Microbial update
bakery products

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Dr Phil Voysey works within the microbiology department at Campden and Chorleywood Food Research Association (CCFRA). CCFRA is one of the largest independent food research organisations in the world, offering advice, information, and scientific and technical consultancy to all parts of the food and associated industries on a worldwide basis.

A wide variety of bakery products can be found on supermarket shelves including breads, savoury and fruit pies, quiches, pizza, biscuits and cakes.

In the UK in 2006, it has been estimated that 1.78 million tonnes of bread were sold worth an estimated £2,115 million. Similarly, the estimated value of cakes sold in the UK in 2006 was £1,522 million. Consequently, it can be seen that this is an important part of the UK food sector.

This article looks at the microbiology of baked products from the angles of spoilage and safety.

Spoilage of bakery products

In addition to microbiological spoilage (from bacteria, yeasts and moulds), bakery products can also undergo physical (moisture loss and staling) and chemical (rancidity) spoilage. Only microbiological spoilage will be outlined here.

The major bacterial problem associated with bread is 'rope'. This condition is caused by the spore-former Bacillus subtilis. The bacterium usually originates from raw ingredients such as flour, survives baking, and goes on to break down bread, whilst producing a characteristic 'fruity' odour. Bacteria can also cause problems with the fillings of many pastries and other baked goods. These products can support the growth of spoilage bacteria such as lactic acid bacteria and some pathogens.

Yeasts can cause 'visible' (in products with high water activity (aw) and short shelf life) and 'fermentative' (in products with low aw and long shelf life) spoilage of baked products. Pichia burtonii (which causes 'chalk mould' of bread) and Zygosaccharomyces rouxii (which grows in highly sugared toppings and fillings) are examples of yeasts encountered from time to time with bakery products.

Moulds can grow at lower aw values than other micro-organisms; consequently their growth frequently limits the shelf life of bakery products – especially those held at ambient temperatures. A wide range of mould genera are encountered, with the 'blue-green' coloured Penicillium most frequently associated with bread spoilage in the UK.

There are three basic strategies to extending the microbiological shelf life of bakery products. The first of these is to prevent post-baking contamination. This is easier said than done, but access of moulds to baked products can be minimised by screening of post-bake, pre-package areas of the bakery. This prevents the airborne mould spores (high in numbers in areas where ingredients such as flour are handled) from accessing the baked products. Technologies such as 'baking-in-pack' and 'aseptic packaging' in filtered air environments, may help with this in the future.

The second strategy is destruction of post-baking contaminants. Several traditional and novel methods have been investigated to destroy post-baking contaminants of bakery products. These have included ultra violet light, infrared radiation, microwave heating, low dose irradiation, pulsed light technology and ultra high pressure. These technologies are certainly able to limit the problem of survival and microbial growth on the product, but all have a cost implication to the manufacturer.

Controlling the growth of post-baking contaminants is a third strategy for extending the microbiological shelf life of baked products. This strategy is the most practical, common, and cost efficient approach used by the baking industry. Product reformulation to reduce the product aw, and hence rate of microbial growth, is one way of achieving this. It is principally applied to products such as cakes, which lend themselves to recipe manipulation. Commercial software is available to help with this.

Chemical preservatives are an alternative and commonly used means for controlling microbial growth. In the UK, the chemical preservatives most frequently used with baked products are calcium propionate and potassium sorbate. Work is on-going looking at 'natural' alternatives to these chemicals. Some essential oils such as mustard oil have shown potential for controlling micro-organisms in baked products, but these compounds cannot be used as preservatives as they are not permitted in legislation.

Modified Atmosphere Packaging (MAP), using gas packaging or interactive packaging sachet technology is a third means of controlling the growth of post-baking contaminants used by the baking and other food industries. The major concern associated with this technology appears to be the potential for Clostridium botulinum growth in the product and consequent consumer poisoning. Thankfully, however, there have been no cases of Clostridium botulinum food poisoning associated with MAP products.

Safety concerns

While foods such as meat, fish, poultry, eggs and dairy products are the most common vehicles of foodborne illnesses worldwide, bakery products have also been implicated in foodborne disease outbreaks.

Sockett estimated that between 1980 and 1981, 4% of foodborne illnesses in England and Wales were due to bakery products.

Similar rates are reported by Smith et al. for other countries (for example USA and Australia), although Todd reported that 35-47% of all foodborne disease outbreaks in Poland, Portugal, Bulgaria and Switzerland were caused through bakery products.

There are several reasons why bakery products are implicated in outbreaks of foodborne disease:

- **Processing conditions.** The time and temperature used to bake products is set to achieve a good quality product. A consequence of this is that vegetative micro-organisms, including yeast used to raise bread for example, are killed. However, sometimes spore-formers can survive. Also,

some baked products include cream, cold custard, icing, spices, nuts, or fruit toppings or fillings, which may be prepared without any heating.

● **Hazardous products/ingredients.** Many bakery products and their ingredients have a pH of >4.6 and an aw of >0.85, conditions that are conducive to the growth of pathogenic bacteria. For example, the pH of custard used in many filled bakery products is 5.8-6.6 and is ideal for the growth of Salmonella spp.

● **Storage conditions.** Most bakery products, with the exception of cream, custard, and meat-filled products, are held at ambient temperature for maximum storage quality. However, such storage conditions may be conducive to microbiological growth and may compromise safety.

For example, English style crumpets, a high moisture food product held at ambient temperature, have been implicated in food poisoning involving Bacillus cereus. Foodstuffs which are held at chill temperatures can support the growth of psychrotrophic pathogens such as Listeria monocytogenes, and other pathogens if there is a break in the cold chain.

Micro-organisms of concern

Some of the principal micro-organisms of concern with baked products include:

● **Salmonella spp**

Salmonella is normally isolated from animals (including humans). It may be introduced into bakery products through a range of ingredients including eggs. Other ingredients that can be a source of the organism include flour and chocolate. Although the organism does not grow in these foods, it can survive for a substantial time.

In most reported outbreaks of salmonellosis caused by eating contaminated bakery products, eggs have been the suspected vehicle of transmission. To get around this, pasteurised egg rather than raw shell eggs are now used in bakeries. The bakery foods implicated in salmonellosis include custard pies, bread pudding, custard-filled cakes and pastries, quiche, meringue, puddings and cheesecake.

● **Staphylococcus aureus**

The major reservoirs of Staph. aureus are humans and animals. This bacterium is carried by 30-50% of humans in the nasal passage and throat, and on skin. It is also found associated with air, water, sewage, and food contact surfaces. Dairy ingredients can also be sources of the organism.

The number of cases of Staph. aureus food poisoning associated with the poor handling and storage of custard or cream-filled bakery products, has diminished in the UK and USA over recent years.

However, the bacterium is still seen as a problem in temperate countries where refrigeration is a problem. A period of growth is needed before toxin is produced, typically when the population reaches 100,000cfu/g. Other foods where Staph. aureus has been implicated include oatmeal raisin cookies, apple muffins, cream puffs and pizza.

Important attributes of this bacterium which make it an issue with baked problems include its ability to grow at low (≤0.83) water activities and the toxin that is produced by it is heat stable.

● **Bacillus cereus**

The spore former Bacillus cereus has been implicated in several outbreaks of foodborne illnesses involving bakery products. There is also some evidence that B. subtilis and B. licheniformis (responsible for 'rope' spoilage of bread) can cause foodborne illness.

Species of Bacillus are commonly found in the environment. From there, they contaminate ingredients such as flour, milk, cream, spices, dried egg, yeast and improvers, dried fruits and cocoa.

As with Staph. aureus, B. cereus is a toxin producer. In fact it produces two toxin types (an 'emetic' type which is associated with cereal based foods and a 'diarrhoeal' type which is associated with proteinaceous foods). The emetic type is heat stable and so can survive a baking process, as can the spores of the organism.

Outbreaks of Bacillus food poisoning have been associated with naan bread, crumpets, and cream and custard-filled pastries. B. cereus has also been isolated from meat pies, bread and pastry.

● **Clostridium botulinum**

C. botulinum is another spore forming, toxin producing bacterium. It is able to grow in the absence of oxygen. The bacterium has caused food poisoning outbreaks where mortality rate has been high. Therefore it is regarded as an important pathogen.

There is no evidence of any association of this bacterium with baked products, but there is a perceived potential risk. The bacterium is found in soil and the environment. It has also been found associated with agricultural and animal products, including dairy products such as cheese, fruits and vegetables, and honey.

Two forms of this pathogen are known. A cold-tolerant ('psychrotrophic') form, which has been associated with chilled foods, and a 'mesophilic' (literally ambient temperature-liking) form, which has a potential for causing problems with MAP breads. Other micro-organisms of concern include:

● **Listeria monocytogenes.**

L. monocytogenes is a pathogen which is readily found in the environment, and is occasionally associated with bakery ingredients such as flour and dairy products.

● **Mycotoxigenic moulds.**

Mycotoxins are toxins which can be excreted into foods by moulds. Some of these can be carcinogenic, and many are very heat resistant. If moulds are prevented from growing on baked products and in ingredients, then mycotoxins are not an issue.

Conclusions

In general, the level of food poisoning associated with baked foods is low compared to many other types of food. A wide range of micro-organisms – bacteria, yeasts and moulds – can cause spoilage and food safety issues with baked products.

However, these can be minimised by adopting strategies to prevent post-baking contamination, destroy post-baking contaminants, and control the growth of post-baking contaminants. ■

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References

● References are available from the author on request.