Microbial update

chocolate

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Chocolate originates from the fruits of the cocoa plant Theobroma cacao, which is widely grown in parts of Africa, the Far East and South America. The fruits are known as pods; they contain 30 to 50 beans contained in a pulp and are manually cut from the tree by harvesters. After harvest the pods are broken and undergo a process known as fermentation. In the fermentation process, the pulp is broken down by various enzymes, which leads to the production of flavour compounds. Heat generated during fermentation destroys the germ, preventing germination.

Fermentation techniques vary depending on region, but starts via growth of a variety of natural microflora. This proceeds by growth of yeasts that metabolise sugars, reduce oxygen levels and allows formation of ethanol and various pectinases that break down the pulp.

This allows development of a lactic microflora forming lactic acid. Increases in oxygen levels at this stage favour the development of acetic acid bacteria, converting ethanol to acetic acid and finally carbon dioxide. This is accompanied by an increase in temperature up to around 50°C.

These conditions, together with a gradually increasing pH allow the development of a microflora of thermophilic spore forming bacilli.

The flora of fermented beans is therefore made up of various yeasts, acetic and lactic bacteria and Bacillus species, as well as various natural flora remaining from the natural pod environment.

Fully fermented beans are dried, which reduces water content to <8%, and these can then be shipped to chocolate production plants for the chocolate making process to begin.

Processing fermented beans

Fermented beans arriving at a chocolate manufacturer may be expected to contain a fairly high microbiological loading. This will usually be confined to the outside surfaces of the bean shell, but any cracks or defects in this shell may allow contaminating organisms inside the bean.

As noted previously the organisms contaminating fermented beans are made up of natural flora and organisms remaining from the fermentation process. As the beans are still raw agricultural products there is always a chance that potential human pathogens, such as salmonella, may be present. At the start of processing, the raw fermented beans will go through a clean up process to remove extraneous materials.

They may then, depending on manufacturer, have some form of steam treatment or infrared heating; this allows a better separation of shells but also provides an antimicrobial process.

The beans then move onto the roasting process. Roasting can be done in a variety of ways, but essentially all involve:

- Application of a heat process.
- The breaking of the beans to release nibs (winnowing).
- The production of cocoa liquor by passing nibs through grinders and refiners.

The roasting process usually involves application of heat up to 150°C, can be applied directly to beans, and be followed by winnowing and grinding; or it can be applied to nibs released from raw bean, after which roasted nibs are ground; or it can be applied to liquor, after raw bean is broken and unprocessed nibs are ground. Whichever is used, the heat process applied at this stage in the chocolate production process will usually be the last heat application able to provide any level of microbial kill.

Microbiological problems

Micro-organisms in cocoa liquor at this point (usually a range of Bacillus species, such as B. subtilis, B. coagulans, B. stearothermophilus, B. lichiniformis, and B. megaterium) or that contaminate the liquor after the roasting process, are likely to remain in final chocolate products.

Cocoa liquor will be subjected to a variety of handling steps that will vary according to manufacturer. This will often include mixing or blending with other ingredients such as milk powder, sugar and cocoa butter; conching to allow flavour and plasticity development, then tempering and finally moulding. None of these processes will have any significant effect on the microbiological content of the chocolate.

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The first thing to note is that chocolate is a low water activity product with an Aw of 0.4 to 0.5. As such, micro-organisms are unable to grow. However, due to the low Aw, many organisms can survive for some considerable periods of time.

The raw cocoa beans are highly contaminated with a range of micro-organisms; the only processes that are applied to beans that are antimicrobial are any primary steam or infra red heating, then roasting.

These both occur very early in the chocolate making process. After this, there are no other steps that could be considered antimicrobial. Therefore care must be taken in ensuring that the antimicrobial processes are correctly applied, have the desired effects and additionally, that the remainder of the chocolate making process is 'protected' and microbiological contamination of process intermediates and final product is avoided.

Microbial spoilage

Microbial spoilage of any food will usually require growth of a 'spoilage microflora' within the product causing some form of visual or organoleptic change that renders the product unfit for consumption.

As chocolate has such a low water activity it would be highly unusual to find any organism capable of growing within it and causing any change in quality. It is very likely that a range of organisms will be present in the chocolate in a viable state, but unable to grow.

This must be kept in mind if the chocolate is being used as an ingredient in any other food product, particularly if that food has a higher water activity that may allow these contaminating organisms to grow. Whilst chocolate per se does not tend to be spoiled by micro-organisms, chocolate products such as fondant filled chocolate shells can spoil. If the fondant filling is at a water activity that can allow specialist xerophilic organisms (for example various species of the yeasts Zygosaccharomyces and Chrysosporium) to develop, these can grow and even produce gas within the centre of a chocolate shell.

Presence of pathogens

As with spoilage organisms, the water activity of chocolate is too low to allow the growth of pathogenic bacteria, they can however survive well in the product. The only pathogens of significance in chocolate therefore, are bacteria with a low infective dose. There have been a number of fairly well know instances of chocolate products causing outbreaks of salmonella food poisoning.

These issues have often been characterised by a low infective dose (less than 10 salmonella ingested), and often involve a slightly higher proportion of children than adults. The reason for the low infective dose that appears to be associated with salmonella cases originating from chocolate, has often been discussed.

There is a hypothesis that one of the major defences in the human body against food pathogen attack, is the very low pH within the stomach, and that this will inactivate many potentially pathogenic organisms. In the case of chocolate (and this will apply to other fatty/oily products such as peanut butter), if the organisms are coated in fat as they travel through the stomach, then this will protect them from the acid and they will enter the intestine in a viable format, able to grow and subsequently cause illness.

Whilst there have been no cases of verocytotoxin producing E. coli (VTEC, for example E. coli O157) reported to originate from chocolate, there is no reason to believe that such organisms could not contaminate the beans. Research work on chocolate artificially contaminated at a low level, has shown that VTEC can be detected in chocolate after over a year's storage at 22°C. Control of this group would be through the same measures as used for salmonella (heat process and prevention of recontamination).

Conclusions

Chocolate is a very widely consumed snack and luxury food that has been on the market for many years and has an interesting history dating back to Aztec times.

It is a very stable product, being able to be stored at ambient temperature for a considerable period of time. Due to its very low water activity, micro-organisms are unable to grow in normal chocolate, however most organisms can survive for considerable periods of time.

This means that microbiological spoilage is unlikely to occur, but pathogen survival must be considered seriously and suitable controls put in place to eliminate pathogens during the manufacturing process.

Nevertheless, considerable quantities of chocolate have been sold and consumed around the world for a many years and cases of food poisoning linked to it are very rare indeed. It should be considered to be a safe and stable product that is widely enjoyed all over the world. ■

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