive the applied process. The equipment used for drying must also be carefully considered.

An outbreak of salmonellosis associated with dried milk powder used in infant feeds in the UK, was linked to small holes in the inner surface of the spray drier used. The insulating material contained moist milk powder and this was contaminated with salmonella. The implication here, was that during the spray drying process, the powder was becoming contaminated from the spray drier itself. No definite route by which the spray drier was originally contaminated was found.

Once a dehydrated product is formed, its water activity is usually too low to allow any microbial growth, and it is considered a microbiologically stable product. It must, however, always be remembered that any micro-organisms contained with the dried material will also be stable, usually for a very long period, and will be able to grow as soon as the product is rehydrated.

So, to produce dried dairy products, the wet raw material must be of very good microbiological quality, the method of drying must be hygienic, the post process handling and storage should not introduce any contamination, and once rehydrated the product must be considered to be at risk from microbial growth.

Conclusions

Dairy products are made and consumed on a large scale throughout the world. They form a very diverse group being made from milk originating from different animal species. They may be 'preserved' by chilling, heating, drying, fermenting or freezing, and are open to microbiological attack from a range of potential spoilage organisms or pathogens. We may see, on occasion, spoilage incidents and even outbreaks of food poisoning linked to particular dairy products, but on the whole they form a group of very well established, nutritious and safe products.

This is, in large part, due to the detailed understanding of those products by their producers, by careful choice of raw materials, of good processing based on sound scientific principles, and of hygienic post process handling. ■

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